Lake Erie Region Source Protection Committee

Agenda

Thursday, June 21, 2018

1:00 pm

Auditorium

Grand River Conservation Authority

400 Clyde Road, Box 729

Cambridge, ON N1R 5W6

Pages

1. **Call to Order**

2. **Roll Call and Certification of Quorum – 17 Members Constitute a Quorum (2/3 of Members plus Chair)**

3. **Chair's Remarks**

4. **Review of Agenda**

5. **Declarations of Pecuniary Interest**

6. **Minutes of the Previous Meeting**

7. **Hearing of Delegations**

8. **Presentations**

9. **Correspondence**

   a. RE: Submission of the Catfish Creek 2017 Annual Progress Report and Annual Progress Reporting Supplemental Form — 1

   Correspondence from Rick Cerna, Catfish Creek Source Protection Authority Chair to, Heather Malcolmson, Director, Source Protection Programs Branch, Ministry of the Environment and Climate Change.

14. Next SPC Meeting

October 4, 2018 at 1:00pm, Grand River Conservation Authority, 400 Clyde Rd., Cambridge.

15. Adjourn

CATFISH CREEK CONSERVATION AUTHORITY
8079 Springwater Road, RR# 5, Aylmer, Ontario N5H 2R4
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April 24, 2018

Heather Malcolmson
Director, Source Programs Branch
Ministry of the Environment and Climate Change
14th Floor, 40 St. Clair Avenue West
Toronto, Ontario M4V 1M2

Dear Ms. Malcolmson:

RE: Submission of the Catfish Creek Annual Progress Report and Annual Progress Reporting Supplemental Form

It is my pleasure to submit to you the first Catfish Creek Annual Progress Report and Annual Progress Reporting Supplemental Form. The Catfish Creek Source Protection Authority passed the following resolution at its meeting April 12, 2018:

> *THAT, the Catfish Creek Source Protection Authority accept the Lake Erie Region Source Protection Committee comments regarding the extent to which objectives of the Catfish Creek Source Protection Plan have been achieved during the first annual reporting period; and further,*
>
> *THAT, the Catfish Creek Source Protection Authority direct Lake Erie Source Protection Region staff to submit the Catfish Creek Annual Reports to the Ministry of the Environment and Climate Change, together with the Lake Erie Region Source Protection Committee's comments and any comments the Source Protection Authority wishes to make, in accordance with S. 46 of the Clean Water Act, 2006, and any Director's instructions established under O.Reg. 287 / 07 S. 52.*

As indicated in the resolution, the Source Protection Authority is satisfied with the Source Protection Committee's comments regarding the extent to which objectives of the Catfish Creek Source Protection Plan have been achieved during the first annual reporting period. The Source Protection Authority does not have any additional comments regarding the annual progress reports or annual progress reporting results.

In accordance with *S.46 of the Clean Water Act, 2006* and *O.Reg. 287/07 S.52*, we provide you with the following attachments:

- 2017 Catfish Creek Annual Progress Report
- 2017 Catfish Creek Annual Progress Reporting Supplemental Form

In addition to the prescribed annual progress reports, Lake Erie Region, in collaboration with Oxford County staff, has developed a 2017 Catfish Creek Annual Report. The report provides a snapshot of the program's progress in the Catfish Creek watershed and is designed to complement the Annual Progress Report and Supplemental Form (see attached).

If you have any questions regarding the Catfish Creek Annual Progress Report or Annual Progress Reporting Supplemental Form, please contact Ilona Feldmann, Source Protection Program Assistant (519 621 2763 x 2318; ifeldmann@grandriver.ca).

Sincerely,

Rick Cerna, Chair
Catfish Creek Source Protection Authority

Cc:
W. Wright-Cascaden, Chair, Lake Erie Region Source Protection Committee

Kettle Creek Conservation Authority

44015 Ferguson Line
St. Thomas, ON N5P 3T3
P 519-631-1270 | F 519-631-5026
www.kettlecreekconservation.on.ca
Member of Conservation Ontario

April 25, 2018

Heather Malcolmson
Director, Source Programs Branch
Ministry of the Environment and Climate Change
14th Floor, 40 St. Clair Avenue West
Toronto, Ontario M4V 1M2

Dear Ms. Malcolmson:

RE: Submission of the Kettle Creek Annual Progress Report and Annual Progress Reporting Supplemental Form

It is my pleasure to submit to you the first Kettle Creek Annual Progress Report and Annual Progress Reporting Supplemental Form. The Kettle Creek Source Protection Authority passed the following resolution at its meeting April 18, 2018:

> *THAT the Kettle Creek Source Protection Authority accept the Lake Erie Region Source Protection Committee comments regarding the extent to which objectives of the Kettle Creek Source Protection Plan have been achieved during the first annual reporting period.*
>
> *AND THAT the Kettle Creek Source Protection Authority direct Lake Erie Source Protection Region staff to submit the Kettle Creek annual reports to the Ministry of the Environment and Climate Change, together with the Lake Erie Region Source Protection Committee's comments and any comments the Source Protection Authority wishes to make, in accordance with S.46 of the Clean Water Act, 2006 and any Director's instructions established under O.Reg. 287/07 S.52.*

As indicated in the resolution, the Source Protection Authority is satisfied with the Source Protection Committee's comments regarding the extent to which objectives of the Kettle Creek Source Protection Plan have been achieved during the first annual reporting period. The Source Protection Authority does not have any additional comments regarding the annual progress reports or annual progress reporting results.

In accordance with *S.46 of the Clean Water Act, 2006* and *O.Reg. 287/07 S.52*, we provide you with the following attachments:

- 2017 Kettle Creek Annual Progress Report
- 2017 Kettle Creek Annual Progress Reporting Supplemental Form

In addition to the prescribed annual progress reports, Kettle Creek Conservation Authority, in collaboration with Lake Erie Region staff, has developed a 2017 Kettle Creek Annual Report. The report provides a snapshot of the program's progress in the Kettle Creek watershed and is designed to complement the Annual Progress Report and Supplemental Form (see attached).

If you have any questions regarding the Kettle Creek Annual Progress Report or Annual Progress Reporting Supplemental Form, please contact Ilona Feldmann, Source Protection Program Assistant (519 621 2763 x 2318; ifeldmann@grandriver.ca).

Sincerely,

Heather Jackson, Chair
Kettle Creek Source Protection Authority

Cc:
W. Wright-Cascaden, Chair, Lake Erie Region Source Protection Committee

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-01 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Source Protection Program Update

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-01 – Source Protection Program Update – for information.

REPORT:

Regulatory Decision Notice Posted on the Environmental Registry

The Ministry of the Environment and Climate Change (MOECC) posted two decision notices on the Environmental Registry in April 2018: EBR #013-1840 regarding a new regulation under the *Safe Drinking Water Act (SDWA), 2002.* This regulation requires municipal residential drinking water system owners ensure work to assess the vulnerability of new or expanding drinking water systems is completed and accepted by the local source protection authority (SPA) before they can apply for a drinking water works permit, and that the water not be provided to the public until the source protection plan that protects the system is approved. The SDWA amendments more closely integrate source protection work with the Environmental Assessment (EA) process and make the provision of municipal drinking water dependent on timely updates and amendments of source protection plans.

Decision notice EBR #013-1839 identifies the amendments that were made to Ontario Regulation 287/07 – "General" under the *Clean Water Act, 2006.* To support the implementation of the new regulation under the SDWA, the regulation requires that source protection authorities issue a notice to a drinking water system owner when they have received, and are satisfied that work to update vulnerable area information for any new or expanding drinking water system where it differs from existing vulnerable areas, has been completed. The notice must also identify what changes to the source protection plan are required and an indication of the timeline for the plan amendments. Lake Erie Region staff understand that the notice the SPA is required to issue to a municipality/system owner is administrative in nature, placing no approval authority or obligation on SPAs. This reduces concerns originally identified about increased liability.

To help with implementation of these new requirements, Conservation Ontario is developing a best practices document for Source Protection Authorities, and a sub-group of the Lake Erie Region Implementation Working Group (IWG) is working to establish a guidance document/protocol for municipalities and SPAs in the Lake Erie Region. The protocol will be developed in consultation with the broader IWG and presented to the SPC at the October 4, 2018 meeting for official release to municipalities. Amendments to both the SDWA and CWA will come into effect July 1, 2018.

S. 36 Workplans for Catfish Creek and Kettle Creek Source Protection Areas

At the time of approval for each Lake Erie Region Source Protection Plan, the Minister specified which parts of the Assessment Report and plan were to be reviewed under s. 36 of the Act.

A workplan must be developed for each assessment report and plan in consultation with the Source Protection Committee, Source Protection Authorities, municipalities and the MOECC as part of the review process. The workplan will set out what aspects of the assessment report and plan should be reviewed. Kettle Creek and Catfish Creek workplans are due for submission to the MOECC in November 2018; Grand River and Long Point Region will follow in November 2019.

Workplan discussions have begun with Kettle Creek Conservation Authority, Central Elgin, and Elgin Area Primary Water Supply System (EAPWSS) as well as Oxford County staff and Catfish Creek Conservation Authority, to develop S.36 workplans for a comprehensive review of the Kettle Creek and Catfish Creek assessment report and source protection plan.

SPC Meeting Outlook

Lake Erie Region is planning to complete two S.34 updates of the Grand River Source Protection Plan in the coming year. The first update will be for the County of Grey, Township of Dundalk municipal water supply system and the second a larger “bundled” Grand River update for other municipal water supply systems.

Lake Erie Region staff originally planned to include the Dundalk system update in the bundled Grand River plan update. However, because of the recent amendments to the SDWA and CWA and the requirement that the plan updates be approved before water can be provided to the public, in response to the Township of Southgate’s planned timeline to commission new Well D5, Lake Erie Region will proceed with a distinct S.34 update to address the Dundalk amendment. Details regarding the plan update process, e.g., timing of pre-consultation and public consultation, are still being discussed.

Technical studies and updated Grand River Assessment Report and Source Protection Plan sections will be presented to the Source Protection Committee as work is completed over the next four (4) committee meetings starting on June 21, 2018. The next committee meetings will be on October 4, 2018, December 6, 2018, and January 17, 2019. Staff anticipate that a complete amended Assessment Report and Source Protection Plan will be presented to the SPC on April 4, 2019 and released for public consultation, with the aim to bring back comments to the SPC on June 6, 2019 and revise the documents as necessary. The Grand River Source Protection Authority would then submit the amended Assessment Report and Source Protection Plan to the MOECC at its meeting on June 28, 2019. The following table provides an overview of the next several SPC meetings and anticipated agenda items related to the S.34 Dundalk and S.34 Grand River updates.

SPC Meeting Date	**Agenda Items**	
	S. 34 Dundalk Update	**S.34 Grand River Update**
October 4, 2018		• Bethel water quality technical study • Mt. Pleasant water quality technical

SPC Meeting Date	Agenda Items	
	S. 34 Dundalk Update	**S.34 Grand River Update**
		study • Guelph/Guelph-Eramosa Tier 3 draft water quantity policy approaches • Draft updated AR and SPP sections: Hamilton, Oxford • Draft updated AR sections: introduction, watershed characterization update, overview of water budget framework, Tier 2 water budget
December 6, 2018	• Complete draft updated AR and SPP; release for pre-consultation and public consultation process	• Water quality technical reports • Draft updated AR and SPP sections • Draft water quantity policies
January 17, 2019		• Draft updated AR and SPP sections; release for pre-consultation and public consultation process • Revised draft water quantity policies
Mid-January – mid February 2019 (dates TBD)	Municipal and ministry pre-consultation period	
January 21–March 17, 2019		Municipal and ministry pre-consultation period
Mid-February – mid March 2019 (dates TBD)	Formal public consultation period	
April 4, 2019	• Revised draft updated AR and SPP; receive public comments for consideration; release the document to the Grand River Source Protection Authority for submission to the Ministry	• Complete draft updated AR and SPP
April 8-May 19, 2019		Formal public consultation period

SPC Meeting Date	Agenda Items	
	S. 34 Dundalk Update	**S.34 Grand River Update**
June 6, 2019		• Revised draft updated AR and SPP; receive public comments for consideration; release the document to the Grand River Source Protection Authority for submission to the Ministry

Prepared by:

Ilona Feldmann
Source Protection Program Assistant

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-02 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Proposed SPC Member Terms of Appointment

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-02 – Proposed SPC Member Terms of Appointment – for information.

REPORT:

Background

In 2015 regulation governing the SPCs was amended to allow for increased flexibility with regard to committee size and member terms of appointment. The amendments require that all terms of members that were appointed prior to the regulation amendments coming into force must expire before January 1, 2021 (this applies to the majority of current members). This regulation amendment does not apply to First Nations appointments – member nomination and term selection is a responsibility of the respective Band Council.

Discussions were initiated in 2016 among Lake Erie Region staff, the SPC and Lake Erie Source Protection Management Committee members regarding committee size and how SPC term expiries could be managed into the future**.** The Management Committee, with input from the SPC, at that time decided against changing the size of the SPC for the near future. The thought was to complete most of the technical work before reconsidering reduction. Additionally, the Management Committee and SPC noted the challenge in reducing municipal representatives. Proposed SPC terms of appointment and configuration options were put on hold and a focus was placed on securing replacements for recently resigned members. Since 2016, three new members have been appointed: one from the agriculture sector, one municipal and one public sector.

Proposed SPC Member Terms of Appointment Plan

With the above information in mind, and with the committee at its full member complement, Lake Erie Region staff, with input from the Management Committee, re-evaluated the current status of SPC memberships and developed a proposed SPC terms of appointment plan to guide the decision-making process (see **Appendix A**). The proposed plan presents a scenario in which term expiry dates are staggered over time with terms of those members appointed before the regulation amendments came into force expiring before January 1, 2021.

There are no term limits for SPC members, i.e., members can re-apply or be re-appointed for successive terms. O. Reg. 288/07 stipulates member's terms between 6 months and 5 years. As recommended by the Lake Erie Region Management Committee, since the regulation

amendment, new members or re-appointed members have been appointed for a four-year term. The Source Protection Authority can also remove a member if the member does not regularly attend meetings of the source protection committee as per regulation 288/07, “Source Protection Committees”.

In developing the proposed plan, Lake Erie Region considered the following:

- Results of the 2016 SPC member survey. The survey was conducted in order to gauge which members of the committee were interested in staying on and for how long.
- The importance of ensuring that expiries are spaced fairly evenly over the next two and a half-years (until January 1, 2021).
- The amount of effort that would be required to find new members if a number of terms expired simultaneously.
- Timing of the upcoming municipal election. The “lame duck” period for local councils may begin July 27, 2018 and last until the end of Council term (November 30, 2018). It is anticipated that the process to find a new municipal member may not be complete until the first quarter of 2019 once new councils are in place.
- Members that have recently expressed their intentions to resign from the committee.
- Agricultural members are also often active farmers. It may be easier to approach agricultural sector organizations and nominate new members during the winter months when farmers are less busy.

While specific member names are attached to specific expiry timelines, the proposed plan is and will be a living document. It provides a flexible framework to ensure the committee continues to evolve into the future while also maintaining a measure of stability and knowledge.

Source Protection Committee member feedback/comments on the proposed terms of appointment plan is requested. Member comments together with an updated plan, will be brought back to the Management Committee for their consideration and endorsement.

Prepared by:

Ilona Feldmann
Source Protection Program Assistant

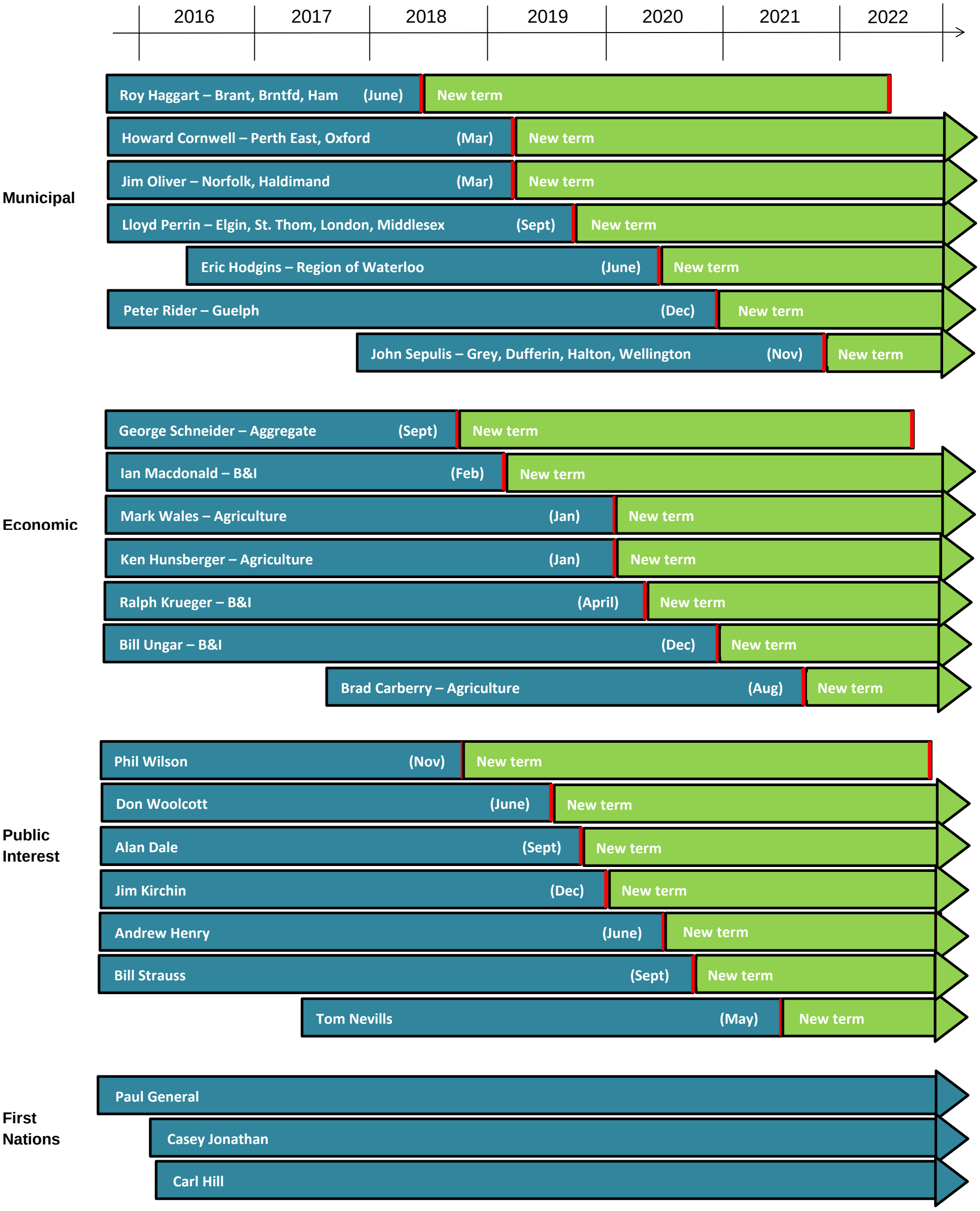
Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

Proposed SPC Member Terms of Appointment Plan

Proposed Lake Erie Region Source Protection Committee Member Terms of Appointment



Of Note:

- There are no term limits for Source Protection Committee members, i.e., members can re-apply or be re-appointed for successive terms
- 4-year term applies to all member re-appointments and new appointments, as recommended by the Lake Erie Region Management Committee
- First Nations member nominations and term selection is the responsibility of the respective Band Council

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-03 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Guelph-Guelph/Eramosa Water Quantity Policy Development Study

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RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-03 – Source Protection Program Update – for information.

AND THAT the Lake Erie Region Source Protection Committee direct Lake Erie Region staff to continue to work with the Project Team, with input from the Implementing Municipal Group (IMG) and Community Liaison Group (CLG), to develop water quantity policies for the Guelph-Guelph/Eramosa WHPA-Q and IPZ-Q.

SUMMARY:

In April 2017, the City of Guelph and Township of Guelph/Eramosa Tier 3 Water Budget and Local Area Risk Assessment report was accepted by the Lake Erie Region Source Protection Committee, following sign off from the provincial peer review committee and acceptance from the MOECC in accordance with the Technical Rules under the Clean Water Act, 2006. A significant risk level was assigned to the water quantity wellhead protection area (WHPA-Q) and intake protection zone (IPZ-Q) for the City of Guelph and Township of Guelph/Eramosa (Hamilton Drive) water supply systems.

A Risk Management Measures Evaluation Process (RMMEP) has been undertaken and the results captured in a Threats Management Strategy (TMS). The TMS is attached in **Appendix A**. This technical study was led by the Project Team comprised of municipal, conservation authority and provincial staff with input from affected municipalities (Implementing Municipal Group IMG). In parallel, the Project Team developed a Water Quantity Policy Discussion Paper (**Appendix B**), with input from the IMG and the Community Liaison Group (CLG), comprised of stakeholders and community members.

The aim of the RMMEP/TMS was to identify the impacts of water quantity threats on water levels in municipal wells and to assess whether they can still be pumped under existing, future and drought conditions. The RMMEP/TMS also ranked the water quantity threats, and selected preliminary Risk Management Measures (RMM) that could address the risk. Results show that municipal wells rank high and can have an impact on themselves. Individually, non-municipal takings have little influence on municipal wells, with the dewatering for the Dolime Quarry (River Valley Developments) the one exception. Recommended Risk Management Measures include well optimization, water conservation and efficiency, addition of new water supplies, maintaining pre-development aquifer recharge rates, and mitigating impacts from non-municipal consumptive water takings.

The Water Quantity Policy Discussion Paper was developed as part of the process to update

the Grand River Source Protection Plan to address water quantity threats in the vulnerable areas (WHPA-Q and IPZ-Q). The Discussion Paper provides an overview of the technical studies and drinking water quantity threats, a brief summary of the existing legislation, policies and programs at the federal, provincial and municipal level, lays out the policy tools and options available, reviews them, and provides a list of promising policy tools that could be used to protect water quantity sources of drinking water.

The Threats Management Strategy (TMS) and policy Discussion Paper provide the foundation for water quantity policy development. Over the summer, the Project Team will be working on developing a policy framework and a list of policy approaches.

Lake Erie Region is committed to a collaborative process for policy development, with municipal and stakeholder engagement through the Project Team, IMG, and CLG. Policy approaches will be presented to the SPC on October 4, 2018, with drafting of the water quantity policy text expected to be begin in the early fall. On June 26, 2018, the CLG will receive the results of the Threats Management Strategy and Discussion Paper.

REPORT:

Background

In April 2017, the City of Guelph and Township of Guelph/Eramosa Tier 3 Water Budget and Local Area Risk Assessment report was accepted by the Lake Erie Region Source Protection Committee, following sign off from the provincial peer review committee and acceptance from the MOECC in accordance with the Technical Rules under the *Clean Water Act, 2006*. The study was initiated as the City of Guelph Tier 3 Water Budget Pilot Project in 2008, and starting in 2013, work commenced to integrate Guelph/Eramosa Township's Rockwood and Hamilton Drive Tier 3 Risk Assessment with the City of Guelph Tier 3 Risk Assessment. A significant risk level was assigned to the water quantity wellhead protection area (WHPA-Q) and intake protection zone (IPZ-Q) for the water supply systems of the City of Guelph and Township of Guelph/Eramosa (Hamilton Drive).

Risk Management Measures Evaluation Process and Threats Management Strategy

With the significant risk level assigned to the WHPA-Q and IPZ-Q for the City of Guelph and Township of Guelph/Eramosa (Hamilton Drive), the next step was to undertake a Risk Management Measures Evaluation Process (RMMEP), a technical study that has the purpose to 1) identify and rank significant drinking water threats (i.e., permitted and non-permitted consumptive water takings and recharge reductions), 2) select and evaluate Risk Management Measures to address the risk, and 3) develop a Threats Management Strategy (TMS). The TMS can be found in **Appendix A**. This study was done using the Risk Management Measures Catalogue developed for Source Protection and followed the "Guide – Water Quantity Risk Management Measures Evaluation Process" prepared by the Toronto and Region Conservation Authority (TRCA, 2013). This technical study was led by the Project Team comprised of municipal, conservation authority and provincial staff with input from affected municipalities (Implementing Municipal Group IMG).

The RMMEP was implemented using the groundwater flow model developed for the Tier 3 Assessment. The model was used to compare the impact of municipal and non-municipal

water takings on the municipal wells under existing and future demands and under drought conditions as well as reductions in groundwater recharge. The model was also used to assess a number of risk management scenarios to determine the effectiveness of the measures to reduce the risk level on the drinking water sources.

The RMMEP is intended to address the provincially prescribed water quantity threats (O. Reg. 287/07):

> Threat #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.
>
> Threat #20: An activity that reduces the recharge of an aquifer

1) Threats Ranking and Identification of Impact

Following the guidance, the technical study determined the impact from identified significant water quantity threats on water levels in municipal wells and whether the municipal wells can still be pumped under existing, future and drought conditions. The significant water quantity threats were then ranked according to the relative impact they may cause to water levels at a municipal supply well.

Table 1 below lists the municipal wells ranked from highest to lowest impact. The ranking shows a relative comparison of the threats, and illustrates that municipal wells are a threat to themselves. That means that when municipal wells pump water out of the ground, the drawdown at the municipal wells is increased, leaving less water available for taking. Queensdale well is ranked #1 with a 72% impact on itself, meaning that 72% of the overall drawdown at the Queensdale well is caused by the pumping of this well. The Arkell system as a whole is ranked #2 with a 53% impact on Arkell Well 8. It was expected that Queensdale well and Arkell Well 1 (as part of the Arkell system) ranked high as these were the two wells that triggered the significant risk level.

Table 1: Ranking of Significant Municipal Drinking Water Threats in Guelph-Guelph/Eramosa WHPA-Q

Water Quantity Threat Group or Individual Threat	Greatest % Impact	Rank	Well under Greatest % Impact
Queensdale Well	72%	1	Queensdale
Arkell System (Arkell 1, Arkell 6, Arkell 7, Arkell 8, Arkell 14, Arkell 15 wells & artificial recharge and collector system)	53%	2	Arkell 8
Clythe Creek Well	32%	4	Clythe Creek
Calico Well	24%	5	Calico
Sacco Well	22%	6	Sacco
Helmar Well	19%	7	Helmar
Smallfield Well	19%	8	Smallfield
Carter Wells	17%	9	Carter Wells
Water St. Well	17%	10	Water St.
Burke Well	15%	11	Burke

Membro Well	13%	12	Membro
Downey Well	12%	13	Downey
University Well	7%	16	University
Dean Well	4%	17	Dean
Paisley Well	2%	18	Paisley
Future Municipal Takings: Hamilton Drive (GET)	<1%	22	-

Table 2 below lists the permitted, non-municipal water takings within WHPA-Q ranked from highest to lowest impact on municipal wells. Individually, the majority of non-municipal water taking has little influence on municipal wells. The exception is the dewatering permit at the Dolime Quarry that is ranked #3 and responsible for 50% of drawdown at the Membro well. All other permitted, non-municipal takings exert 10% influence on the municipal wells. As examples, the 10% influence includes Gay Lea (rank #19), responsible for 2% drawdown at the Emma well, and Nestle (rank #20), responsible for 1% drawdown at the Burke well. The combined influence of recharge reduction from land development (rank #15) is responsible for 9% drawdown at the Burke well, and the combined influence of all domestic wells (rank #21) is 1% drawdown at the Helmar well.

Table 2: Ranking of Significant Non-Municipal Drinking Water Threats in Guelph-Guelph/Eramosa WHPA-Q

Water Quantity Threat	**Greatest % Impact**	**Rank**	**Well under Greatest % Impact**
Group or Individual Threat			
5080-8TAKK2 (Dolime - River Valley Developments)	50%	3	Membro
All other Permitted, Non-Municipal Takings Inside WHPA-Q except Dewatering, Commercial, and Industrial	10%	14	Emma
1245-AB8RMW (Gay Lea Foods)	2%	19	Emma
1381-95ATPY (Nestle Waters)	1%	20	Burke
5448-9FLM5E (Holody Electro Plating)	<1%	23	-
5736-8QSS7B (Flochem)	<1%	24	-
All Recharge Reduction Areas (due to future land use)	9%	15	Burke
All Non-Permitted Takings (WWIS-Domestic)	1%	21	Helmar

The threats ranking for the IPZ-Q has not been completed yet. This work will be undertaken as part of the climate change assessment later in 2018. Water takings in the IPZ-Q are small compared to the natural variability of flow in the Eramosa River, and the threats impact on municipal wells from these takings is expected to be limited by comparison.

2) Selection and Evaluation of Risk Management Measures

As the next step, Risk Management Measures (RMM) were selected using the Risk Management Measures Catalogue. In the Catalogue, measures include increase in supply (i.e., addition of new wells), protection of groundwater recharge areas, upgrades to municipal

infrastructure such as increasing connections throughout the system and system optimization, leakage reduction programs and repairs for residential usage, the addition of water storage facilities and acquiring land to protect future supplies.

To test the RMMs using the Tier 3 model, ten (10) different scenarios were developed based on the results of the threats ranking. These scenarios adjusted the well pumping rates, well locations, and other conditions to reduce the significant risk level. A complete list of the 10 scenarios can be found in **Appendix A, Table 2**; in summary, there were two (2) scenarios to assess conservation measures using the water use target from the City of Guelph Water Supply Master Plan, four (4) scenarios to test alternative municipal pumping configurations and optimizations, one (1) scenario to test municipal pumping optimization with no dewatering from the Dolime Quarry, and three (3) scenarios to assess new municipal test well locations.

The results of the scenario testing showed that the following Risk Management Scenarios are successful in reducing the risk to municipal wells:

- Pumping optimization with demand reductions through conservation programs (Scenarios 5 and 6)
- Pumping optimization with addition of new municipal wells (Scenarios 8, 9 and 10)
- Pumping optimization with cessation of dewatering at Dolime Quarry (Scenario 7)

However, these scenarios also predicted reductions in groundwater discharge to some cold water streams that need to be managed through source protection plan policies and further evaluated through water supply management.

A modelling sensitivity analysis was also run to test impacts at municipal wells if non-municipal, non-dewatering permitted pumping was increased. The results show that for average annual climate conditions, all municipal wells could meet future pumping rates. However, the sensitivity analysis also predicts that non-municipal, non-dewatering takings at permitted maximum rates would result in municipal wells not being able to meet future planned demand under drought conditions. This suggests that permitted maximum rates of non-municipal, non-dewatering permits need to be reviewed since the maximum rates are not sustainable. The current non-municipal, non-dewatering permitted takings may be able to increase by approximately three times their current amount before impacts are predicted at municipal wells under drought conditions. The model results also indicate that potentially more water may be available away from municipal wells. One of the assumptions of the sensitivity analysis is that future conservation targets at municipal wells (WSMPU rates) are achieved.

3) Threats Management Strategy

The Threats Management Strategy (TMS) summarizes the results of the Risk Management Measures Evaluation Process (RMMEP) and discusses recommended measures based on what was learned from the model scenarios. Key elements of the TMS include the identification of moderate and/or significant drinking water quantity threats, the identification of measures that are predicted to be most effective at meeting future municipal demands, and specific recommendations on how the measures could be implemented and tested further. **Table 3** below lists the recommended RMMs.

Table 3: Recommended Risk Management Measures

Recommended RMM Category	Risk Management Measures Description
Well Optimization	This category includes re-allocating municipal pumping rates without violating critical low-water level thresholds in municipal wells.
Water Conservation and Efficiency	This category includes a series of specific RMMs designed to minimize residential, industrial, commercial, and institutional water demands. These RMMs aim to minimize total water demand, with a goal of keeping that water demand below the future rates evaluated in the Tier 3 Assessment.
Addition of New Water Supplies	This category includes the addition of new supplies (wells or intakes) or the addition of new alternate or backup water supplies. Cooperation across municipalities/agencies required.
Maintaining Pre-Development Aquifer Recharge Rates	This category includes RMMs such as Low Impact Development (downspout disconnection, pervious pavement), and stormwater retention ponds designed to maintain and increase recharge. Balance water quality and water quantity concerns.
Mitigating Impacts from Non-Municipal Consumptive Water Takings	This RMM includes the introduction of management or monitoring activities for current or future permitted consumptive water takings that have the potential to increase the risk to one or more municipal wells. Includes non-dewatering and dewatering (Dolime Quarry) water use.

The TMS also makes other recommendations to ensure the Tier 3 model is up to date and maintained. Recommendations include the ongoing collection, compilation, and incorporation into the Tier 3 model of the newest, available data including hydrogeological characterization, groundwater and surface water monitoring data, municipal demands and future projections, non-municipal demands, and groundwater recharge estimates. This will ensure that the Tier 3 model is maintained as a valuable tool to assess water takings in WHPA-Q and IPZ-Q into the future.

The RMMEP and TMS have provided the Project Team with a more detailed understanding of the activities that pose a water quantity risks to the municipal drinking water sources. While the TMS has proposed management measures to address the risk, continued growth and new demands on the local water resources will continue to add stress to the groundwater and surface water systems that, without effective water resource management, will be unsustainable. Collective water resource management by municipalities, the conservation authority and the province is required to effectively manage water takings to ensure that municipal drinking water is sustainable and that other water uses (i.e., non-municipal takings, surface water flows and domestic users) have sufficient water to meet their respective needs. A recommendation of the Project Team is that source protection plan policies be developed that incorporate water resource management strategies. These municipal/CA/province strategies could include coordinated conservation programs, improved water monitoring and reporting, enhanced communication programs, regular coordination meetings, Tier 3 model management partnerships, coordinated information sharing and an overall joint water management model.

Water Quantity Policy Discussion Paper

In parallel to the technical study (RMMEP), the Project Team developed a Water Quantity Policy Discussion Paper (attached in **Appendix B**), with input from the Implementing Municipal Group (IMG) and the Community Liaison Group (CLG), comprised of stakeholders and community members. The purpose of the Discussion Paper is to aid policy makers by providing background information on technical studies, drinking water quantity threats, existing legislation, policies and programs, and a review of policy tools and available approaches. The Discussion Paper presents promising policy tools that could be used to protect water quantity sources.

Existing Legislation, Policies and Other Programs

The Discussion Paper provides a brief overview of the existing legislation, policies and other programs at the federal, provincial, and municipal level with respect to consumptive water takings and recharge reduction (see Appendix B of the Discussion Paper). The summary illustrates the multifaceted and complex nature of the water management framework around water takings and recharge reduction.

Policy Toolbox

This section of the Discussion Paper provides an overview of the policy tools that are available for addressing the provincially prescribed water quantity threats (i.e., Threat #19: consumptive water use and Threat #20: recharge reduction) as per the *Clean Water Act, 2006*, and O. Reg. 287/07. The policy tool box is the same as for addressing water quality threats, and includes *Clean Water Act* Part IV authorities (prohibition and risk management plans), prescribed instruments, land use planning, education and outreach, incentive programs, stewardship programs, best management practices, pilot programs, research, and specify actions.

Policy Options

As the next step, the Discussion Paper lays out the policy options. Table 4 below presents a summary list of policy options that could be used to address significant drinking water quantity threats with respect to consumptive use and recharge reduction activities, respectively. More details can be found in Tables 6 and 7 in the Discussion Paper. This section also provides links to other approved water quantity policies in neighbouring Source Protection Regions, for comparison.

Table 4: Policy options for consumptive use and recharge reduction activities

Policy Tool	Intent
Part IV Tool: Prohibition	• Prohibit recharge reduction or consumptive water taking in an area where prohibition us justified due to the excessive risk to drinking water supplies
Part IV Tool: Regulation (Risk Management Plans)	• Require that a Risk Management Plan be developed to ensure that consumptive takings are managed and pre-development recharge is maintained
Part IV Tool: Restricted Land Uses	• The policy would be used in conjunction with either Part IV: Prohibition or Part IV: Risk Management Plans to act as a screening tool for development applications (planning or

	building) that may trigger a Part IV policy
Prescribed Instruments	• The policy would direct the Province to review and/or include conditions in a Permit To Take Water or Environmental Compliance Approval to ensure that the municipal drinking water supply is sustainable.
Land Use Planning	• The policy would manage new development by restricting specific uses through official plans and zoning by-laws which result in excessive risk to the aquifer due to consumptive use or recharge reduction, or including specific criteria as part of development approvals to minimize the impact of consumptive use or maintain or improve recharge of the aquifer
Education, Outreach/Incentive Programs	• The policy would continue and/or expand water conservation or water recharge education initiatives and develop new water quantity outreach materials to be shared across the region for both residents and businesses
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• The policy would continue and/or expand risk reduction projects (e.g., water conservation, protection of recharge areas) implemented through stewardship programs; • Promote Best Management Practices, e.g., water conservation, downspout disconnect encouraged through Land Use Planning approvals, use of best management practices for municipal infrastructure and facilities; Promote pilot programs to assist in implementing water conservation programs for private business; • Allow for the consideration of alternative water supplies (i.e., water reuse) to assist in creating a resilient water supply system; and • Develop municipal water saving programs
Other: Specify Actions	• The policy would establish specific action(s) to help manage consumptive use and recharge reduction activities, such as: o MOECC to use Tier 3 model for PTTW decisions o Municipality encouraged to locate additional water supplies o When implementing the new growth targets as set out within the Provincial Places to Grow Plan, municipal growth forecasts to consider incorporating Tier 3 information o Update or develop municipal water conservations plans and water management plans to support sustainable use o Update or develop water management plans to maximize aquifer recharge o Require maintenance of storm water management infrastructure

Policy Tool Review

The Project Team, with input from the Implementing Municipalities Group (IMG) and Community Liaison Group (CLG) reviewed potential strengths, opportunities, weaknesses and challenges of policy tools available to the Lake Erie Region Source Protection Committee (SPC) to address existing and future water quantity threats in the Guelph Guelph/Eramosa

WHPA-Q and IPZ-Q. **Table 5** below provides a high-level summary of that review. More detailed information can be found in Tables 8 and 9 and Appendix C of the Discussion Paper.

Table 5: Policy tool review summary for consumptive use and recharge reduction activities

Policy Tool	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Part IV Tool: Prohibition	• Can be very effective by completely removing the threat • Potential to delineate smaller zones in a vulnerable area where prohibition could be justified	• Impact to the property owner could be high • Difficult to justify if used broadly across a vulnerable area
Part IV Tool: Regulation (Risk Management Plans)	• Can be property/activity specific making it flexible • Consumptive use - could be applied to takings where PTTW does not apply • Recharge reduction – ability to include monitoring program and measure implementation success	• Potentially high level of resources required to administer and enforce • Consumptive use - Implementation and legal challenges (e.g. appeal to ERT) if application of RMP is not applied consistently and/or locally justified.
Part IV Tool: Restricted Land Uses	• Can manage an activity without restricting an entire land use and able to provide exemptions • Can link tool to Planning Act process and integrate into municipal development review process	• Only applies to existing land use when activity is changing or expanding • Consumptive use - activity may not always be flagged through a development application • Recharge reduction – land uses named in the policy must match the names that appear in local official plans or zoning bylaws
Prescribed Instruments (PTTW)	• Science-based, pre-cautionary, transparent and peer-reviewed • Existing, relatively well understood regulatory framework • Broad powers to collect new data through monitoring conditions and require studies • Consumptive use - adaptive management: ability to require review of existing PIs within a certain timeframe; and maximum 10-year PTTW period	• Financial implications for property owners from new requirements • Consumptive use - need for improved monitoring • Consumptive use - all permits are treated the same regardless of how the water is used • Consumptive use - may not be seen as equitable as single tool as not all consumptive water takings are captured
Land Use Planning	• Can be tailored to specific areas with specific restrictions • Consumptive use - water taking can be considered a land use and can be regulated through land use planning • Recharge reduction - land use plans could be updated using	• Addresses future threats only • Appeals to the Local Planning Appeal Tribunal (LPAT) could result in this body that is not familiar with water issues making uninformed rulings that cannot be overturned • Consumptive use - land use

	update recharge information on a regular basis	planning tools untested as a means to address water takings • Recharge reduction – unclear where land use would apply to recharge
Education, Outreach/Incentive Programs	• Increases landowner awareness and community engagement • Recharge reduction – can encourage effective Best Management Practices	• Public understanding of water quantity is poor • Time and cost to implement program could be high • Recharge reduction – increased recharge in all areas may not be appropriate and justified
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• Reduction in financial burden for the applicant • Fills data gaps • Consumptive use - can motivate changes in behaviour with little cost to municipality compared to cost of producing water and maintaining or expanding infrastructure	• May not be sufficient to address threats on its own • Continuous funding required • Effectiveness relies on property owner participation • Difficult to ensure compliance
Other: Specify Actions	• Tool is flexible • Can require specific action and provides options for local situations • Consumptive use - could increase engagement from non-municipal water takers	• Implementation cost could be high and coordination could be challenging if multiple parties involved

<u>Promising Policy Tools</u>

The Project Team, through the review of the policy options, has identified a number of promising policy tools that merit further discussion. The list presented in not an exhaustive list and does not preclude other tools from being considered. Policy tools may also be used in combination. The Project Team will consider all policy tools throughout the policy development process.

Consumptive Water Use – Threat #19

Addressing consumptive water takings that are identified as a significant drinking water threat could be achieved through the use of Prescribed Instruments, specifically the PTTW program. Where a PTTW already exists, policies may be developed to direct the Province to review, and amend or revoke existing permits using the Tier 3 model results or the model itself, and require that additional terms and conditions are added to ensure that the municipality's existing and future water supply is sustainable. New or increased takings subject to the PTTW process could also include similar terms and conditions.

Where consumptive water takings may not be able to be adequately addressed by Prescribed Instruments (e.g., takings within the WHPA-Q that are exempt from the PTTW process), the

Part IV tools (i.e., Prohibition, Risk Management Plans, together with Restricted Use) may be an option to meet the source protection plan objectives.

A prohibition tool would only be considered after all other feasible management options have been assessed as being insufficient in protecting the municipalities' drinking water supply.

Municipal land use planning policies could be considered a tool to address consumptive water use activities. However, land use planning tools are untested as a means to address water takings. Consumptive water use and availability could be considered by the Province when allocating growth through provincial planning tools such as the Growth Plan.

Additional policies addressing water consumption could also be addressed through policy within Official Plans, e.g., specific restrictions in certain areas of the municipality or by the type of development and/or water taking. The need for additional restrictiveness of the land use policies may vary depending on existing municipal land use policies and the geographic setting of the vulnerable areas.

Policies could also be written for municipalities to incorporate the long-term sustainability of the municipal water supply into their decisions about water services when approving growth and development. This could be achieved by requiring an approved PTTW where the MOECC has determined that the proposed taking does not become a significant drinking water quantity threat.

The specify action tool could also be valuable in addressing existing and future consumptive use activities through the development of locally-specific policies. For example, policies could focus on:

- ensuring that municipal water management plans and/or water conservation plans are developed or updated;
- developing joint water resource management systems to provide collaboration and cooperation between the province, Source Protection Authority and municipalities to manage local water resources to protect drinking water sources;
- that Tier 3 information is used in making informed decisions and that Tier 3 models are provincially funded and maintained on an ongoing basis; and
- ensuring that existing and future municipal water demands are met before allocating water to other users in the WHPA-Q and IPZ-Q. This would mean shifting to a "priority of use" concept instead of the current "first in time, first in right" approach.

Recharge Reduction – Threat #20

Perhaps the most effective tools to address recharge reduction threats are municipal land use planning policies and implementation of best management practices as part of updated municipal practices and development approval requirements. Policies could be developed to require the local planning authority to manage new developments by including criteria for approval that ensure the proposed activity does not become a significant drinking water threat. The restrictiveness of the policies may vary depending on existing municipal land use policies and the geographic setting of the vulnerable area.

Recharge reduction activities could also be addressed through Prescribed Instrument policies, specifically Environmental Compliance Approvals (ECA) such as sewage works projects being used for low-impact development, storm water ponds, etc.

Softer tools such as education and outreach and incentive programs can be used to promote source protection policies in general and focus on promoting BMPs, as well as low impact development (LID) in specific areas where feasible. Outreach programs could target specific sectors in the vulnerable area.

Policy Framework and Next Steps

The Threats Management Strategy (TMS) and policy Discussion Paper provide the foundation for water quantity policy development. Over the summer, the Project Team will be working on developing a policy framework and a list of policy approaches. Aspects that the Project Team will consider in developing the policy framework include managing water takings and recharge reduction, water conservation, information sharing and collaboration between government agencies, and Tier 3 model management, including funding and monitoring.

Lake Erie Region is committed to a collaborative process for policy development, with municipal and stakeholder engagement through the Project Team, IMG, and CLG. Policy approaches will be presented to the SPC on October 4, 2018, with drafting of the water quantity policy text expected to be begin in the early fall. On June 26, 2018, the CLG will receive the results of the Threats Management Strategy and Discussion Paper.

Prepared and Approved by:

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Appendix A

Guelph-Guelph/Eramosa Water Quantity Policy Development Study

Threats Management Study

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

GUELPH-GUELPH/ERAMOSA WATER QUANTITY POLICY DEVELOPMENT STUDY: THREATS MANAGEMENT STRATEGY

Report Prepared for:
LAKE ERIE SOURCE PROTECTION REGION

Prepared by:
MATRIX SOLUTIONS INC.

Version 1.0
June 2018
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GUELPH-GUELPH/ERAMOSA WATER QUANTITY POLICY DEVELOPMENT STUDY:

THREATS MANAGEMENT STRATEGY

Report prepared for Lake Erie Source Protection Region, June 2018

June 14, 2018

Jeffrey Melchin, M.Sc., P.Geo.
Hydrogeologist

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V1.0	14-June-2018	Final	15072-527 Threats Management Strategy R 2018-06-14 final V1.0.docx	Issued to client

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APPENDICES

1 INTRODUCTION

1.1 Background

The Province of Ontario introduced the *Clean Water Act, 2006* (Bill 43; Government of Ontario 2018) to ensure that all residents have access to safe drinking water. The City of Guelph and Township of Guelph/Eramosa (GGET) lie within the Grand River Source Protection Area (watershed), which, along with the Long Point Region, Catfish Creek, and Kettle Creek Source Protection areas, are part of the larger Lake Erie Source Protection Region. The Lake Erie Region Source Protection Committee (SPC) was established in 2007 and has the responsibility under the *Clean Water Act*, *2006* to develop local Source Protection Plans (SPPs) and report on implementation in all four watersheds. The goal of each SPP is to develop policies and programs to eliminate reduce and/or manage existing Significant Drinking Water Threats (i.e., water quality and water quantity threats) and ensure no future drinking water threats become Significant. These policies might relate to activities in identified vulnerable areas (e.g., Wellhead Protection Areas for Water Quantity [WHPA-Qs] and Intake Protection Zones for Water Quantity [IPZ-Qs]) and might include public education programs, or programs to promote best management practices (BMPs). Current approved SPPs address threats related to water quality. The Risk Management Measures Evaluation Process (RMMEP), culminating in a Threats Management Strategy, represents a major piece of work to complete the water quantity component.

This report summarizes the results of the RMMEP for GGET and proposes a Threats Management Strategy that will help ensure that these and surrounding municipalities maintain a sustainable drinking water supply.

1.2 Water Budget Studies in the Grand River Watershed and City of Guelph and Township of Guelph/Eramosa Area

The *Clean Water Act, 2006* requires that each SPC prepare an Assessment Report for their source protection area in accordance with Ontario Regulation 287/07 (Government of Ontario 2018) and the *Technical Rules: Assessment Report, Clean Water Act, 2006* (Technical Rules; MOECC 2017). A requirement of the Assessment Report is the development of water budgets that assess the threats to water quantity sources under a tiered framework. Tier One and Tier Two Water Budget and Stress Assessments (Tier One Assessment and Tier Two Assessment) of this framework evaluate a subwatershed's hydrological stresses, while a Tier Three Water Budget and Local Area Risk Assessment (Tier Three Assessment) identifies threats to water quantity and evaluates the ability of a communities wells and intakes to meet current and future drinking water needs.

1.2.1 Grand River Watershed Water Budget and Tier Two Water Quantity Stress Assessment

A Tier Two Assessment was completed for the Grand River Watershed in 2009 (AquaResource 2009a, 2009b). The study identified subwatersheds and groundwater assessment areas that contain municipal water supply systems that had an elevated (Moderate or Significant) potential for hydrologic stress from a surface water or groundwater perspective. This included the Upper Eramosa River Subwatershed and the Upper Speed River Assessment Area, which were classified in the Tier Two Assessment as having a Moderate stress level from a surface water and groundwater perspective, respectively. Some of the municipal water supplies for the City of Guelph, as well as Rockwood and Hamilton Drive in the Township of Guelph/Eramosa (Figure 1), were contained within these areas and were therefore required to undertake a Tier Three Assessment (Matrix 2017).

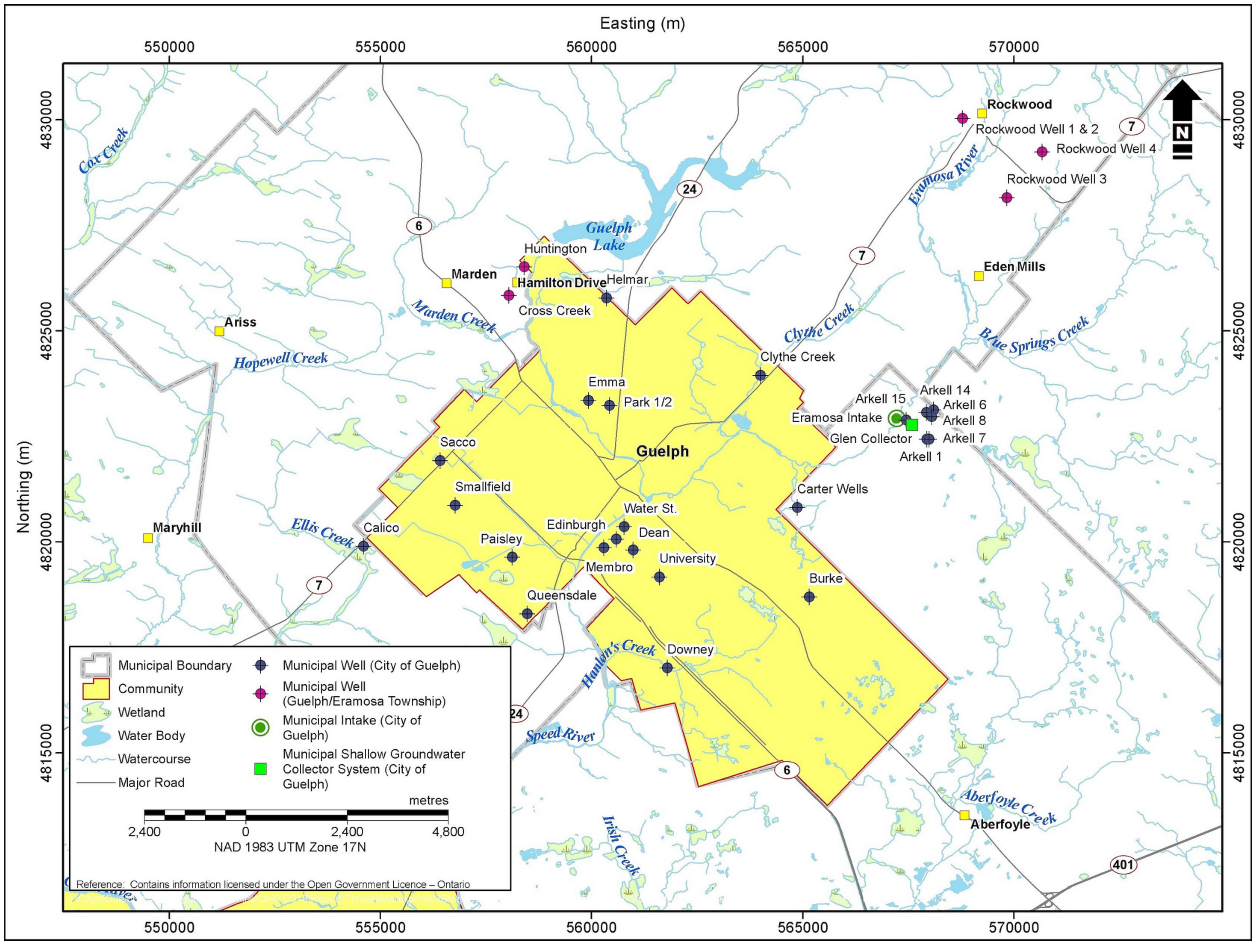

FIGURE 1 Tier Three Assessment Municipal Water Supply Systems

1.2.2 City of Guelph and Township of Guelph/Eramosa Tier Three Water Budget and Local Area Risk Assessment

A Tier Three Assessment evaluates the ability of municipal water supply systems to meet current and future demands, as well as impacts to other water uses under conditions set out in the Technical Rules. If the Tier Three Assessment results in conditions where municipal wells cannot meet their demands, or if there is an impact on other water uses (e.g., coldwater streams), activities resulting in consumptive water use or groundwater recharge reduction may be classified as Moderate or Significant Drinking Water Quantity Threats (Significant Threats). Consumptive water use refers to the amount of water removed from a source without being returned to the same source. The following sections describe the Tier Three Assessment carried out for the City of Guelph and Township of Guelph/Eramosa water supply systems.

1.2.2.1 Tier Three Assessment Municipal Water Supply Systems

With some exceptions such as firefighting and livestock watering, any persons or organizations withdrawing water at a rate greater than 50,000 L/d must apply for, and be granted, a Permit to Take Water (PTTW) from the Ministry of Environment and Climate Change (MOECC). This includes water takings permitted for municipal supply purposes, such as water obtained by GGET to meet their municipal water supply needs. A total of 31 municipal wells, a surface water intake that feeds water to an artificial recharge system, and a shallow groundwater collector are permitted as part of the PTTW program. These were assessed as part of the GGET Tier Three Assessment.

City of Guelph

The City of Guelph relies mainly on groundwater for its municipal supply demands, and it obtains its water from 25 municipal wells and a shallow infiltration gallery (Glen Collector; Figure 1); however, not all of the wells are currently in use where there is a lack of demand or due to water quality concerns. All of these wells, with the exception of the Edinburgh well, were used in the Tier Three Assessment, and in this RMMEP, to meet future demands.

The City of Guelph also sources a portion of its water supply from the Eramosa River intake, where surface water is pumped and then directed into an artificial recharge system that provides shallow groundwater to the Glen Collector (Figure 1). The Eramosa River intake is allowed to operate between April 15 and November 15 of each year according to the conditions of its PTTW.

Township of Guelph/Eramosa

The residents of Rockwood and Hamilton Drive rely entirely on groundwater for their potable water supplies. In Rockwood, this water is pumped from three existing bedrock wells. A fourth bedrock well was recently constructed by the Township of Guelph/Eramosa and now has a PTTW. The township expects to add this well to the Rockwood water supply system in the near future. These wells are located northeast of the City of Guelph (Figure 1).

In Hamilton Drive, municipal water is pumped from two bedrock wells completed in the same bedrock aquifer as Rockwood and the City of Guelph. These wells are located just north of the City's municipal boundary (Figure 1).

1.2.2.2 Tier Three Assessment Water Budget

The GGET Tier Three Assessment was completed in March 2017 (Matrix 2017) following the Province's Technical Rules (MOECC 2017), *Technical Bulletin: Part IX Local Area Risk Level* (Technical Bulletin; MOE and MNR 2010), and the *Memorandum: Assignment of Water Quantity Risk based on the Evaluation of Impacts to Other Water Users* (Technical Guidance Memorandum; MOE 2013). As part of the Tier Three Assessment, surface water and groundwater numerical models were developed, calibrated, and applied to help evaluate the sustainability of the municipal water supplies of GGET. The models developed helped quantify a water budget for the municipal supplies, including estimates of the magnitude of water entering and leaving the system.

The models were also used to delineate the WHPA-Q (Groundwater Vulnerable Area) and IPZ-Q (Surface Water Vulnerable Area) where the municipal drinking water systems could be affected by other existing, new, or expanded water takings. The final WHPA-Q was defined as the combined area that is the cone of influence of a municipal well and the whole of the cones of influence of all other wells that intersect that area, plus any area where a future reduction in recharge may have a measureable impact on the cone of influence (MOECC 2017). The IPZ-Q was defined as the drainage area that contributes surface water to the intake and the area that provides recharge to aquifers that contribute groundwater discharge to the drainage area. Four WHPA-Qs were delineated surrounding the municipal wells for GGET (Figure 2); one IPZ-Q was delineated as the upstream contributing area for the Eramosa intake (Figure 3).

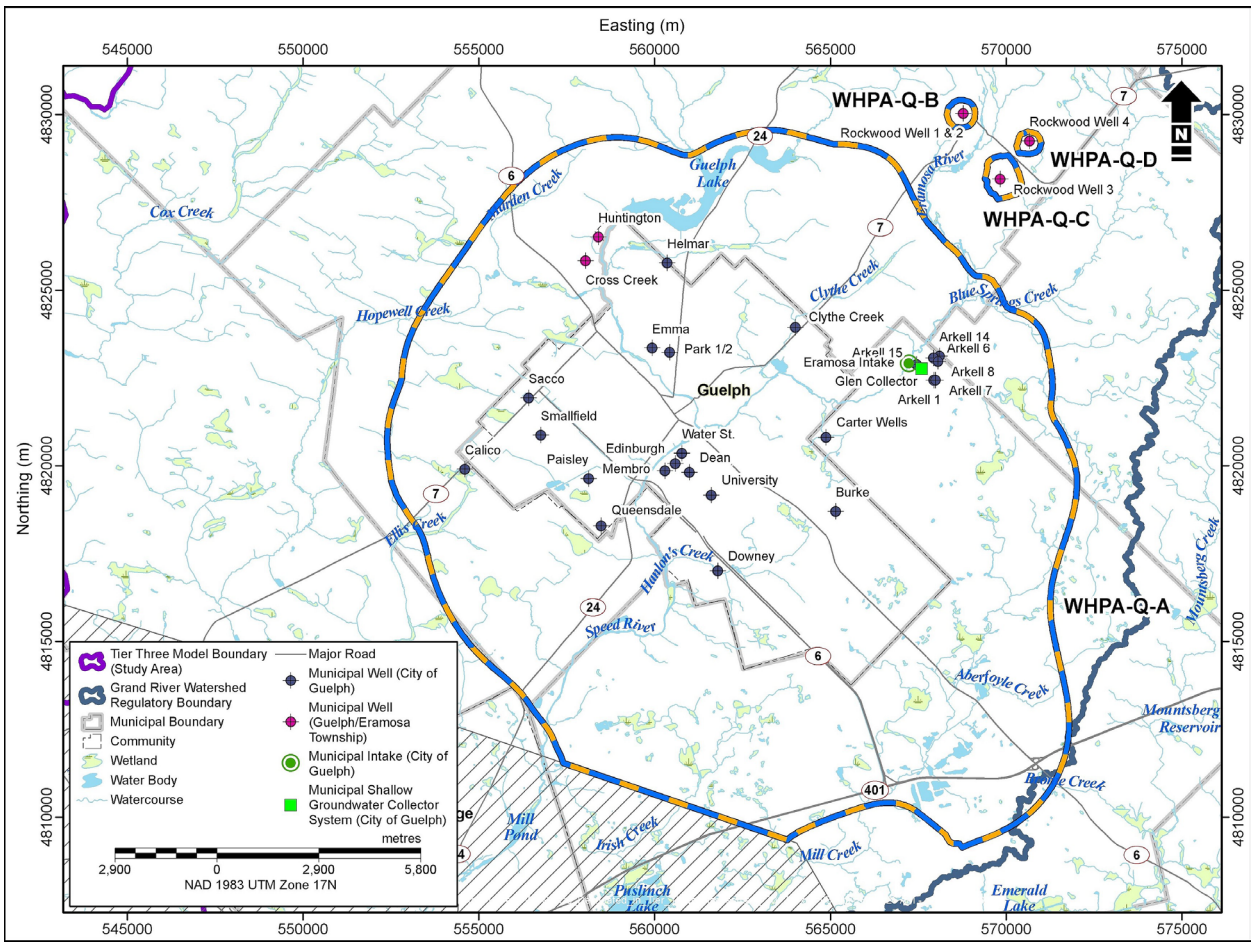

FIGURE 2 WHPA-Qs Delineated in Tier Three Assessment (Matrix 2017)

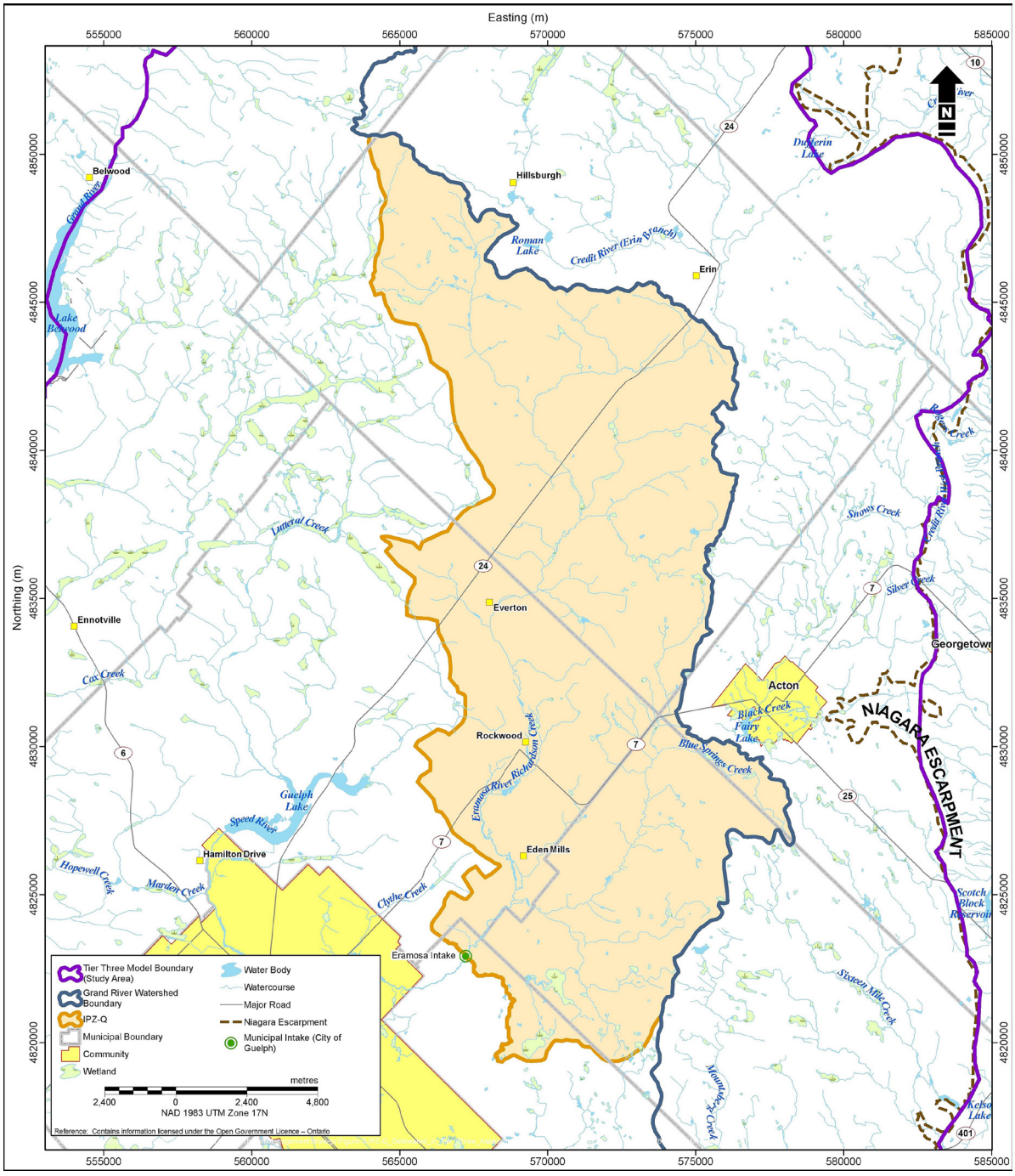

FIGURE 3 IPZ-Q Delineated in Tier Three Assessment (Matrix 2017)

1.2.2.3 Tier Three Assessment of Water Quantity Threats

The final task of the Tier Three Assessment was to assign a Risk Level to the WHPA-Qs and IPZ-Q, and identify water quantity threats. The Tier Three Assessment scenarios predicted that the GGET municipal wells can meet current water demands; however the Tier Three model scenarios predicted that the City's Queensdale municipal well may not be able to meet future needs under normal climate conditions

and during prolonged drought. The City's other wells and Guelph/Eramosa Township's (GET) wells were expected to meet future needs under all scenarios. However, there is a high level of uncertainty for the results of the City's Arkell Well 1, which also triggers a Significant Risk Level. Because of these findings, the largest WHPA-Q surrounding the City of Guelph (WHPA-Q-A; Figure 2) was assigned a Significant Risk Level; the other three smaller WHPA-Q areas (WHPA-Q-B/C/D) were assigned a Low Risk Level (Figure 2). Further, because water pumped from the Eramosa River intake is not pumped directly into the City of Guelph's drinking water system, and that the Glen Collector was included in the Risk Assessment for groundwater, a Risk Assessment for the surface water supply was not completed. However, to ensure the sustainability of the Glen Collector and the Eramosa intake, the IPZ-Q was assigned the same Risk Level as the WHPA-Q, containing the Glen Collector. For the remainder of this report, WHPA-Q-A will be referred to as WHPA-Q. More details on the delineation of the WHPA-Q and the Significant Risk designation are provided in the Tier Three Assessment (Matrix 2017).

The Tier Three Assessment also predicted that groundwater discharge into some coldwater streams may be reduced by 10% or more as municipal pumping is increased to future rates. This magnitude of impact would result in a Moderate Risk Level applied to the WHPA-Q; however, the Moderate Risk Level associated with the surface water impacts is superseded by the Significant Risk Level.

Under the source protection program (Section 1.1 of Ontario Regulation 287/07), the Province identified 21 activities that are prescribed as drinking water threat activities. For water quantity vulnerable areas with a Significant Risk Level, all existing and new consumptive water takings (i.e., prescribed drinking water threat #19) located within the areas that draw water from within the WHPA-Q or the IPZ-Q or activities that reduce groundwater recharge (i.e., prescribed drinking water threat #20) are classified as Significant Threats. Within the Tier Three Assessment WHPA-Q (Figure 4) and IPZ-Q (Figure 5), the Significant Threats included the following:

- municipal permitted water takings
- non-municipal permitted water takings
- non-municipal, non-permitted water takings (e.g., domestic takings and livestock operations)
- recharge reduction activities

The above-mentioned consumptive takings and recharge reduction areas are classified as Significant Threats regardless of their location within the WHPA-Q. Municipal permitted water takings are classified as Significant Threats as increases in municipal pumping from a well may result in the water level in that same well to decline below its safe threshold. This concept of a well as a threat to itself is discussed in Section 2.2.

After the Significant Threats were identified, the RMMEP and Threats Management Strategy were initiated to recommend an overall plan to mitigate the threats and reduce the Risk Level.

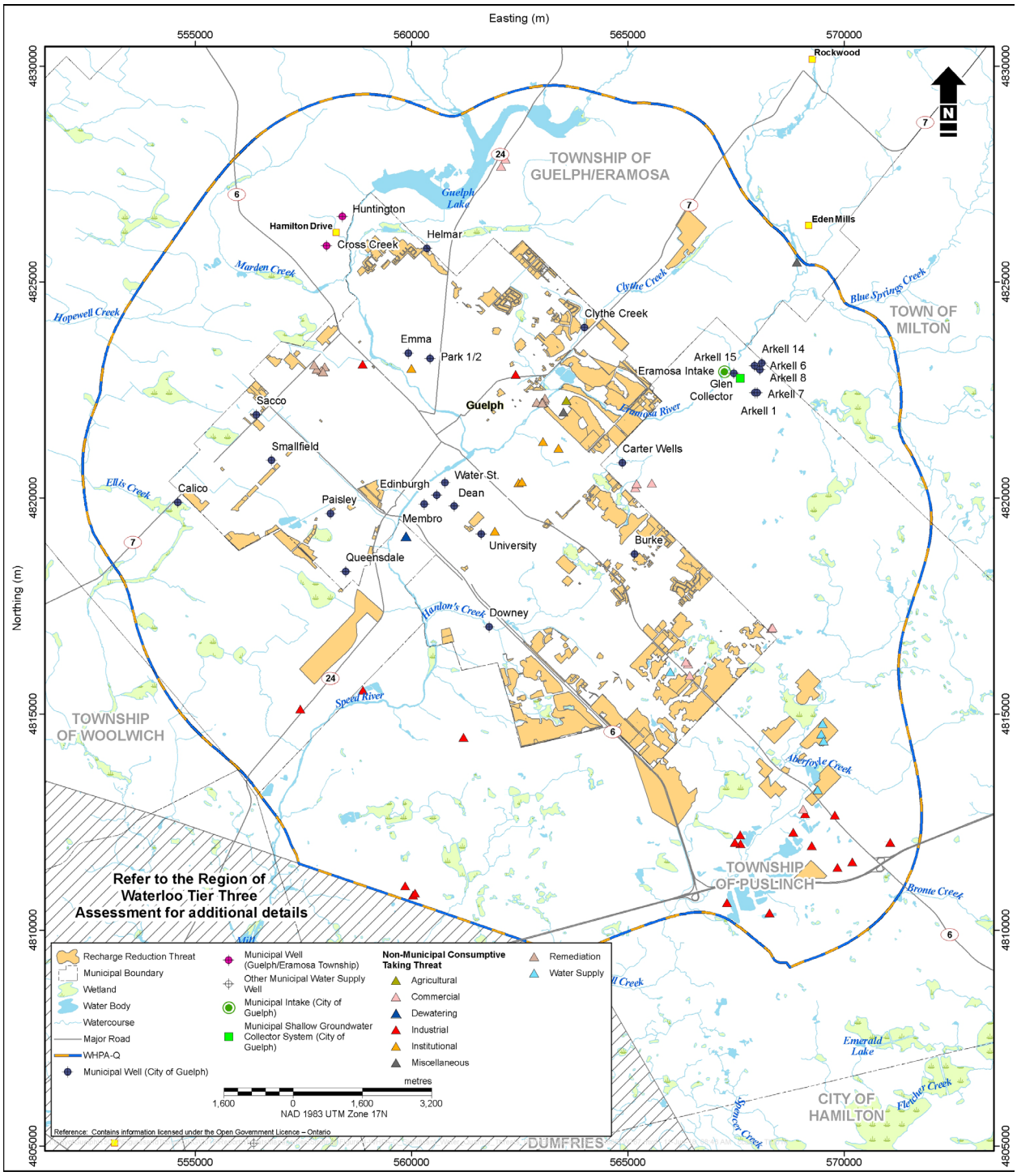

FIGURE 4 WHPA-Q Significant Water Quantity Threats (Matrix 2017)

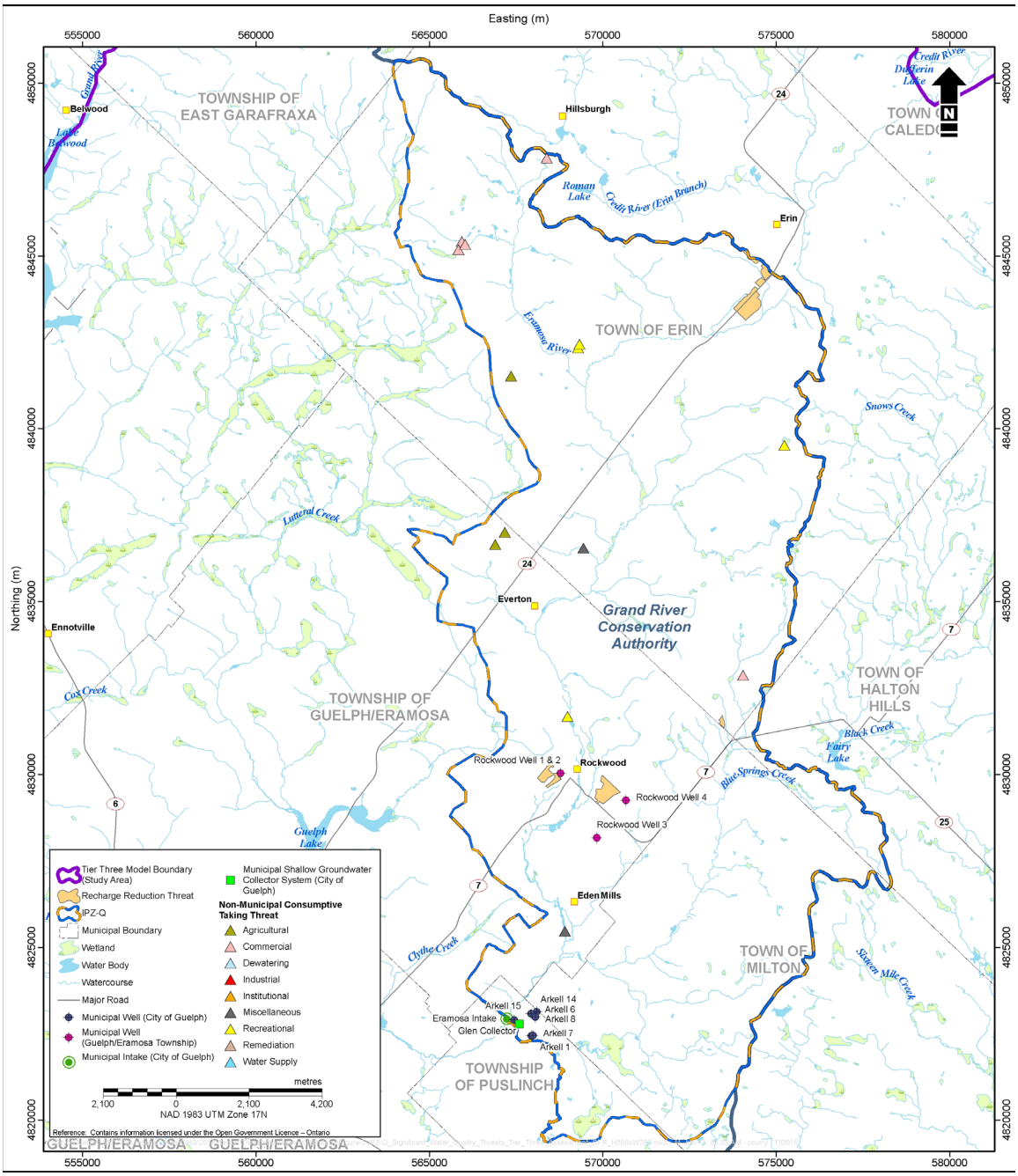

FIGURE 5 IPZ-Q Significant Water Quantity Threats (Matrix 2017)

1.3 Risk Management Measure Evaluation Process Methodology

The general RMMEP follows the document entitled *Guide - Water Quantity Risk Management Measures Evaluation Process* (TRCA 2013) for use by SPCs to prepare SPPs under the *Clean Water Act, 2006*. In particular, the RMMEP includes identification and ranking of Significant Threats, selecting and evaluating risk management measures (RMMs), and developing a Threats Management Strategy (Figure 6). The following describes the process in more detail.

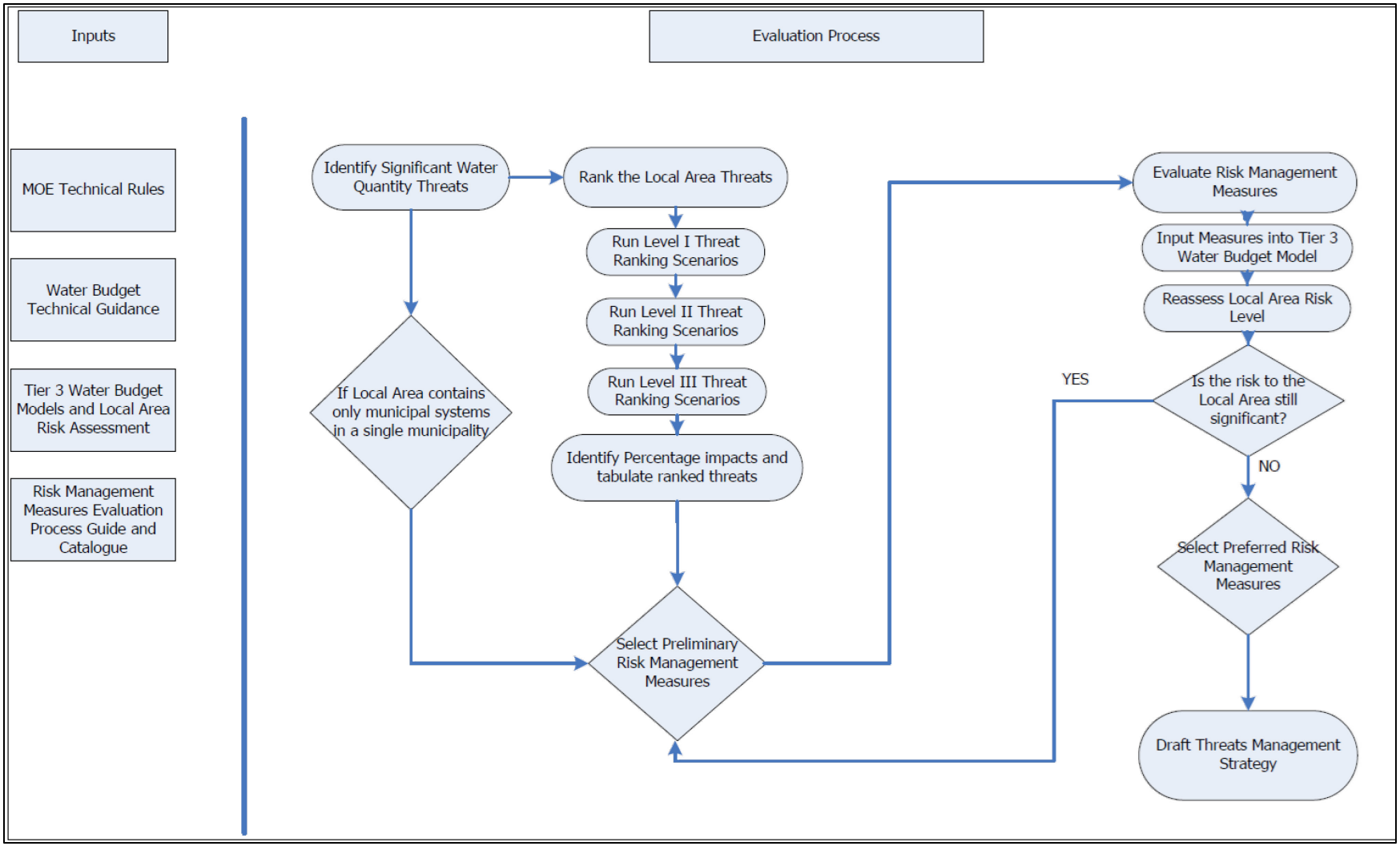

FIGURE 6 Risk Management Measures Evaluation Process Flow Chart (TRCA 2013)

The RMMEP relies on the Significant Threats identified in the Tier Three Assessment. These threats include consumptive water takings and recharge reduction areas that fall within a WHPA-Q or IPZ-Q assigned with a Significant Risk Level. These threats are assessed at progressively finer levels of detail to rank which threats have the greatest impact on municipal drinking water systems within that WHPA-Q or IPZ-Q (Figure 7). The first level of ranking (Level I) estimates the influence of major groups of threats (i.e., municipal permitted takings versus non-municipal permitted takings versus non-municipal, non-permitted takings versus recharge reductions) to identify which groups warrant a more detailed level of investigation.

The second level of ranking (Level II) estimates the relative influence of specific sectors of threats within each group. For example, for municipal permitted takings, a Level II ranking may rank the influence of municipal permits of one municipality versus those of other municipalities. The third level of ranking (Level III) estimates the influence of individual water users or land use change. For example, for municipal permitted takings, a Level III ranking may rank the relative influence of individual municipal supply wells. The Significant Threats are ranked according to the greatest impact they may cause to water levels at a municipal water supply well or intake.

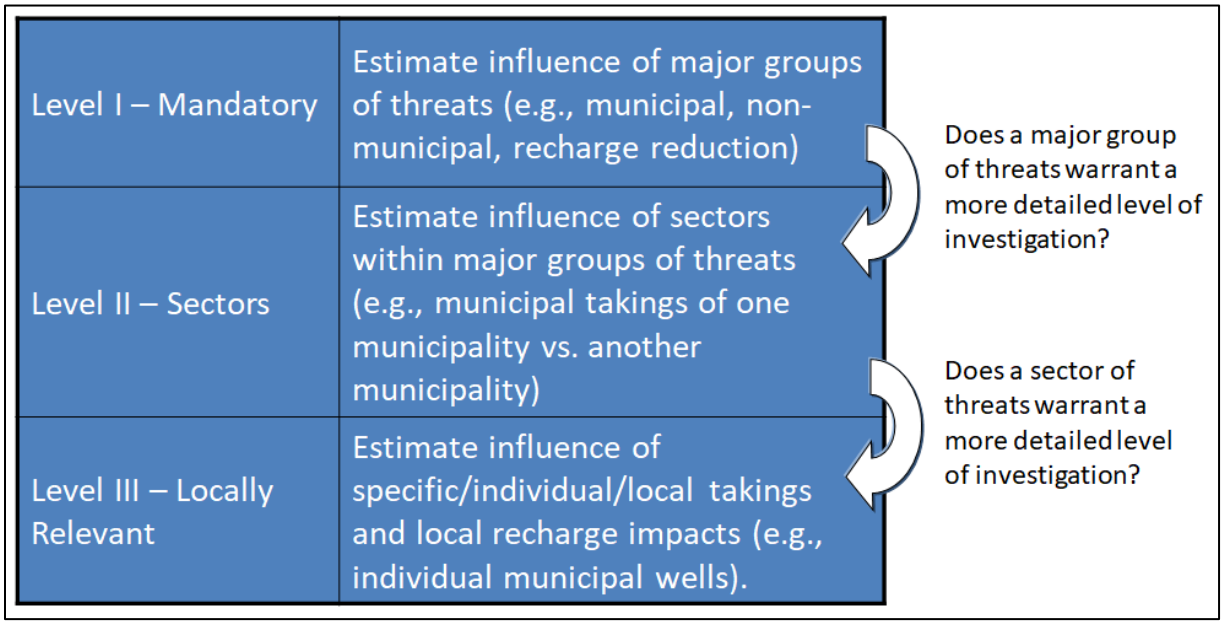

FIGURE 7 Three-stage Approach to Threats Ranking

The results of the risk ranking are used to guide the selection of RMMs representing different approaches for reducing the water quantity risks to municipal water supply systems. Each RMM is evaluated by developing and testing a number of risk management scenarios using the Tier Three Assessment groundwater flow model (Tier Three model). For example, if the greatest threat to a municipal water well is from elevated municipal demand, a RMM may include shifting a portion of the demand to a nearby municipal well if it can be accommodated. The RMMs are tested using the Tier

Three model, and the Risk Level to the Vulnerable Area is reassessed until a set of RMMs are identified that can, theoretically, successfully reduce the Risk Level applied to the Vulnerable Area from Significant to Moderate or Low. These potential measures are documented in a Threats Management Strategy.

1.4 Purpose of the Threats Management Strategy

The Threats Management Strategy summarizes the results of the RMMEP and discusses the recommended RMMs based on learnings from the RMM scenarios. Key elements of a Threats Management Strategy include the identification of Moderate and/or Significant Threats, the identification of RMMs that are predicted to be most effective at reducing the risk to municipal wells, and specific recommendations on how these RMMs can be implemented and tested through further iterations of the Tier Three Assessment framework.

2 CITY OF GUELPH AND TOWNSHIP OF GUELPH/ERAMOSA RISK MANAGEMENT MEASURES EVALUATION PROCESS

A RMMEP was initiated for the GGET municipal water supply systems to assess municipal supply sustainability by further evaluating the Significant Threats within the WHPA-Q and exploring potential RMMs. RMMs were evaluated using the Tier Three model to identify the most effective approaches to address the risk to the municipal systems. This process followed the methodology outlined in Section 1.3 (TRCA 2013). The following sections provide a summary of the results of the RMMEP and additional details of the technical work are provided in Appendix A (Threats Ranking), Appendix B (Preliminary RMMEP Scenario Results), Appendix C (Additional RMMEP Scenario Results), and Appendix D (Sensitivity Analysis Results).

The threats evaluation discussed in this section focusses only on consumptive water takings and recharge reduction threats. The potential impact of climate change as a threat to municipal water supplies will be assessed as part of a separate study and will be reported on later in 2018.

2.1 Identification of Significant Drinking Water Quantity Threats in WHPA-Q

The Significant Threats previously identified in the WHPA-Q within and surrounding the City of Guelph during the GGET Tier Three Assessment (Matrix 2017) were used as the starting point for the GGET RMMEP (Figure 4). For consumptive takings, these included 29 municipal takings (27 wells plus the Glen Collector and Eramosa River intake), 71 non-municipal permitted water takings, and over 5,100 non-municipal, non-permitted (e.g., domestic) takings.

In addition to consumptive takings, potential reductions in groundwater recharge within the WHPA-Q surrounding the City of Guelph were classified as Significant Threats in the Tier Three Assessment (Figure 4). These areas of recharge reduction were identified as areas for future potential land development and represented a total area of 16 km^2 or 5% of the WHPA-Q.

2.1.1 WHPA-Q Threat Updates

As the Tier Three Assessment was initiated in 2008, updates were made to the consumptive takings threats, and recharge reductions threats within the WHPA-Q to ensure that the Tier Three model reflected current, non-municipal permitted water use (2016) and revised plans for future land development. The following provides a list of these updates and additional details are provided in Appendix B. The WHPA-Q was not redelineated following these model updates; however, these updates are not expected to significantly change the WHPA-Q boundary. The WHPA--Q boundary may be revised in future updates to the Tier Three Assessment.

- PTTW Database and Water Taking Reporting System - These resources were reviewed to ensure that the non-municipal, permitted takings represented in the Tier Three model were representative of current (2016) conditions. This update resulted in a decrease of 15 non-municipal PTTWs within the WHPA-Q from the Tier Three Assessment for a total of 56 non-municipal PTTWs (Figure 7).

- Representation of Dolime Quarry Dewatering (PTTW 5080-8TAKK2) - The simulated elevation of the quarry pond level was reduced from 290 m above sea level (asl) to 288.4 m asl to reflect existing dewatering operations reported in 2015 and 2016 (MTE 2016, 2017).

- Land Use Change - New potential recharge reduction areas due to the proposed Clair-Maltby development in the south part of the City of Guelph and other proposed developments in Guelph-Eramosa Township and Puslinch Township were included where they were not previously identified for the Tier Three Assessment (Figure 8). An additional 2.4 km^2 of potential areas of recharge reductions were identified throughout the model.

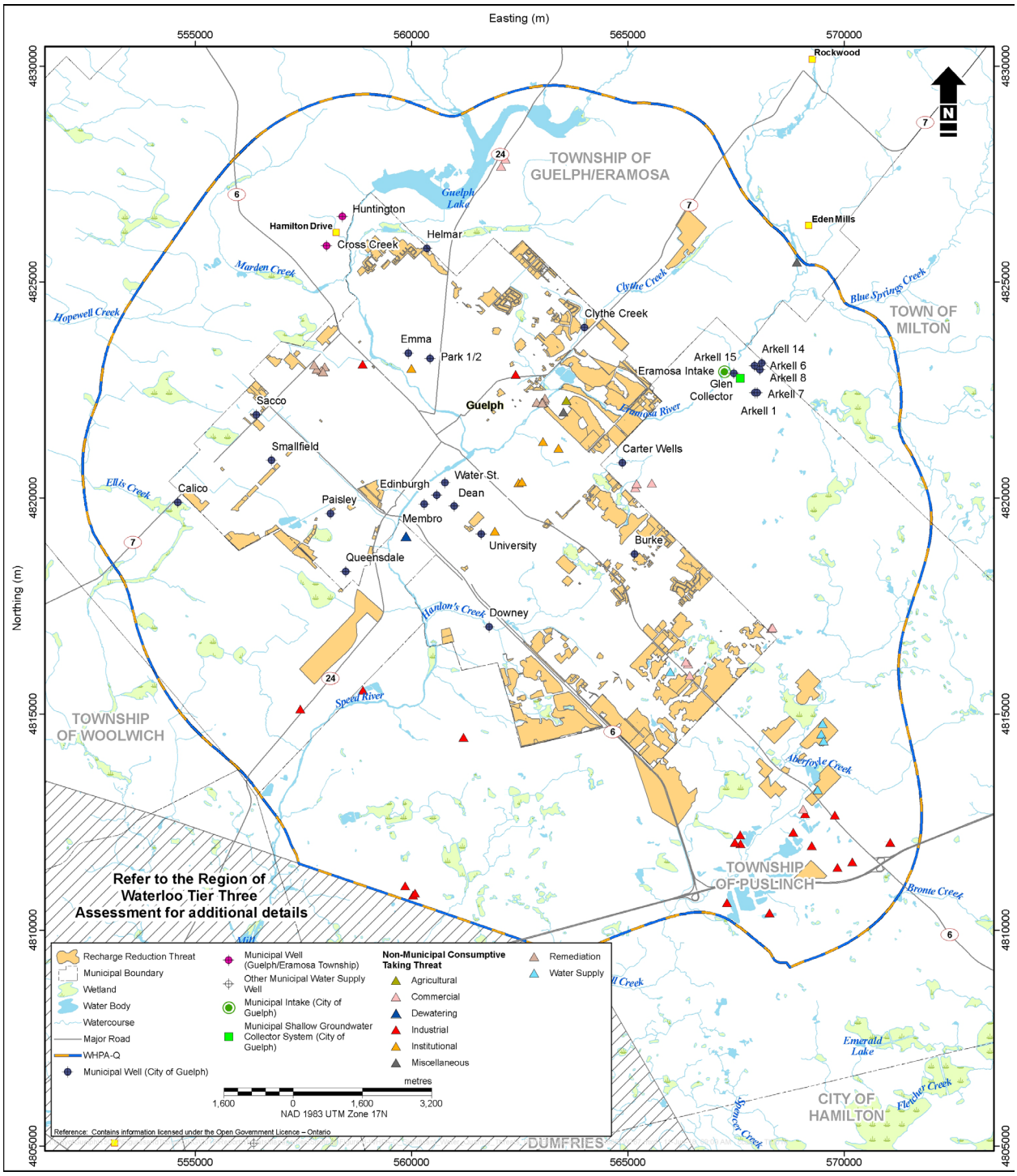

FIGURE 8 WHPA-Q Significant Water Quantity Threats - Risk Management Measures Evaluation Process 2017 Update

2.2 WHPA-Q Threats Ranking

As introduced in Section 1.3 and Figure 4, the threats ranking followed a three-stage process whereby Significant Threats found within the WHPA-Q were ranked at progressively finer levels of detail based on predicted impacts to municipal wells located within the WHPA-Q. Other municipal wells previously evaluated as part of the Tier Three Assessment (i.e., Rockwood wells) were not ranked as part of this threats ranking exercise because the WHPA-Qs surrounding those wells (Figure 2) were assigned a Low Risk Level (Matrix 2017). As a result, the consumptive water takings and recharge reduction areas within those areas were not considered Significant Threats.

The Level I assessment ranked major groups of threats, while the Level II and III assessments ranked sectors within each threat group and individual threats within the sectors, respectively. Threats predicted as having the greatest percent impact on water levels at a municipal well were ranked highest. Percent impact was calculated as the incremental drawdown at a municipal well that was caused by a threat or group of threats, divided by the amount of available drawdown in that municipal well. This ranking approach served to identify the threats that have the greatest potential benefit from RMMs to reduce the overall impact. Figure 9 summarizes the percent impact graphically.

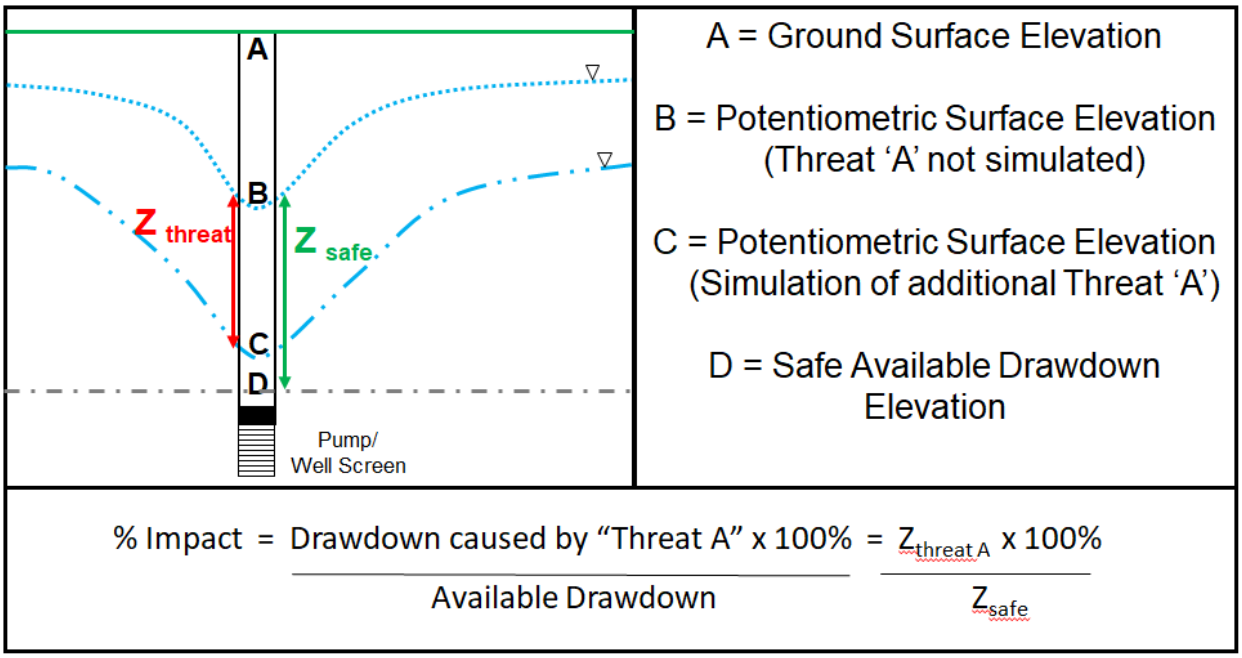

FIGURE 9 Graphical Representation of Percent Impact

The following summary describes the threats ranking results and additional details are provided in Appendices A and B. Appendix A describes the overall threats ranking process, scenarios, and results using the original permits included in the Tier Three model. Appendix B includes a revised threats ranking based on updates to the water quality threats within the WHPA-Q, where potential recharge

reduction areas were revised and permitted takings were added, removed or updated based on more current data.

The risk ranking results predicted that the greatest percent impact to municipal wells was caused by increased municipal takings within the Study Area, from their existing rates to future rates. Non-municipal, permitted takings resulted in the next greatest impact. Recharge reductions due to future development were also predicted to have an impact on water levels at some municipal wells. While this impact from recharge reductions is comparatively small, it would be measureable and potentially impact future municipal drinking water sources, groundwater discharge to coldwater streams or Provincially Significant wetlands. Table 1 summarizes the results of the threats ranking exercise, including identification of the municipal well that is predicted to be impacted the most by a water quantity threat, and the magnitude of that impact (i.e., percent impact). The following summarizes specific results:

- **Municipal Wells** - The final ranking (Table 1) suggests that the City of Guelph municipal wells are the water quantity threats having the greatest impact on groundwater levels in the WHPA-Q. A total of 12 out of the top 15 ranked threats are City of Guelph municipal wells having the greatest impact on themselves when pumping was increased from existing to future rates. In other words, the increase in drawdown caused by increased pumping at these municipal wells is greater than the increase in drawdown at these wells caused by other threats. This included Queensdale well and the Arkell water system (i.e., Arkell 1, Arkell 6, Arkell 7, Arkell 8, Arkell 14, and Arkell 15 wells; and artificial recharge system and Glen Collector System), which are ranked 1 and 2, respectively. The Arkell water system was considered as a group rather than individually due to the complex interaction among the six wells and the artificial recharge and Glen Collector systems. If the Arkell system would be considered separately, all, or a subset of these individual municipal takings, may also rank high on this list, but possibly with individual percent impacts that are less than the cumulative impact of 53% (Table 1).

- **Non-Municipal Permitted Takings** - The final ranking (Table 1) illustrates that, as a group, non-municipal permitted takings have up to a 51% impact on water levels. The Level II and Level III scenarios illustrate the relative impact of individual or groups of non-municipal permits as summarized below.

    - **Dolime Quarry** - For non-municipal permitted takings, dewatering at the Dolime quarry associated with PTTW 5080-8TAKK2 (River Valley Developments) is predicted to be the third highest ranked threat (Rank 3), with a 50% impact on water levels at the Membro well.

    - **Other Non-municipal Permitted Takings** - The next highest non-municipal threat is a group of 32 non-municipal, permitted takings (as of 2008) found within the WHPA-Q that did not include dewatering permits, commercial permits, and industrial permits (Rank 14). This group has a cumulative maximum drawdown greater than 1 m within the City of Guelph and results in a maximum 10% impact on water levels at a municipal well. Other, individual non-municipal

permits are ranked low on the list. For example, the water takings for Gay Lea Foods (1245-AB8RMW) and Nestle Water Canada in Aberfoyle (PTTW 1381-95ATPY) are predicted to have a maximum percent impact of 2% and 1% on municipal wells, respectively.

- **Recharge Reductions** - All recharge reduction threats due to land use development according to Official Plans were assessed as a combined group. The impacts of this collective recharge reduction are predicted to be greatest at the Burke Well, with a 9% impact on water levels at that well. As a result, recharge reduction threats are ranked less (Rank 15) than many of the consumptive water use threats. The scenario predicts a relatively small predicted water level decline in the municipal production aquifer at the Burke Well (i.e. less than 0.4 m); however, greater water level declines (i.e., greater than 2.4 m) are predicted in the shallower flow system and in areas that may be considered for future water supplies. The magnitude of this decline is greater than historical observed seasonal water level fluctuations (Appendix A in Matrix 2017) and may reduce groundwater discharge to neighbouring coldwater streams. Therefore, while recharge reductions do not result in a comparatively high ranking impact at municipal wells, RMMs that maintain or enhance recharge should be explored to mitigate impacts to other water uses.

While not considered Significant Threats, other permitted consumptive water takings located outside of the WHPA-Q were assessed for their impact on municipal wells within the WHPA-Q. These included the following four groups:

- Rockwood municipal wells
- Cambridge municipal wells
- all non-municipal permitted takings found outside of the WHPA-Q

The impact of each of the above-mentioned groups is 1% or less of drawdown at a municipal well within the WHPA-Q. This result is expected and supports the WHPA-Q delineation, as consumptive water takings that contribute more to the collective drawdown in the production aquifer are expected to be found within the WHPA-Q and vice versa.

Non-permitted (i.e., domestic water wells) were assessed as a combined group of takings and predicted to cause a maximum combined impact of 1% on the drawdown of a municipal well. As such, this group is ranked low on the threats ranking list.

The threats ranking results were used to select potential RMMs, which were incorporated into RMM scenarios that could be tested with the Tier Three model.

TABLE 1 Threats Ranking

Water Quantity Threat	Greatest % Impact	Rank	Well under Greatest % Impact
Municipal Well Takings	91%	-	Queensdale
Queensdale well	72%	1	Queensdale
Arkell System (Arkell 1, Arkell 6, Arkell 7, Arkell 8, Arkell 14, Arkell 15 wells and artificial recharge and collector system)	53%	2	Arkell 8
Clythe Creek well	32%	4	Clythe Creek
Calico well	24%	5	Calico
Sacco well	22%	6	Sacco
Helmar well	19%	7	Helmar
Smallfield well	19%	8	Smallfield
Carter wells	17%	9	Carter Wells
Water St. well	17%	10	Water St.
Burke well	15%	11	Burke
Membro well	13%	12	Membro
Downey well	12%	13	Downey
University well	7%	16	University
Dean well	4%	17	Dean
Paisley well	2%	18	Paisley
Future Municipal Takings: Hamilton Drive (GET)	<1%	22	-
All Permitted, Non-Municipal Takings	51%	-	Dean
5080-8TAKK2 (River Valley Developments)	50%	3	Membro
All other Permitted, Non-Municipal Takings Inside WHPA-Q except Dewatering, Commercial, and Industrial Permits (32 permits as of 2008)	10%	14	Emma
1245-AB8RMW (Gay Lea Foods)	2%	19	Emma
1381-95ATPY (Nestle Waters)	1%	20	Burke
5448-9FLM5E (Holody Electro Plating)	< 1%	23	-
5736-8QSS7B (Flochem)	<1%	24	-
All Recharge Reduction Areas (due to future land use)	9%	15	Burke
All Non-Permitted Takings (WWIS-Domestic)	1%	21	Helmar

2.3 IPZ-Q Threats Ranking

As discussed above, the water quantity risk within the IPZ-Q is Significant, and as a result, each of the consumptive water uses within the IPZ-Q are categorized as Significant. The risk ranking exercise for IPZ-Q threats has not been completed at this time. The net consumptive water use within the IPZ-Q is small as compared to the natural variability of flow of the Eramosa River at the intake; therefore, on an average basis, consumptive water taking threats are not expected to impact the municipal surface water intake's ability to pump. Further evaluation of the threats in the IPZ-Q will be completed as part of the climate change assessment being carried out in spring 2018.

2.4 Risk Management Measures

The *Water Quantity Risk Management Measures Catalogue* (the Catalogue; TRCA 2014) contains approximately 70 water quantity RMMs that are grouped into one or more of the following conservation and "terrain" (e.g., land use and land-practice) management targets to mitigate water quantity threats:

- indoor water use reduction
- outdoor water use reduction
- industrial, commercial, and institutional (ICI) water efficiencies
- municipal water loss management
- water resource awareness
- increase in recharge
- increase in water supply
- municipal water efficiencies
- agricultural water efficiencies - crop management
- agricultural water efficiencies - livestock management

Relevant RMMs in the Catalogue can be selected based on the threat activity (i.e., consumptive water use and recharge reduction). The threats ranking reveals that the highest ranked threats are municipal and non-municipal permitted consumptive water takings; therefore, the Catalogue was consulted under the specific threat category: "Consumptive water use - wells." Under this category, RMMs related to water conservation/Industrial – Commercial – Institutional (ICI) efficiencies, well optimization and increase of supply were considered for representation in the RMM scenarios. A fourth RMM was designed that considered the mitigation of impacts from non-municipal consumptive water takings that may impact municipal wells.

The following sections consider the RMMs designed to manage the water quantity threats in the WHPA-Q. RMMs that may be recommended to address the water quantity threats in the IPZ-Q will be assessed at a later date, if necessary, following the completion of the climate change assessment.

2.4.1 Risk Management Measure Scenarios

2.4.1.1 Scenario Development

Based on the RMMs considered, 10 RMM scenarios were developed and tested using the Tier Three model to determine whether impacts to municipal well drawdown and other water uses could be reduced considering both long-term average and drought conditions (Table 2). Long-term average and drought conditions were assessed separately with different municipal pumping rates. During drought periods, water supply from the Glenn Collector is reduced due to the decrease in pumping from the Eramosa intake, and as a result, pumping from the municipal wells is increased to compensate for this loss of supply. Different total municipal pumping rate targets were used across the scenarios to consider

the various estimates of total demand estimated as part of the *Water Conservation and Efficiency Strategy Update* (WC&ESU; RMSi 2009) and *The Corporation of the City of Guelph Water Supply Master Plan Update* (WSMPU; AECOM and Golder 2014). In some scenarios, lower future pumping targets were used under drought conditions account for potential water use reductions that might be expected during low water response situations. A sensitivity analysis was undertaken to test the potential impacts of future increases in pumping from existing non-municipal PTTWs in the WHPA-Q. While this analysis did not evaluate the ability of an RMM to reduce impacts, it provided insight into the sensitivity of water levels in municipal wells to increased non-municipal demands (i.e., assessing impacts from potential future increases in non-municipal water takings and not considering RMM to address the increases). The details of the development and results of those scenarios are provided in Appendices B, C, and D. A summary of the setup of the 10 RMM scenarios is provided in Table 2 and described further below:

- Two scenarios (Scenarios 1 and 6) were developed to assess the effectiveness of additional water conservation measures plus municipal pumping optimization to reduce the Risk Level in the WHPA-Q. Water conservation measures included a reduction in the total demand for the City of Guelph from the Tier Three Assessment future rate to approximately the 2038 projected demand (69,872 m^3/day) determined for the WSMPU (AECOM and Golder 2014). This reduced demand includes conservation measures already achieved, but not guaranteed into the future. Both scenarios included variations in the distribution of municipal pumping rates. Scenario 6 considered the elimination of pumping at Arkell 1 to minimize possible drawdown impacts in this area.

- Four scenarios (Scenarios 2, 3, 4, and 5) tested alternative municipal pumping configurations where pumping rates at municipal wells were increased or decreased with consideration given to what was achievable from these wells. These scenarios considered municipal pumping at the Tier Three Assessment future rate (73,450 m^3/day) during average climate conditions but reduced to a minimum of approximately 71,525 m^3/day during drought periods. This lower rate corresponds to the projected water demand for 2031 used in the Tier Three Assessment and based on the WC&ESU (RMSi 2009). The lower WC&ESU pumping rate is realistic during drought periods, when municipal efforts to enforce water use restrictions could be most effective.

- A single scenario (Scenario 7) tested municipal pumping optimization plus the mitigation of impacts from non-municipal consumptive water takings that have an impact on municipal wells. This scenario evaluated the impacts where there is no dewatering operations at Dolime quarry (PTTW 5080-8TAKK2 - River Valley Developments). This scenario assumed that the Tier Three Assessment future pumping rate is maintained during average climate and drought conditions.

- Three scenarios (Scenarios 8, 9, and 10) tested municipal pumping configurations, where total pumping was equivalent to the Tier Three Assessment future rate during average climate and drought conditions, plus the consideration of adding additional wells to the City of Guelph municipal water supply system (i.e., unpermitted test wells such as Logan Well, Ironwood and Steffler Wells, or Well GSTW-01-08). The demands partitioned to the unpermitted test wells in these scenarios were

ultimately less than the individual capacities of these wells as documented previously (AECOM and Golder 2014; Stantec 2009).

A sensitivity analysis was completed to test the overall sensitivity of drawdown at municipal water supply wells to increased non-municipal, non-dewatering permitted water takings within the WHPA-Q if the total municipal WSMPU rate was achievable under average climate and drought conditions. This analysis tested the possible implications if RMMs for non-municipal PTTWs were not implemented (e.g., no implementation of ICI efficiency strategies) and non-municipal permitted pumping progressively increased from their current (2016) rates to their maximum permitted consumptive rates.

TABLE 2 Risk Management Measures Scenario Summary

RMM Scenario #	Description	Future City of Guelph Demand Target Tested*		Reduction in Risk to Municipal Wells? (Y/N)
		Under Long-term Average Conditions	Under Drought Conditions	
Tier Three Assessment	City of Guelph municipal wells pumping at future rates determined for the Tier Three Assessment.	Tier Three Assessment	Tier Three Assessment	N
1	Redistribution of pumping rates across City of Guelph municipal wells and reduced water demand during average and drought conditions to reflect additional conservation measures in the WSMPU.	WSMPU	WSMPU	N
2	Variations of redistribution of pumping rates across City of Guelph municipal wells and reduced water demand during drought conditions to reflect conservation measures in WC&ESU.	Tier Three Assessment	WC&ESU	N
3				N
4				N
5				Y
6	Redistribution of pumping rates across City of Guelph municipal wells (except Arkell 1) and reduced water demand during average and drought conditions to reflect additional conservation measures in the WSMPU.	WSMPU	WSMPU	Y
7	Redistribution of pumping rates across City of Guelph municipal wells (except Arkell 1) and cessation of dewatering from Dolime quarry.	Tier Three Assessment	Tier Three Assessment	Y
8	Redistribution of pumping rates across City of Guelph municipal wells (except Arkell 1) and to a possible new municipal taking, Logan Test Well.			Y
9	Redistribution of pumping rates across City of Guelph municipal wells (except Arkell 1) and to a possible new municipal taking, GSTW-01-08 test well.			Y
10	Redistribution of pumping rates across City of Guelph municipal wells (except Arkell 1) and to 2 possible new municipal takings, Ironwood and Steffler Park Test Wells.			Y

Notes:
* Tier Three Assessment Demand Target = 73,450 m^3/day
WSMPU 2038 Demand Target = 69,872 m^3/day
WC&ESU 2031 Demand Target = 71,525 m^3/day

2.4.1.2 Scenario Results

All RMM scenarios were evaluated based on the predicted drawdown impacts at municipal wells. For a given scenario, it is concluded that the municipal wells can meet demand if the drawdown at each well does not exceed the safe thresholds assigned during the Tier Three Assessment.

The RMM scenarios are model-based evaluations of the response of municipal wells to variations in pumping rates. In most cases, the actual response to variations in municipal pumping rates will need to be confirmed in the field through testing programs.

Impacts Due to Drawdown

The modelling results of the RMM scenarios revealed that the municipal wells can meet the future demands specified in 6 of the 10 RMM scenarios based on drawdown impacts at municipal wells (Table 2). In all cases this was achieved through municipal well pumping optimization combined with another strategy. Specifically, drawdown thresholds are not predicted to be exceeded in scenarios where:

1) Pumping optimization was coupled with the assumption that total demands could be reduced below the total Tier Three Assessment future rate, either to the WC&ESU rate during drought conditions (Scenario 5), or to the WSMPU rate during both average and drought conditions (Scenario 6).

2) Pumping optimization was coupled with the addition of new municipal water supply wells (Scenarios 8, 9, and 10).

3) Pumping optimization was coupled with the cessation of dewatering operations at Dolime quarry (PTTW 5080-8TAKK2 - River Valley Developments; Scenario 7).

The original Tier Three Assessment allocated pumping rates are larger than the WC&ESU and WSMPU rates, which further account for water conservation. The only RMM scenarios that resulted in municipal wells being able to pump the Tier Three future demand in both average climate and drought conditions include those that simulate the following:

1) new municipal wells (Scenarios 8, 9, and 10); and

2) removal of Dolime quarry dewatering (Scenario 7)

Impacts to Coldwater Streams

Impacts to coldwater streams were assessed for the RMM scenarios that resulted in no impacts to municipal well drawdown (Scenarios 5, 6, 7, 8, 9, and 10). The results of this assessment shows that all six of these scenarios leads to predicted reductions in groundwater discharge to some coldwater streams in an amount greater than 10%. This includes predicted impacts to Blue Springs Creek, Chilligo/Ellis Creek, and Hanlon Creek. As a result, RMM Scenarios 5 to 10 results in a Moderate Risk Level for the WHPA-Q. This is a lower than the Significant Risk Level that was assigned during the Tier

Three Assessment; however, none of the evaluated RMMs were successful in achieving a Low Risk Level by reducing the groundwater discharge impact to less than 10% to all streams. It is expected that the MOECC would look for alternatives to mitigate additional potential surface water impacts when permitting new wells.

Non-municipal Water Demand Sensitivity Analysis

A sensitivity analysis was run to test impacts at municipal wells if non-municipal, non-dewatering permitted pumping was progressively increased from current (2016) reported consumptive rates to maximum permitted consumptive rates. This analysis did not increase pumping from the Dolime quarry permit. The modeling results show that municipal pumping wells can maintain their Allocated rates under average annual conditions, with non-municipal, non-dewatering pumping rates increasing up to the current maximum permitted consumptive demand. The results of the sensitivity analysis revealed that, within the assumptions of the analysis, the current non-municipal, non-dewatering permitted takings may increase by approximately three times what they are currently taking (i.e., the 2016 reported consumptive amount) before impacts are predicted at municipal wells under drought conditions. These results suggest that there may be capacity within the WHPA-Q for some increased water takings. However, the model results suggest that the total permitted rates are over-allocated and that the water resource could not sustain all permit holders pumping at their permitted rates. Further, if future water demand targets that include additional conservation and efficiency efforts are not met, there will be reduced capacity for increased takings within the WHPA-Q. This sensitivity analysis looked at increased water takings within existing permitted takings and did not consider new takings in different locations inside the WHPA-Q.

3 THREATS MANAGEMENT STRATEGY

The Threats Management Strategy consists of a recommended set of RMMs designed to achieve the overall goal of maintaining the supply of drinking water. The strategy builds on the results of the RMM scenarios and identifies the RMMs that were identified to be most effective at reducing impacts to municipal wells in the WHPA-Q. The Threats Management Strategy expands on each of these recommended RMMs and describes what could be done to maximize the benefits of each RMM.

3.1 Recommended Risk Management Measures

All the RMMs tested in the modelling scenarios successfully demonstrate successful in demonstrating that impacts to municipal wells in the WHPA-Q could be reduced and were therefore considered categories of recommended RMMs. The categories of RMMs found to reduce the Risk Level in the WHPA-Q are summarized in Table 3. Each of these RMM categories areis individually discussed in greater detail in the following sections.

TABLE 3 Recommended Risk Management Measure Categories

Recommended RMM Category	Risk Management Measures Description
Well Optimization	This category includes re-allocating municipal pumping rates without violating critical low-water level thresholds in municipal wells.
Water Conservation and Efficiency	This category includes a series of specific RMMs designed to minimize residential, industrial, commercial, and institutional water demands. These RMMs aim to minimize total water demand, with a goal of keeping that water demand below the future rates evaluated in the Tier Three Assessment.
Addition of New Water Supplies	This category includes the addition of new supplies (wells or intakes) or the addition of new alternate or backup water supplies.
Maintaining Pre-development Aquifer Recharge Rates	This category includes RMMs such as Low Impact Development (downspout disconnection, and pervious pavement), and stormwater retention ponds designed to maintain and increase recharge.
Mitigating Impacts from Non-municipal Consumptive Water Takings	This RMM includes the introduction of management or monitoring activities for current or future permitted consumptive water takings that have the potential to increase the risk to one or more municipal wells.

3.2 Well Optimization

Operators of municipal drinking water wells regularly optimize pumping, or modify or redistribute pumping rates between different wells. Adjustment of pumping rates is necessary to adapt to various planned and unplanned disruptions to the municipal water supply system, such as reductions in individual well efficiencies, reductions in groundwater levels, or to allow for well rehabilitation/ maintenance efforts to be completed. The RMM scenarios illustrate the importance of optimization to reduce impacts to municipal wells in the WHPA-Q. The most successful optimization scenarios from a modelling perspective, are those that reduce pumping from the wells potentially not able to meet demands (e.g., Queensdale well and Arkell 1). The scenarios suggest that optimization efforts may be limited by the ability of other municipal wells to increase pumping to offset decreases elsewhere. These limitations are summarized as follows:

- Individual well pumping capacities - some municipal wells may have excess room to accommodate additional drawdown but they are limited by their maximum pumping capacity.

- Mutual drawdown interference - some municipal wells may have the ability to accommodate additional drawdown and have additional pumping capacity. However, the ability for these wells to increase pumping is limited where they create additional drawdown at neighbouring wells with minimal available additional drawdown (e.g., Membro Well is limited by Water St. Well, Park 1 and 2 wells are limited by Emma Well, and the Arkell bedrock wells are limited by other Arkell bedrock wells).

In practice, there are additional factors for municipal operators to consider when operating their water supply system that were not included as part of the RMM scenarios, including well and energy efficiency, water quality impacts, infrastructure constraints and the additional cost of increasing pumping at some of the wells (e.g., Calico well, Dean well, Helmar well, and Queensdale well).

The results from modelling different well optimization scenarios highlight a potential challenge in meeting future water demands, in the case where one or more wells or intakes must be taken offline for mechanical, maintenance, or water quality concerns. Removing wells from service reduces the ability to optimize pumping rates, therefore relying on other RMMs to manage the risk. The results and recommendations provided relating to optimization are based on modelling results.

3.3 Water Conservation and Efficiency Programs

Water conservation and efficiency programs are recommended RMMs and represent the main tools to minimize increases in long-term water demand beyond those forecasted for the Tier Three Assessment (73,450 m^3/day). The scenarios illustrate that, if successful, the conservation measures considered in the City of Guelph's WC&ESU (with a total demand forecast of 71,525 m^3/day) and in the WSMPU (total demand forecast of 69,872 m^3/day) can help reduce the Risk Level. To achieve this reduction in Risk Level, water conservation and efficiency programs that minimize long-term residential and ICI water demands should be maintained with a high priority. Conversely, if demands increase through increased population/ICI growth or if conservation programs fail to achieve conservation targets, the proposed RMM's may be insufficient.

Managing the water supply for residential water customers requires a combination of planning needed to satisfy future growth imposed by the Province, and developing and implementing water conservation and efficiency programs to minimize average and peak water demand. A similar strategy is required for ICI water customers, where their demands are necessary for a municipality to meet the economic and social needs of the community.

A municipality may carry out the following activities to manage municipal residential and ICI water demands:

- forecast long-term residential and ICI water demands based on population and ICI growth targets
- develop water conservation and efficiency programs including outreach and education platforms
- develop residential and ICI water leak detection programs
- develop residential and ICI water conservation rebate programs and financial assistance programs (e.g., low-volume toilet and washing machine programs, capital projects, operations and maintenance)
- develop home, multi-residential, and ICI water use audit programs
- develop construction standards and rebates for new residential homes
- provide residential and ICI customer submetering

- implement drought and low-water response program

The municipalities in the WHPA-Q may carry out all or a subset of the above example activities as part of their existing water conservation efforts. Where there are opportunities for implementing these or additional activities, municipalities in the WHPA-Q should be encouraged to develop and implement residential and ICI water conservation programs, as appropriate, to minimize total water demand.

3.4 Addition of New Water Supplies

The RMM scenarios evaluated the impact of new municipal water supply wells in reducing the Risk Level. The scenarios consider the potential to develop existing test wells into new municipal supply wells, followed by optimizing pumping rates across the system with these new supply wells. The scenarios tested the following new water supplies:

- new wells located near existing wells (i.e., Ironwood and Steffler Test Wells)
- new wells located at a distance from existing wells, both inside (i.e., GSTW-01-08) and outside (i.e., Logan Test Well) City of Guelph boundaries

The scenarios illustrated that new additional wells would help optimize water demand and redistribute drawdown across the WHPA-Q, with a result of reducing the Risk Level.

These RMM scenarios identify four potential new water supply wells that may ensure existing municipal wells can meet the demands forecasted in the Tier Three Assessment. These new water supplies are based on locations that contain at least one municipal test well and have been hydraulically tested. In addition to these locations, there are many other areas within the WHPA-Q at some distance from the existing municipal wells that could be explored, tested, and potentially become locations for future water supply wells.

Municipalities and regulatory agencies are recommended to work together and continue exploration for these locations to meet the demands of future growth. For example, the model indicates the potential for new wells to impact surface water and further environmental assessment is required. In addition to the need for these new water supplies to meet future water supply requirements, it is recommended that new locations be identified and tested as potential supply sources to add redundancy to the existing system in the case that existing wells must be taken offline for maintenance or water quality reasons. The need for water supply redundancy has been highlighted in several instances within the City of Guelph. For example, the City's Smallfield well was taken offline in 1994 due to anthropogenic water quality issues and, since the groundwater contamination has not been addressed, has not yet returned to service.

3.5 Maintaining Pre-development Groundwater Recharge Rates

Following the requirements of the Technical Rules for the Tier Three Assessment, all potential reductions in groundwater recharge within the WHPA-Q were classified as Significant Threats. The threats ranking exercise evaluate all potential recharge reductions due to land use development within the WHPA-Q as a single, combined group. The cumulative groundwater recharge rate reductions result in a maximum drawdown of 2.4 m in the overburden aquifer. This modelled drawdown is greater than historical seasonal water level fluctuations and is prominent in the areas of south Guelph where future drinking water supplies may be located. Furthermore, the extent of groundwater recharge reductions could result in an impact to some coldwater streams and wetlands. If there are impacts to coldwater streams or wetlands, it may be difficult to permit future, new drinking water sources that may have an additional cumulative impact to those streams.

While recharge reductions do not result in a high Risk Level at municipal wells, RMMs that maintain or enhance recharge should be explored to protect potential future water supplies and to mitigate impacts to other water uses.

Municipalities typically employ policies that do not allow for reductions in groundwater recharge in areas with Significant Groundwater Recharge Areas and groundwater and surface water interactions. Low Impact Development (LID) design and construction techniques proven to maintain or enhance pre-development groundwater recharge rates include infiltration trenches, downspout disconnection, and pervious pavement, and these should continue to be used within the WHPA-Q to protect current and future drinking water supplies.

Pre- and post-development recharge can be estimated using water budget tools, such as the Tier Three model, or other smaller-scale numerical models introduced into the process of planning, designing and constructing residential and ICI development projects. However, recharge for water quantity purposes needs to be balanced against potential water quality concerns (i.e., recharge of poor quality road runoff from salt applications). Recharge maintenance can be introduced into the following types of projects:

- Secondary Plans and Master Environmental Servicing Plans
- Site Servicing and Stormwater Management System Designs
- Post-construction Monitoring

3.6 Mitigating Impacts from Non-municipal Water Takings

While the current reported (2016) consumptive groundwater takings for non-municipal, non-dewatering permits within the WHPA-Q is approximately 7,440 m^3/day, the estimated maximum permitted consumptive groundwater demand for those same takings is approximately 42,000 m^3/day. At present, non-municipal water demand is regulated by the MOECC under the *Ontario Water Resources Act* (OWRA; Government of Ontario 2016) and the PTTW program. The purpose of the OWRA is to provide

for the conservation, protection, and management of Ontario's waters and for their efficient and sustainable use, to promote Ontario's long-term environmental, social, and economic well-being.

Currently, the PTTW program is managed independently of the source water protection program, but the Province has committed to integrating the water quantity technical work into the PTTW program. Currently, municipalities and conservation authorities have the opportunity to provide comments on long-term, non-agricultural PTTW applications. Assessment of the threats ranking and RMM scenarios indicates that the evaluation of permitted water demand across the WHPA-Q is important, and the evaluation of individual permits in the WHPA-Q is critical to ensuring that new permitted water takings do not interfere with the reliability of municipal water supplies. The model results suggest that there may be capacity within the WHPA-Q for increased water takings at current levels of water use. However, the model results also suggest that the permitted pumping rates may not be sustainable if all permit holders continuously pump at their current permitted rates. Routine evaluation of actual reported pumping rates and renewal applications for PTTWs is recommended to ensure that municipal water supplies are protected.

The future management of non-municipal, permitted threats, and assessment of cumulative impacts would benefit from recurring updates to the Tier Three model and revisiting the Tier Three Assessment and RMMEP as new hydrogeological and water taking information become available. Assessment of individual permits should be completed during review of new permit applications, or when existing permits in the WHPA-Q are updated or renewed.

The threats ranking exercise evaluated the relative impacts of non-municipal, permitted water demand, both as groups and as single water takings. A sensitivity analysis and RMM scenario were developed to examine both non-dewatering and dewatering water takings.

3.6.1 Non-dewatering Water Use

A sensitivity analysis was completed to predict the impacts at municipal wells if non-municipal, non-dewatering permitted pumping were increased from current (2016) consumptive rates to maximum consumptive rates within existing permits. The results of this sensitivity analysis suggest that the consumptive water demand could be increased by as much as three times relative to what is currently being used (i.e., the 2016 reported consumptive amount) before the existing municipal wells would be unable to meet their future demands. The results suggest that there is capacity within the WHPA-Q for increased consumptive use, providing that these increases occur away from the existing municipal wells. Monitoring and ongoing assessment of impacts will be necessary to assess the reliability of the municipal water supply. This sensitivity analysis assessed increases in consumptive rates that have already been allocated through permitting. This result suggests that existing maximum permitted takings may not be sustainable.

3.6.2 Dewatering Water Use

The threats ranking scenarios highlighted the dewatering operations at Dolime quarry as being the third highest water quantity threat, primarily due to the high volume of pumping and proximity to municipal drinking water wells.

The RMM scenarios illustrate that a reduction of some or all of the Dolime Quarry water demand will reduce the Risk Level. Any increases in pumping from the Dolime quarry will increase the Risk Level.

3.7 Verification of Tier Three Assessment Assumptions

The Tier Three Assessment completed in 2017 and RMMEP described in this document provide a defensible and repeatable framework to assess the water quantity risk to municipal drinking water and to recommend the most appropriate RMMs to reduce this risk in the Risk Level of the WHPA-Q. The Tier Three model used to evaluate the RMMs was developed with the best information available at the time of its creation. However, the model is based on characterization work and assumptions that may not remain valid into the future and should be reviewed on a regular basis to manage the risk to the municipal drinking water in the WHPA-Q. If the Tier Three model is to be maintained as a valuable tool in the evaluation of water takings in the WHPA-Q, then it is essential that supporting data and information be collected and shared among the municipalities, conservation authority, and Province and incorporated into the model. The collective involvement from all these parties will support a shared responsibility to protect and manage the shared water resource. The following sections describe the elements of the Tier Three Assessment and RMMEP that should be reviewed on a regular basis.

3.7.1 Hydrogeological Characterization

The bulk of the hydrogeological characterization that formed the basis of the Tier Three Assessment numerical model was developed and peer reviewed for the Tier Three Assessment by individuals with a great deal of hydrogeology experience within the WHPA-Q. The focus of this characterization was bedrock within the City of Guelph and communities of Rockwood and Hamilton Drive, with less certainty outside of these areas. The assumptions made with the development of the conceptual model are valid with respect to the assessment of the water supplies in Guelph, Hamilton Drive, and Rockwood; however, there may be more uncertainty when dealing with new or existing water supplies outside of these areas.

Ongoing management of water quantity threats within the WHPA-Q should include collection and compilation of geological and hydrogeological information and updates or revisions to the Tier Three model so that it includes characterization of bedrock and overburden hydrogeology that is consistent with the best available data in new areas of interest.

3.7.2 Groundwater and Surface Water Monitoring Data

The Tier Three model was calibrated to match groundwater elevations and surface water baseflow that was measured approximately 10 years ago. Since that time, there has been a significant amount of surface water and groundwater elevation monitoring completed within the WHPA-Q by the City of Guelph, Township of Puslinch, Guelph/Eramosa Township, and others. The Tier Three Assessment and RMMEP are intended to address the current threats to municipal water supply and groundwater and surface water measurements are critical indicators of the amount of water supply.

Ongoing management of water quantity threats within the WHPA-Q should include programs to collect groundwater and surface water monitoring data and updates or revisions to the Tier Three model to verify that it is consistent with current groundwater and surface water conditions.

3.7.3 Municipal Demands and Future Projections

The Tier Three Assessment and RMM scenarios are based on estimated municipal water demands until 2031 as documented in the *Water Conservation and Efficiency Strategy Update* (RMSi 2009) and 2038 as documented in the City of Guelph Water Supply Master Plan Update (AECOM and Golder 2014). The future demand is estimated based on population projections, ICI development, and the success of water conservation and efficiency programs. Ongoing management of water quantity threats within the WHPA-Q should include an update of current water demand and future water demand projections should they change from those considered within the Tier Three Assessment.

3.7.4 Non-municipal Water Demands

The Tier Three Assessment included a rigorous evaluation of existing PTTWs and the consumptive demand was calculated for each permit using either reported water takings from 2008 or earlier, or using the maximum permitted rate if no reported data were available (Appendix B in Matrix 2017). Consumptive demand was determined by multiplying the pumping rate by a consumptive use factor related to the specific purpose of the taking. For example, golf course irrigation takings have an assumed consumptive use factor of 0.85 (Kinkead Consulting and AquaResource 2009), which means that 85% of that water is not interpreted to be returned to the original source.

The non-municipal PTTWs in the WHPA-Q were reviewed and updated for the RMMEP. Expired permits were removed from the Tier Three model and new and previously existing permitted consumptive takings were represented using actual reported pumping data from 2016. Permit holders report their actual water takings to the Province on an annual basis; this data is an important component of the estimated consumptive demand for an individual permit as well as the total across the WHPA-Q.

Ongoing management of water quantity threats within the WHPA-Q should include an update of the individual and total non-municipal, permitted consumptive water demand using existing, new, or revised PTTWs. It should also include an update of the annual reported pumped water across the WHPA-Q and incorporation of the data into updates of the Tier Three model. Details of the reported

takings can be obtained with permission from the MOECC. To better manage the resource as a whole, it is recommended that this information is shared with the municipalities, conservation authorities, and/or the public.

3.7.5 Groundwater Recharge Estimates

The Tier Three model was calibrated to rely on groundwater recharge values that were estimated approximately 10 years ago. New hydrogeology studies being carried out within the WHPA-Q may introduce new information or new methods that will result in changes to estimated groundwater recharge locally or across the WHPA-Q. Ongoing management of water quantity threats within the WHPA-Q should include updates to groundwater recharge rates used in the Tier Three model. This should be completed at the same time that the model is recalibrated to match new groundwater and surface water monitoring data and future model predictions should include recharge estimates that consider possible effects due to climate change.

4 CONCLUSIONS AND RECOMMENDATIONS

This document summarizes an RMMEP and a Threats Management Strategy completed to mitigate Significant Drinking Water Quantity Threats found within the WHPA-Q delineated during the GGET Tier Three Assessment. The RMMEP identifies and updates Significant Threats within the WHPA-Q, and ranking them to determine those that impact the municipal water supplies the greatest. The Tier Three model tests different RMMs having the potential to mitigate those threats and reduce the Risk Level of the WHPA-Q from Significant to Moderate or Low.

The RMMEP reveals that the majority of the highest ranked threats were City of Guelph municipal wells that impacted themselves. However, non-municipal permitted dewatering activities at the Dolime quarry are the third highest ranked threat after the Queensdale well (Rank 1) and the Arkell water supply system (Rank 2). These results were used to establish RMM categories focusing on municipal and non-municipal water takings, including consideration of 1) municipal well optimization, 2) increased water conservation and efficiency, 3) addition of new water supplies, and 4) the mitigation of impacts from non-municipal water takings.

A series of RMM scenarios consider different variations of the selected RMMs and were evaluated using the Tier Three model. The model predictions suggested that multiple different scenarios could result in a decrease in Risk Level to the WHPA-Q from Significant to Moderate. However, the only scenarios that could achieve this result, while still maintaining the future rates from the Tier Three Assessment, are those that included bringing new water supply wells online or where dewatering at the Dolime quarry was reduced or eliminated. An additional sensitivity analysis revealed that if future municipal demands that included conservation targets could be achieved, then additional consumptive permitted takings could be accommodated within the WHPA-Q. All scenarios predict that there will be reduced groundwater discharge to coldwater streams and therefore the Risk Level of the WHPA-Q could not

decrease lower than Moderate; therefore, new or increased water takings would still be Significant Threats. The potential for water takings to impact coldwater streams would also require source protection policies to address them.

Based on the results of the scenarios, all four tested RMM categories are recommended to manage the risk to water quantity and incorporate into the Threats Management Strategy. A fifth recommended RMM designed to maintain or enhance recharge rates is included to mitigate potential impacts to other water uses (i.e., coldwater streams). It is recommended that all five of these RMMs should be considered during Source Protection Plan policy development and as part of a broader water resource management plan that includes a shared management responsibility among the Province, the municipalities, and the source protection authority. Historically, management of water resources and the allocation of water has been largely the responsibility of the MOECC. The implementation of the Grand River SPP provides a framework allowing for the implementation of the recommended RMMs within the WHPA-Q.

The data and assumptions that contributed to the development of the Tier Three Assessment and RMMEP be reviewed on a regular basis to ensure they remain valid. This review would include the collection, compilation, and sharing of new data and information and the review of the hydrogeological characterization, groundwater and surface water monitoring data, municipal demands and future projections, non-municipal water demands, and groundwater recharge estimates.

Ultimately, the results of this technical study should be considered when developing water quantity policies within the WHPA-Q for the GGET municipal water supply systems. A separate water quantity discussion paper is being developed concurrent to this technical study and will outline the current legislative framework in Ontario for managing water quantity threats. This document will describe the available and most promising policy tools to manage those threats. Water quantity policies will be developed later in 2018 under the oversight of the Lake Erie SPC and will include collaboration with partner municipalities and input from the community.

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Appendix B

Guelph-Guelph/Eramosa Water Quantity Policy Development Study

Discussion Paper

DRINKING WATER
SOURCE PROTECTION
Our Actions Matter

Lake Erie Source Protection Region

Guelph-Guelph/Eramosa Water Quantity Policy Development Study

Discussion Paper

Drinking Water Threats:

An activity that takes water from an aquifer or surface water body without returning the water taken to the same aquifer or surface water body; and

An activity that reduces the recharge of an aquifer

June 21, 2018

Executive Summary

As part of the development of the Source Protection Plan, the Lake Erie Source Protection Region has prepared a discussion paper addressing policy development for the two drinking water quantity threats identified by the Ministry of the Environment and Climate Change (MOECC) in Regulation 287/07 under the Ontario Clean Water Act, 2006. This discussion paper provides a summary of the Guelph-Guelph/Eramosa Tier 3 Water Budget and Local Area Risk Assessment, a description of drinking water threats identified for groundwater and surface water sources in the Guelph-Guelph/Eramosa water quantity Wellhead Protection Area (WHPA-Q) and water quantity Intake Protection Zone (IPZ-Q), reviews existing legislation, policies and programs to be considered for policy development, outlines and reviews policy tool options available, and provides a discussion on future policy options that could be used to protect water quantity sources in the WHPA-Q and IPZ-Q, and outlines the next steps. Input from municipalities, stakeholders and experts was sought and considered during the review of policy tools.

Guelph-Guelph/Eramosa Tier Water Budget and Local Area Risk Assessment Summary

The Tier 2 Water Budget study completed for the Grand River watershed in 2009 identified the Upper Speed Assessment Area as having a moderate potential for groundwater stress. Since the municipal drinking water systems for the City of Guelph and Guelph/Eramosa Township take groundwater from the Upper Speed Assessment area, a Tier 3 Water Budget and Local Area Risk Assessment was triggered for these drinking water systems.

As part of the Tier 3 Assessment, complex surface water and groundwater computer models were developed to help evaluate the sustainability of the municipal water supplies in the City of Guelph (City) and Guelph/Eramosa Township (GET). The models were also used to complete a risk assessment to determine the sustainability of the system under a number of scenarios.

Results of the Tier 3 Assessment assigned a significant risk level to the City of Guelph's and GET's Hamilton Drive water quantity vulnerable areas (WHPA-Q and IPZ-Q) that triggering the need for a Risk Management Measures Evaluation Process (RMMEP) and water quantity policy development. GET's Rockwood WHPA-Q were assigned a low risk level and no additional work is required.

Description of the Drinking Water Threats

Prescribed Drinking Water Threat #19: an activity that takes water from an aquifer or surface water body without returning the water taken to the same aquifer or surface water body.

Threat 19 occurs when water is taken and not returned and is no longer available for other users of the same water source. This is called consumptive use. The taking of water from an aquifer or surface water body used as a municipal drinking water source (without returning it to the same source) could result in a depletion of available supply that could impair the long-term sustainability of a drinking water system. Unlike water quality threats, where the threat level is a product of the vulnerability score and the hazard score (of the activity), water quantity threats are a function of exposure and tolerance. Consumptive use is or would be a significant drinking water threat in WHPA-Qs and IPZ-Qs that are assigned a significant risk level.

Prescribed Drinking Water Threat #20: an activity that reduces the recharge of an aquifer.

Threat 20 occurs when an activity reduces recharge of the water table. Examples of activities that could reduce the infiltration of water into the ground include paving of parking lots, construction of buildings and the pumping of water out of the ground (i.e., sump pumps) where the water is diverted to a discharge location (i.e., storm sewer or surface water) rather than allowing the water to recharge the water table. A reduction in recharge could result in a reduction of available supply that may impair the long-term sustainability of a drinking water system. Recharge reduction is or would be a significant drinking water threat in WHPA-Qs and IPZ-Qs that are assigned a significant risk level.

A review of the significant drinking water threats identified in the Guelph-Guelph/Eramosa Tier 3 Water Budget and Local Area Risk Assessment indicates that a number of drinking water threat activities related to consumptive use and recharge reduction are located/present in water quantity vulnerable areas in the City of Guelph, Guelph/Eramosa Township (County of Wellington), Township of Puslinch (County of Wellington) and the Town of Erin (County of Wellington) within the Grand River Source Protection Area.

Existing Legislation, Policies and Other Programs

Existing legislation, policies and other programs, used for current management associated with consumptive use and recharge reduction, are summarized in **Section 4** and **Appendix B** of the discussion paper and include:

- Federal legislation

- Provincial legislation
- Municipal policies, strategies, plans and programs
- Other programs

Examples:

The *Ontario Water Resources Act, 1990* protects the sustainability of the Province of Ontario's water resources. The Act, among other things, requires those taking greater than 50,000 litres per day to obtain a Permit to Take Water (PTTW). There are exceptions for residential use, livestock watering, frost protection and firefighting (less than 379,000 litres per day). No permit can be issued for more than ten years. The purpose of the PTTW program is to ensure the conservation, protection and wise use and management of provincial waters.

The City of Guelph has a Water Efficiency Strategy that was updated in 2016. The Strategy includes a number of plans, initiatives and other programs that work together to reduce water demand on a daily basis to ensure more water is available for future use and the source water remains sustainable.

Wellington County's Official Plan pertains to Water Resources and includes policies on watershed planning, surface and groundwater protection, source water protection and specific policies on the protection of the Paris and Galt Moraine.

The Township of Puslinch initiated a municipal servicing feasibility study in 2017 for municipal servicing (water and wastewater) within the Guelph-Guelph/Eramosa Tier 3 study area. Guelph/Eramosa Township has established and employed water conservation measures, including water use restrictions and a toilet rebate program for Rockwood residents.

Policy Toolbox and Options

The objective of the Source Protection Plan is to protect existing and future drinking water sources. Within the Grand River Source Protection Area, the plan must ensure that for every area identified in the assessment report as an area where an activity is or would be a significant threat, the activity never becomes a significant threat, or the activity ceases to be a significant drinking water threat. Policy tools are provided by the Province through the CWA to achieve these objectives, and they include:

- Part IV Prohibition
- Part IV Regulation (Risk Management Plan)
- Part IV Restricted Land Uses
- Prescribed Instruments
- Land Use Planning

- Other: Stewardship, Pilot Programs, and Research
- Other: Specify Action

The policy options presented in the table below could be used to address significant drinking water quantity threats with respect to consumptive use and recharge reduction activities, respectively.

Table 1: Policy options for consumptive use and recharge reduction activities

Policy Tool	Intent
Part IV Tool: Prohibition	• Prohibit recharge reduction or consumptive water taking in an area where prohibition us justified due to the excessive risk to drinking water supplies
Part IV Tool: Regulation (Risk Management Plans)	• Require that a Risk Management Plan be developed to ensure that consumptive takings are managed and pre-development recharge is maintained
Part IV Tool: Restricted Land Uses	• The policy would be used in conjunction with either Part IV: Prohibition or Part IV: Risk Management Plans to act as a screening tool for development applications (planning or building) that may trigger a Part IV policy
Prescribed Instruments	• The policy would direct the Province to review and/or include conditions in a Permit To Take Water or Environmental Compliance Approval to ensure that the municipal drinking water supply is sustainable.
Land Use Planning	• The policy would manage new development by restricting specific uses through official plans and zoning by-laws which result in excessive risk to the aquifer due to consumptive use or recharge reduction, or including specific criteria as part of development approvals to minimize the impact of consumptive use or maintain or improve recharge of the aquifer
Education, Outreach/Incentive Programs	• The policy would continue and/or expand water conservation or water recharge education initiatives and develop new water quantity outreach materials to be shared across the region for both residents and businesses
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• The policy would continue and/or expand risk reduction projects (e.g., water conservation, protection of recharge areas) implemented through stewardship programs; • Promote Best Management Practices, e.g., water conservation, downspout disconnect encouraged through Land Use Planning approvals, use of best

	management practices for municipal infrastructure and facilities; Promote pilot programs to assist in implementing water conservation programs for private business; • Allow for the consideration of alternative water supplies (i.e., water reuse) to assist in creating a resilient water supply system; and • Develop municipal water saving programs
Other: Specify Actions	• The policy would establish specific action(s) to help manage consumptive use and recharge reduction activities, such as: ○ MOECC to use Tier 3 model for PTTW decisions ○ Municipality encouraged to locate additional water supplies ○ When implementing the new growth targets as set out within the Provincial Places to Grow Plan, municipal growth forecasts to consider incorporating Tier 3 information ○ Update or develop municipal water conservations plans and water management plans to support sustainable use ○ Update or develop water management plans to maximize aquifer recharge ○ Require maintenance of storm water management infrastructure

Policy Tool Review

The Project Team, with input from the Implementing Municipalities Group (IMG) and Community Liaison Group (CLG) reviewed potential strengths, opportunities, weaknesses and challenges of policy tools available to the Lake Erie Region Source Protection Committee (SPC) to address existing and future water quantity threats in the Guelph-Guelph/Eramosa WHPA-Q and IPZ-Q. **Table 2** provides a high-level summary of that review.

Table 2: Policy tool review summary for consumptive use and recharge reduction activities

Policy Tool	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Part IV Tool: Prohibition	• Can be very effective by completely removing and preventing the threat • Potential to delineate smaller zones in a	• Impact to the property owner could be high • Difficult to justify if used broadly across a vulnerable area

	vulnerable area where prohibition could be justified	
Part IV Tool: Regulation (Risk Management Plans)	• Can be property/activity specific making it flexible • Consumptive use - could be applied to takings where PTTW does not apply • Recharge reduction – ability to include monitoring program and measure implementation success	• Potentially high level of resources required to administer and enforce • Consumptive use - Implementation and legal challenges (e.g. appeal to ERT) if application of RMP is not applied consistently and/or locally justified.
Part IV Tool: Restricted Land Uses	• Can manage an activity without restricting an entire land use and able to provide exemptions • Can link tool to Planning Act process and integrate into municipal development review process	• Only applies to existing land use when activity is changing or expanding • Consumptive use - activity may not always be flagged through a development application • Recharge reduction – land uses named in the policy must match the names that appear in local official plans or zoning bylaws
Prescribed Instruments (PTTW)	• Science-based, pre-cautionary, transparent and peer-reviewed • Existing, relatively well understood regulatory framework • Broad powers to collect new data through monitoring conditions and require studies • Consumptive use - adaptive management: ability to require review of existing PIs within a certain timeframe; and maximum 10-year PTTW period	• Financial implications for property owners from new requirements • Consumptive use - need for improved monitoring • Consumptive use - all permits are treated the same regardless of how the water is used • Consumptive use - may not be seen as equitable as single tool as not all consumptive water takings are captured
Land Use Planning	• Can be tailored to specific areas with specific restrictions • Consumptive use - water taking can be considered a land use and can be regulated through land use	• Addresses future threats only • Appeals to the Local Planning Appeal Tribunal (LPAT) could result in this body that is not familiar with water issues making uninformed rulings that cannot be overturned

	planning • Recharge reduction - land use plans could be updated using update recharge information on a regular basis	• Consumptive use - land use planning tools untested as a means to address water takings • Recharge reduction – unclear where land use would apply to recharge
Education, Outreach/Incentive Programs	• Increases landowner awareness and community engagement • Recharge reduction – can encourage effective Best Management Practices	• Public understanding of water quantity is poor • Time and cost to implement program could be high • Recharge reduction – increased recharge in all areas may not be appropriate and justified
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• Reduction in financial burden for the applicant • Fills data gaps • Consumptive use - can motivate changes in behaviour with little cost to municipality compared to cost of producing water and maintaining or expanding infrastructure	• May not be sufficient to address threats on its own • Continuous funding required • Effectiveness relies on property owner participation • Difficult to ensure compliance
Other: Specify Actions	• Tool is flexible • Can require specific action and provides options for local situations • Consumptive use - could increase engagement from non-municipal water takers	• Implementation cost could be high and coordination could be challenging if multiple parties involved

Promising Policy Tools

Through the review of possible policy tools and approaches to address consumptive water taking and recharge reduction activities, certain policy tools have been identified as promising, meriting further discussion to achieve the objectives of the Source Protection Plan.

The promising policy tools described below are not an exhaustive list and do not limit the Project Team from selecting other tools to develop policies throughout the remainder of the policy development process.

Threat 19: Consumptive Water Use

Addressing consumptive water takings that are identified as a significant drinking water threat could be achieved through the use of Prescribed Instruments, specifically the PTTW program. Where a PTTW already exists, policies may be developed to direct the Province to review, and amend or revoke existing permits using the Tier 3 model results or the model itself, and require that additional terms and conditions are added to ensure that the municipality's existing and future water supply is sustainable. New or increased takings subject to the PTTW process could also include similar terms and conditions.

Where consumptive water takings may not be able to be adequately addressed by Prescribed Instruments (e.g., takings within the WHPA-Q that are exempt from the PTTW process), the Part IV tools (i.e., Prohibition, Risk Management Plans, together with Restricted Use) may be an option to meet the source protection plan objectives.

A prohibition tool would only be considered after all other feasible management options have been assessed as being insufficient in protecting the municipalities' drinking water supply.

Municipal land use planning policies could be considered a tool to address consumptive water use activities. However, land use planning tools are untested as a means to address water takings. Consumptive water use and availability could be considered by the Province when allocating growth through provincial planning tools such as the Growth Plan.

Additional policies addressing water consumption could also be addressed through policy within Official Plans, e.g., specific restrictions in certain areas of the municipality or by the type of development and/or water taking. The need for additional restrictiveness of the land use policies may vary depending on existing municipal land use policies and the geographic setting of the vulnerable areas.

Policies could also be written for municipalities to incorporate the long-term sustainability of the municipal water supply into their decisions about water services when approving growth and development. This could be achieved by requiring an approved PTTW where the MOECC has determined that the proposed taking does not become a significant drinking water quantity threat.

The specify action tool could also be valuable in addressing existing and future consumptive use activities through the development of locally-specific policies. For example, policies could focus on:

- ensuring that municipal water management plans and/or water conservation plans are developed or updated;

- developing joint water resource management systems to provide collaboration and cooperation between the province, Source Protection Authority and municipalities to manage local water resources to protect drinking water sources;
- that Tier 3 information is used in making informed decisions and that Tier 3 models are provincially funded and maintained on an ongoing basis; and
- ensuring that existing and future municipal water demands are met before allocating water to other users in the WHPA-Q and IPZ-Q. This would mean shifting to a "priority of use" concept instead of the current "first in time, first in right" approach.

Threat 20: Recharge Reduction

Perhaps the most effective tools to address recharge reduction threats are municipal land use planning policies and implementation of best management practices as part of updated municipal practices and development approval requirements. Policies could be developed to require the local planning authority to manage new developments by including criteria for approval that ensure the proposed activity does not become a significant drinking water threat. The restrictiveness of the policies may vary depending on existing municipal land use policies and the geographic setting of the vulnerable area.

Recharge reduction activities could also be addressed through Prescribed Instrument policies, specifically Environmental Compliance Approvals (ECA) such as sewage works projects being used for low-impact development, stormwater ponds, etc.

Softer tools such as education and outreach and incentive programs can be used to promote source protection policies in general and focus on promoting BMPs, as well as low impact development (LID) in specific areas where feasible. Outreach programs could target specific sectors in the vulnerable area.

Next Steps

Lake Erie Source Protection Region is committed to a collaborative process working with municipalities and stakeholders during policy development. After completion of the discussion paper and release by the Lake Erie Region Source Protection Committee, policy approaches will be drafted by the Guelph-Guelph/Eramosa Water Quantity Policy Development Study Project Team with feedback and support from the Implementing Municipalities Group (IMG) and Community Liaison Group (CLG). Municipalities will be able to identify policy options that best suit their needs based on specific circumstances and resources available. The drafting of water quantity policies is expected to occur in the fall 2018.

Draft policy options will then be developed by the Project Team with support from the IMG and CLG and presented to the SPC. The SPC has the decision making authority regarding the policies to be included in the Source Protection Plan, and with direction from the SPC, Lake Erie Region staff will incorporate the water quantity policies into an updated Grand River Source Protection Plan.

Formal public consultation is a mandatory component prior to the updated plan being submitted to the MOECC for review and approval and is expected to occur in the spring 2019. Municipalities affected by the plan updates will be asked to endorse the plan amendments prior to formal public consultation.

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Appendices

1. Introduction

The Source Protection Program under the Province's *Clean Water Act, 2006* (CWA) was developed to protect the water quality and quantity of existing and proposed municipal drinking water systems across the Province. To date, the water quality components of the Grand River Source Protection Plan have been approved and in place since July 1, 2016. The water quantity components for the Grand River Source Protection Plan are still underway, and water budget studies are a major piece of technical work in the process.

The Tier 2 Water Budget study completed for the Grand River Watershed in 2009 identified the Upper Speed Assessment Area as having a moderate potential for groundwater stress. Since the municipal drinking water systems for the City of Guelph and Guelph/Eramosa Township take groundwater from the Upper Speed Assessment area, a Tier 3 Water Budget and Local Area Risk Assessment was triggered. Results of the Tier 3 Assessment assigned a significant risk level to the City of Guelph's and Guelph/Eramosa Township's Hamilton Drive water quantity vulnerable areas triggering the need for a Risk Management Measures Evaluation Process (RMMEP) and water quantity policy development.

The Lake Erie Source Protection Region has prepared a discussion paper as part of the update of the Grand River Source Protection Plan to address water quantity policy development in the City of Guelph and Guelph/Eramosa Township water quantity vulnerable area. Consumptive water takings and reduction in recharge are the two drinking water quantity threats identified by the Ministry of the Environment and Climate Change (MOECC) in Regulation 287/07 under the *Ontario Clean Water Act (CWA), 2006*.

The aim of this discussion paper is to aid policy makers by providing background information on drinking water quantity threats and an assessment of the policy tools and approaches that are available. This discussion paper provides a summary of the Guelph-Guelph/Eramosa Tier 3 Water Budget and Local Area Risk Assessment and results, a description of drinking water threats identified for groundwater and surface water sources in the Guelph-Guelph/Eramosa water quantity Wellhead Protection Area (WHPA-Q) and water quantity Intake Protection Zone (IPZ-Q), reviews existing legislation, policies and programs to be considered for policy development, outlines and evaluates policy tool options available, and provides a discussion on future policy options that could be used to protect water quantity sources in the WHPA-Q and IPZ-Q, and outlines the next steps. Input from municipalities, stakeholders and experts was sought and considered during the review of policy tools.

This discussion paper will form a basis for developing the water quantity policies, and the Lake Erie Region Source Protection Committee, working with municipal partners, stakeholders, and with significant public consultation, will prepare an update to the Grand River Source Protection Plan that will include water quantity technical work and water quantity policies.

2. Guelph-Guelph/Eramosa Tier 3 Water Budget and Local Area Risk Assessment Summary

Tier 3 Water Budget

A Tier 3 Water Budget is a detailed scientific technical study aimed at assessing the water quantity risk to current and future municipal drinking water sources under a variety of scenarios, such as future increased municipal water needs due to growth and a sustained drought. The water budget study uses a computer model to simulate groundwater and surface water flow to evaluate how water levels will change within the municipal wells under the various scenarios. The development of the water budget models will use all available data to understand the groundwater flow system from recharge to discharge areas, and quantify the volume of water flowing through the area. Quantity-related Wellhead Protection Areas and Intake Protection Zones are delineated to identify the subsurface and surface areas where the municipal wells and intakes are sensitive to water takings and reductions to infiltrations of precipitation caused by land use changes.

The Guelph-Guelph/Eramosa Tier 3 Assessment was completed following the Province's Technical Rules, which were applied across southern Ontario. The model findings were verified by observed water monitoring results. Flexibility in the Rules allowed the team of experts to achieve a better match between the model and observed water monitoring results. A review team of local technical experts and academics appointed by the Province have accepted the results before it was presented to the Lake Erie Region Source Protection Committee (SPC) on April 6, 2017. The Ontario Ministry of the Environment and Climate Change (MOECC) has also endorsed the results of the Tier 3 Assessment.

As part of the Tier 3 Assessment, complex surface water and groundwater computer models were developed to help evaluate the sustainability of the municipal water supplies in the City of Guelph (City) and Guelph/Eramosa Township. The models incorporated the best available information about local geology, groundwater and surface water resources, precipitation and infiltration and water withdrawals. The models developed a water budget for municipal water supplies that quantified the additions (e.g., precipitation infiltrating into the ground, runoff to streams and rivers, flow within and between the aquifers) and withdrawals (e.g., surface water and groundwater

flowing out of the study area, water taking by municipalities and other takers and groundwater contributions to rivers). The groundwater and surface water systems are in balance when the water additions and withdrawals are approximately equal.

Risk Assessment

In addition to the water budget calculations, the models were also used to determine an area where the municipal drinking water systems could be affected by other existing, new or expanded water takings, referred to as a water quantity wellhead protection area (WHPA-Q). The WHPA-Q for the City's wells is a circular area with a diameter of approximately 20 km around the City and extending into the adjacent Townships (**Appendix A, Figure 1**). Similarly, the WHPA-Q for the Guelph/Eramosa Township wells for the Rockwood area are circular in shape around the wells but much smaller in size due to lower pumping rates. The surface water Intake Protection Zone for water quantity (IPZ-Q) is the upstream catchment area that contributes water to the City's surface water intake on the Eramosa River (**Appendix A, Figure 2**).

The final task of the Tier 3 Assessment was to assign a risk level to the groundwater and surface water quantity vulnerable areas. According to the Rules, the risk level may be "low", "moderate" or "significant" depending on whether the municipal water supply is predicted to be able to meet the water needs of its customers under the modelled risk scenarios. The Rules guiding the Tier 3 Assessment followed a conservative approach to ensure the cumulative effects of water takings across the vulnerable area are included in the assessment. As a result, the highest risk level triggered in at least one well is assigned to the entire vulnerable area. For example, if the scenario for current and future municipal needs produced a "low" risk, but the added stress of a prolonged drought produced a "significant" risk level, the vulnerable area would be assigned a "significant" risk level. If this significant risk level was found for one well, the significant risk level was also assigned to the entire water quantity vulnerable area.

Risk Assessment Results

The Tier 3 Assessment scenarios predicted that the City's and Guelph/Eramosa Township's municipal wells can meet current needs. However, the assessment predicted that the City's Queensdale municipal well would be unable to meet future needs under normal climate conditions and during prolonged drought. All of the City's other wells and Guelph/Eramosa Township's wells are expected to be able to meet future needs under all scenarios, but there is a high level of uncertainty with the results for the City's Arkell Well 1. As a result of these assessments, and since the City's drinking water system is dependent on the contribution of water from the Eramosa River intake, the City's WHPA-Q and IPZ-Q are assigned a significant risk level.

The findings of the Tier 3 Assessment are supported by the historical operating experience in the City where many of the wells reliably provided water over prolonged periods of time. The City primarily draws water from the deep bedrock aquifer which is protected in most areas by a protective layer. The protective layer isolates the deep bedrock aquifer from short-term changes in climate (e.g., a dry summer with little rainfall) and it takes a prolonged drought, as Ontario experienced in the early 1960s, for declines in water levels to be observed in City's wells. While all the City municipal wells, except the Queensdale Well, are expected to meet the City's future needs, water levels at some of the City's other wells (Arkell Well 1, Arkell Well 8, Arkell Well 14, Arkell Well 15, Burke Well, Carter Well and Emma Well) and Guelph Eramosa Township's Bernardi Well 3 have water levels in the wells that are close to the pump intake and may be more susceptible to drought conditions. With the addition of new Arkell Spring Ground wells, the City's water supplies have the capacity to meet the 2031 estimated water needs; however, there is little redundancy in the water supply system.

Since the Tier 3 Assessment identified areas where the municipal systems may be affected by water takings (WHPA-Q or IPZ-Q), all water takings that could potentially impact the municipal systems were identified. For water quantity vulnerable areas with a significant risk level, all existing and new water takings located within the area that draw water from the municipal aquifers or Eramosa River or activities that reduce groundwater recharge are classified as Significant Drinking Water Quantity Threats (significant threats). The City and Guelph/Eramosa Township municipal wells are significant threats as are other permitted water takings in the WHPA-Q and the IPZ-Q. The significant threats for the WHPA-Q and IPZ-Q are shown in **Appendix A, Figures 3 and 4**, respectively.

3. Description of the Drinking Water Quantity Threats

Definitions

Prescribed Drinking Water Threat #19

Prescribed drinking water threat Number 19 listed in Regulation 287/07 under the *Clean Water Act, 2006* (CWA) is, "an activity that takes water from an aquifer or surface water body without returning the water taken to the same aquifer or surface water body". For this drinking water threat, an aquifer is defined as an underground saturated permeable geological layer that is capable of holding water in sufficient quantities to serve as a source of groundwater supply.

Threat 19 occurs when water is taken and not returned and is no longer available for other users of the same water source. This is called consumptive use. The taking of water from an aquifer or surface water body used as a municipal drinking water source

(without returning it to the same source) could result in a depletion of available supply that could impair the long-term sustainability of a drinking water system.

Unlike water quality threats, where the threat level is a product of the vulnerability score and the hazard score (of the activity), water quantity threats are a function of exposure and tolerance. Consumptive water taking is or would be a significant drinking water threat in WHPA-Qs and IPZ-Qs that are assigned a significant risk level.

Prescribed Drinking Water Threat #20

Prescribed drinking water threat Number 20 listed in Regulation 287/07 under the CWA is, “an activity that reduces the recharge of an aquifer."

Threat 20 occurs when an activity reduces recharge of the water table. Examples of activities that could reduce the infiltration of water into the ground include paving of parking lots, construction of buildings and the pumping of water out of the ground (i.e., sump pumps) where the water is diverted to a discharge location (i.e., storm sewer or surface water) rather than allowing the water to recharge the water table. A reduction in recharge could result in a reduction of available supply that may impair the long-term sustainability of a drinking water system.

Recharge reduction is or would be a significant drinking water threat in WHPA-Qs and IPZ-Qs that are assigned a significant risk level.

Identifying Consumptive Use and Recharge Reduction as Significant Drinking Water Threats

Below is a modification of Table 5 from the Updated CWA Technical Rules which describes the circumstances surrounding how and where consumptive use (**Table 1**) and recharge reduction (**Table 2**) activities are considered Significant Drinking Water Threats.

Table 1: Circumstances in which consumptive use is considered a Significant Drinking Water Threat

Column 1	Reference #	Circumstances	Column 3
Activity (Drinking Water Threat)	Column 2		Areas where Activity is a Significant Drinking Water Threat
An activity that takes water from an	1	1. An existing taking, an increase to an existing taking or a new taking.	IPZ-Q where the water is or would be taken if the area

Table 1: Circumstances in which consumptive use is considered a Significant Drinking Water Threat			
Column 1	Reference #	Circumstances	Column 3
Activity (Drinking Water Threat)	Column 2		Areas where Activity is a Significant Drinking Water Threat
aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.		2. The water is or would be taken from within an IPZ-Q.	relates to one or more surface water intakes and the local area was assessed to have a risk level of significant in accordance with Part IX.
	2	1. An existing taking, an increase to an existing taking or a new taking.	WHPA-Q1 where the water is or would be taken if the area relates to one or more wells and the local area was assessed to have a risk level of significant in accordance with Part IX.
		2. The water is or would be taken from within a WHPA-Q1	
	3	1. An existing taking, an increase to an existing taking or a new taking.	IPZ-Q where the water is or would be taken if the area relates to one or more surface water intakes and the local area was assessed to have a risk level of moderate in accordance with Part IX.
		2. Section 34 of the *Ontario Water Resources Act* requires a permit to take water in respect of the increase or new taking.	
		3. The water is or would be taken from within an IPZ-Q.	
		4. Despite the local area from which the water is or would be taken having been assessed for the purposes of the latest assessment report to have a risk level of moderate in accordance with Part IX, the local area would be assessed to have a risk level of significant if the increase to the existing taking or the new taking	

Table 1: Circumstances in which consumptive use is considered a Significant Drinking Water Threat			
Column 1	Reference #	Circumstances	Column 3
Activity (Drinking Water Threat)	Column 2		Areas where Activity is a Significant Drinking Water Threat
		were factored into the risk level assessment.	
	4	1. An increase to an existing taking or a new taking.	WHPA-Q1 where the water is or would be taken if the area relates to one or more wells and the local area was assessed to have a risk level of moderate in accordance with Part IX.
		2. The water is or would be taken from within a WHPA-Q1.	
		3. Section 34 of the *Ontario Water Resources Act* requires a permit to take water in respect of the increase or new taking.	
		4. Despite the local area from which the water is or would be taken having been assessed for the purposes of the latest assessment report to have a risk level of moderate in accordance with Part IX, the local area would be assessed to have a risk level of significant if the increase to the existing taking or the new taking were factored into the risk level assessment.	
Reference: Ministry of the Environment and Climate Change, Technical Rules under the Clean Water Act, 2017.			

Table 2: Circumstances in which recharge reduction is considered a Significant Drinking Water Threat			
Column 1	Reference #	Circumstances	Column 3
Activity (Drinking Water Threat)	Column 2		Areas where Activity is a Significant Drinking Water Threat
An activity that reduced	5	1. An existing activity, a modified activity or a new activity.	IPZ-Q where the water is or would

Table 2: Circumstances in which recharge reduction is considered a Significant Drinking Water Threat			
Column 1	Reference #	Circumstances	Column 3
Activity (Drinking Water Threat)	Column 2		Areas where Activity is a Significant Drinking Water Threat
recharge to an aquifer.		2. The activity is or would be wholly or partly located within an IPZ-Q.	be taken if the area relates to one or more surface water intakes and the local area was assessed to have a risk level of significant in accordance with Part IX.
	6	1. An existing activity, a modified activity or a new activity.	WHPA-Q2 where the water is or would be taken if the area relates to one or more wells and the local area was assessed to have a risk level of significant in accordance with Part IX.
		2. The activity is or would be wholly or partly located within a WHPA-Q2.	
	7	1. A modified activity or a new activity.	IPZ-Q where the water is or would be taken if the area relates to one or more surface water intakes and the local area was assessed to have a risk level of moderate in accordance with Part IX.
		2. The activity is or would be wholly or partly located within an IPZ-Q.	
		3. Despite the local area from which the water is or would be taken having been assessed for the purposes of the latest assessment report to have a risk level of moderate in accordance with Part IX, the local area would be assessed to have a risk level of significant if the modified activity were factored into the risk level assessment.	
	8	1. A modified activity or a new	WHPA-Q2 where

Table 2: Circumstances in which recharge reduction is considered a Significant Drinking Water Threat

Column 1	Reference #	Circumstances	Column 3
Activity (Drinking Water Threat)	Column 2		Areas where Activity is a Significant Drinking Water Threat
		activity.	the water is or would be taken if the area relates to one or more wells and the local area was assessed to have a risk level of moderate in accordance with Part IX.
		2. The activity is or would be wholly or partly located within a WHPA-Q2.	
		3. Despite the local area from which the water is or would be taken having been assessed for the purposes of the latest assessment report to have a risk level of moderate in accordance with Part IX, the local area would be assessed to have a risk level of significant if the modified activity were factored into the risk level assessment.	
Reference: Ministry of the Environment and Climate Change, Technical Rules under the Clean Water Act, 2017.			

Drinking Water Quantity Threats Identified in Guelph-Guelph/Eramosa

A review of the significant drinking water threats identified in the Guelph-Guelph/ Eramosa Tier 3 Water Budget and Local Area Risk Assessment indicates that a number of drinking water threat activities related to consumptive use (i.e., Permit to Take Water activities) (**Table 3**) and recharge reduction (**Table 4**) are located/present in water quantity vulnerable areas in the City of Guelph, Guelph/ Eramosa Township (County of Wellington), Township of Puslinch (County of Wellington) and the Town of Erin (County of Wellington) within the Grand River Source Protection Area. Significant threat activities related to consumptive use include municipal, non-municipal permitted and non-municipal non-permitted takings. Non-municipal non-permitted takings may include numerous domestic wells in WHPA-Q. The Tier 3 study, while it considers all water takings, is primarily focused on larger permitted takings. The locations of identified water quantity threats (PTTW) in the Guelph-Guelph/ Eramosa WHPA-Q and IPZ-Q are presented in **Appendix A**.

Table 3: Summary of significant drinking water threats (PTTW) identified in the Guelph-Guelph/ Eramosa Tier 3 WHPA-Q and IPZ-Q related to 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

Municipality	Number of Significant Threats*	
	WHPA-Q	IPZ-Q
City of Guelph	47	-
County of Wellington – Puslinch	41**	7***
County of Wellington – Guelph/Eramosa	12	6****
County of Wellington - Erin	-	10

* Does not include threats that are non-municipal non-permitted water takings, e.g., domestic wells of which there are an estimated 5,100 (Guelph-Guelph/Eramosa Threats Management Strategy, May 2018)

- ** This includes the City of Guelph's Eramosa River Intake
- *** This includes the 6 Arkell wells
- **** This includes the 3 Rockwood wells

Table 4: Presence of significant drinking water threats identified in the Guelph-Guelph/Eramosa Tier 3 WHPA-Q and IPZ-Q related to an activity that reduces the recharge of an aquifer

Municipality	Recharge Reduction Threats Present
City of Guelph	Yes
County of Wellington - Puslinch	Yes
County of Wellington – Guelph/Eramosa	Yes
County of Wellington - Erin	Yes

4. Existing Legislation, Policies and Other Programs

A brief summary of the existing legislation, policies, and other programs with respect to consumptive use and recharge reduction as drinking water threats are presented in **Appendix B.**

5. Policy Toolbox

The objective of the Source Protection Plan is to protect existing and future drinking water sources. Within the Grand River Source Protection Area, the plan must ensure that for every area identified in the assessment report as an area where an activity is or

would be a significant threat, the activity never becomes a significant threat, or the activity ceases to be a significant drinking water threat. Policy tools are provided by the MOECC through the CWA to achieve these objectives. A general summary of these policy tools is provided in **Table 5**.

Table 5: Summary of Policy Tools (Government of Ontario, 2006)

Policy Tool	General Example
Part IV Tool: Prohibition	Prohibit the activity using Section 57 of the *Clean Water Act, 2006*. This tool is considered the strongest tool available in the "policy toolbox" for reducing risk associated with significant drinking water threats. When source protection committees consider it as a tool to address activities that already exist on the landscape, they only do so after considering all other feasible options.
Part IV Tool: Regulation (Risk Management Plans)	Regulation of the activity using a Risk Management Plan under Section 58 of the *Clean Water Act, 2006* (i.e., the activity can only occur if an approved plan is in place to manage the risk to the raw water supply from that activity). Risk Management Plans are site specific, locally negotiated plans developed between the municipal official and the person engaged in the threat activity after the Source Protection Plan has been approved.
Part IV Tool: Restricted Land Uses	Using Section 59 under the *Clean Water Act, 2006*, some development applications under the *Planning Act* or the *Building Code Act* related to activities that would be a significant drinking water threat would be subject to certain conditions. It acts as a "pause"/ screening tool/ early warning system by providing municipalities with an administrative procedure to avoid inadvertently approving applications/ building permits for activities that would conflict with Part IV policies. This tool must be used in conjunction with either Part IV: Prohibition or Part IV: Risk Management Plans.
Prescribed Instruments	A tool issued by provincial ministries using government regulations to manage an activity, e.g., Permit To Take Water (PTTW).
Land Use Planning	Policies that affect land use planning decisions under the *Planning Act* and *Condominium Act*. In some cases it may be appropriate to manage or restrict the threat through local land use planning policies, documents and processes (Official Plans, zoning by-laws and site plan controls).
Education, Outreach/Incentive Programs	Used to inform and/ or elicit positive responses from residents and businesses. Education and outreach can be used to inform the identified residents/ owners of the significant threat activity

	associated with their property. Incentives are used to encourage an action by means of support, usually financial.
Other: Stewardship programs, Best Management Practices, Pilot Programs and Research	Stewardship programs partner the landowner and the regulating authority which usually provides financial assistance to mitigate risks. Best Management Practices are methods or techniques found to be the most effective and practical means of achieving an objective while making the optimum use of the resources available. Pilot Programs are implemented to determine best practices. Research is the process of gathering information for the purpose of initiating, modifying or terminating a particular project.
Other: Specify Actions	Specify the actions to be taken to implement the source protection plan or to achieve the plan's objectives (i.e., includes policies that rely upon other municipal authorities such as the *Municipal Act*).

6. Policy Options

The aim of this discussion paper is to aid policy makers by providing background information on drinking water quantity threats and an assessment of the policy tools and approaches that are available. This assessment is to provide guidance on which tools may or may not apply to address existing and future drinking water threats within the Guelph-Guelph/Eramosa WHPA-Q and IPZ-Q.

The main consideration for policy development is to prevent, reduce or manage risks from consumptive use activities and recharge reduction activities. The policy options presented in **Table 6** and **Table 7** could be used to address significant drinking water quantity threats with respect to consumptive use and recharge reduction activities, respectively. These policy options were compiled by reviewing other source protection region source protection plan water quantity policies, government resources, (e.g., provincial acts and regulations).

Prohibition of an existing activity (under the CWA, Part IV, Section 57) is viewed as the strongest tool available in the "policy toolbox" for reducing risk associated with significant drinking water threats. When source protection committees consider prohibition as a tool to address activities that already exist on the landscape, they only do so after considering all other feasible options.

Examples of approved water quantity policies can be found in the: Grand River Source Protection Plan, Townships of Amaranth and East-Garafraxa, section 4-10; the CTC Source Protection Plan, section 10.13; and the South Georgian Bay Lake Simcoe Source Protection Plan, section 16.19.

Table 6: Policy options for 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

Policy Tool	Intent
Part IV Tool: Prohibition	• The policy would prohibit consumptive use in an area where prohibition is justified due to the excessive risk to drinking water supplies.
Part IV Tool: Regulation (Risk Management Plans)	• The policy would require that a Risk Management Plan be developed for consumptive use.
Part IV Tool: Restricted Land Uses	• The policy would be used in conjunction with either Part IV: Prohibition or Part IV: Risk Management Plans to act as a screening tool for development applications (planning or building) that may trigger a Part IV policy.
Prescribed Instruments	• The policy would direct the Province to review and/or include conditions in a Permit To Take Water to ensure that the municipal drinking water supply is sustainable.
Land Use Planning	• The policy would manage new development by restricting specific uses through official plans and zoning by-laws which require consumptive use or including specific criteria as part of development approvals to minimize the impact of uses that require consumptive use
Education, Outreach/Incentive Programs	• The policy would continue and/or expand water conservation outreach and develop new outreach materials to be shared across the region for both residents and businesses
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• The policy would continue and/or expand risk reduction projects (e.g., water conservation) implemented through stewardship programs; • Promote Best Management Practices, e.g., water conservation mandated as part of the Land Use Planning approvals, use of best management practices for municipal infrastructure and facilities; Promote pilot programs to assist in implementing water conservation programs for private business; • Allow for the consideration of alternative water supplies (i.e., water reuse) to assist in creating a resilient water supply system; and • Develop municipal water saving programs

Other: Specify Actions	• The policy would establish specific action(s) to help manage consumptive use, such as: ○ Province supports and funds ongoing maintenance of Tier 3 models ○ MOECC to use Tier 3 model for PTTW decisions ○ Municipality encouraged to locate additional water supplies ○ Municipality encouraged to diversify water profile through the implementation of direct potable reuse and non-potable resource opportunities ○ When implementing the new growth targets as set out within the Provincial Places to Grow Plan, municipal growth forecasts to consider incorporating Tier 3 information ○ Update or develop municipal water conservations plans and water management plans to support sustainable use

Table 7: Policy Options for an activity that reduces the recharge of an aquifer

Policy Tool	Intent
Part IV Tool: Prohibition	• The policy would prohibit development that reduces recharge of an aquifer in an area where prohibition is justified due to the excessive risk to drinking water supplies
Part IV Tool: Regulation (Risk Management Plans)	• The policy would require that a Risk Management Plan be created for developments to ensure that pre-development recharge is maintained
Part IV Tool: Restricted Land Uses	• The policy would be used in conjunction with either Part IV: Prohibition or Part IV: Risk Management Plans to act as a screening tool for development applications (planning or building) that may trigger a Part IV policy
Prescribed Instruments	• The policy would direct the Province to review and/or include conditions in Environmental Compliance Approval (ECA), e.g., for storm water infiltration projects to ensure that the municipal drinking water supply is sustainable
Land Use Planning	• The policy would manage new development by restricting specific uses through official plans and zoning by-laws which result in excessive risk to the aquifer due to reduction in recharge or including specific criteria as part of development approvals to maintain or improve recharge of the aquifer
Education, Outreach/Incentive	• The policy would continue and/or expand water recharge education initiatives and develop new

Programs	outreach materials to be shared across the region for both residents and business
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• The policy would continue or expand risk reduction projects (e.g., protection of recharge areas) implemented through stewardship programs • Promote Best Management Practices (e.g., downspout disconnect) encouraged through Land Use Planning approvals
Other: Specify Actions	• The policy would establish specific action(s) to help manage recharge reduction activities, such as: ○ Provincial/municipal growth forecasts incorporate Tier 3 information ○ Update or develop water management plans to maximize aquifer recharge ○ Province/SPA/municipalities to develop joint water resource management system to support the municipalities in developing mutually beneficial solutions to address water quantity constraints in the WHPA-Q ○ Require maintenance of stormwater management infrastructure ○ Province/municipalities to develop Low Impact Development guidelines that attempt to balance recharge opportunities with water quality risks

7. Policy Tool Review

The Project Team, with input from the Implementing Municipalities Group (IMG) and Community Liaison Group (CLG), completed a review of all the policy tools available to the Lake Erie Region Source Protection Committee (SPC) to address water quantity threats in the Guelph-Guelph/Eramosa WHPA-Q and IPZ-Q. This review, presented in Appendix C, provides details of the potential strengths and opportunities as well as potential weaknesses and challenges of the available policy tools for addressing both existing and future drinking water threats. Table 8 and Table 9 are high-level summaries of the policy tool review tables presented in Appendix C.

Table 8: Policy tool review summary for 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

Policy Tool	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Part IV Tool: Prohibition	• Can be very effective by completely removing the threat	• Impact to the water taker could be high • Difficult to justify if used

	• Potential to delineate smaller zones in a vulnerable area where prohibition could be justified	broadly across a vulnerable area and/or if Tier 3 indicates capacity for increased takings
Part IV Tool: Regulation (Risk Management Plans)	• Can be property/activity specific making it flexible • Could be applied to takings where PTTW does not apply	• Potentially high level of resources required to administer and enforce • Implementation and legal challenges (e.g. appeal to ERT) if application of RMP is not applied consistently and/or locally justified.
Part IV Tool: Restricted Land Uses	• Can manage an activity without restricting an entire land use and able to provide exemptions (e.g. residential) • Can link tool to Planning Act process and integrate into municipal development review process	• Only applies to existing land use when activity is changing or expanding • Activity may not always be flagged through a development application
Prescribed Instruments (PTTW)	• Science-based, pre-cautionary, transparent and peer-reviewed • Existing, relatively well understood regulatory framework • Broad powers to collect information and require studies • Ability to assess cumulative effects, use alongside with prioritization of use, and implement water charges • Adaptive management: ability to require review of existing PIs within a certain timeframe; and maximum 10-year PTTW period	• May not be seen as equitable as single tool as not all consumptive water takings are captured • Financial implications for property owners from new requirements • If used too frequently or harshly can be appealed to ERT and high level decision may not be appropriate for local community • Need for improved monitoring • All permits are treated the same regardless of how the water is used • Lack of control regarding how MOECC implements the instrument
Land Use Planning	• Established municipal tool; Planning Act processes are in place • Water taking can be considered a land use and	• Addresses future threats only • Appeals to the LPAT could result in this body that is not familiar with water issues making uninformed rulings

	can be regulated through land use planning • Can be tailored to specific areas with specific restrictions	that cannot be overturned • Insufficient enforcement powers • Policies may be interpreted differently across municipalities, e.g., water taking requirements for dry industrial vs wet industrial zoning • Use of land use planning tools untested to address water takings
Education, Outreach/Incentive Programs	• Increases landowner awareness and community engagement • Can be effectively applied by using in combination with other tools	• Public understanding of water quantity is poor • Time and cost to implement program could be high • No guarantee the threat will be managed
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• Reduction in financial burden for the applicant • Opportunity to reach residents/businesses where water conservation programs are not currently implemented or at capacity • Can motivate changes in behaviour with little cost to municipality compared to cost of producing water and maintaining or expanding infrastructure	• May not be sufficient to address threats on its own • Continuous funding required • Effectiveness relies on property owner participation • Costs for pilot projects may outweigh benefits • Difficult to ensure compliance
Other: Specify Actions	• Tool is flexible • Can require specific action and provides options for local situations • Could increase engagement from non-municipal water takers	• Implementation cost could be high and coordination could be challenging if multiple parties involved

Table 9: Policy tool review summary for an activity that reduces the recharge of an aquifer

Policy Tool	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Part IV Tool: Prohibition	• Can be very effective by completely removing the threat • Potential to delineate smaller zones in a vulnerable area where prohibition could be justified	• Impact to the property owner could be high • Difficult to implement retroactively under existing conditions • Difficult to justify if used broadly across a vulnerable area
Part IV Tool: Regulation (Risk Management Plans)	• Can be property/activity specific making it flexible • Ability to include monitoring program and measure implementation success • Can be used for multi-residential properties	• Potentially high level of resources required to administer and enforce • Monitoring required to ensure actions sustained over the long term, i.e., operation and maintenance of green infrastructure
Part IV Tool: Restricted Land Uses	• Can manage an activity without restricting an entire land use, i.e. able to provide exemptions • Could be useful for areas identified through the planning process, e.g., greenfield • Can link tool to Planning Act process and integrate into municipal development review process	• Only applies to existing land use when activity is changing or expanding • Land uses named in the policy must match the names that appear in local official plans or zoning bylaws
Prescribed Instruments (ECA)	• Science-based, pre-cautionary, transparent and peer-reviewed • Potential to collect new data though monitoring conditions	• Staff resources for administration and enforcement may be high • Financial implications for property owners from new requirements may be high
Land Use Planning	• Can be tailored to specific areas with specific restrictions • Could strengthen pre/post development water balance	• Addresses future threats only • Appeals to the LPAT could result in this body that is not familiar with water issues making uninformed rulings

	• Land use plans could be updated using update recharge information on a regular basis	that cannot be overturned • Push for growth areas does not currently consider recharge needs • Unclear where land use would apply to recharge
Education, Outreach/Incentive Programs	• Increases landowner awareness and community engagement • Can encourage effective Best Management Practices • Retrofits could reverse, i.e. increase recharge in built up areas	• Time and cost to implement program could be high • Adding retrofits more difficult after development • Increased recharge in all areas may not be appropriate and justified
Other: Stewardship programs, Best Management Practices (BMPs), Pilot Programs and Research	• Reduction in financial burden for the applicant • Could prove useful and effective when combined with other tools • Fills data gaps • Can support other tools	• May not be sufficient to address threats on its own • Continuous funding required • Effectives relies on voluntary participation; costs may outweigh benefits • Difficult to ensure compliance
Other: Specify Actions	• Tool is flexible • Can require specific action and provides options for local situations	• Implementation cost could be high and coordination could be challenging if multiple parties involved

8. Promising Policy Tools

In developing this Discussion Paper and through the review of possible policy tools and approaches to address consumptive water taking and recharge reduction activities, certain policy tools have been identified as promising, meriting further discussion to achieve the objectives of the Source Protection Plan.

The objectives, for reference, are that a) any proposed water taking or recharge reduction activity never becomes a significant threat, and b) any existing activity ceases to be a significant drinking water threat.

The promising policy tools described below are not an exhaustive list and do not limit the Project Team from selecting other tools to develop policies. Other tools also have potential applicability and tools may be used in combination to complement each other. All policy tools will be considered by the Project Team throughout the policy development process.

Threat 19: Consumptive Water Use

Addressing consumptive use water takings that are identified as a significant drinking water threat could be achieved through the use of Prescribed Instruments, specifically the PTTW program. Where a PTTW already exists, policies may be developed to direct the Province to review, and amend or revoke existing permits and require that additional terms and conditions are added to ensure that the municipality's existing and future water supply is sustainable. New or increased takings subject to the PTTW process could also include similar terms and conditions. The MOECC could use the Tier 3 model results or the model itself to make PTTW decisions and adaptively manage permits as the model is updated and permits and permit applications are reviewed or assessed for approval. In some areas it may be appropriate to not issue new PTTWs so as to not create a new significant drinking water threat or revoke an existing PTTW to reduce the number of threats. This may be possible in areas with municipal water servicing.

The MOECC already has authority to not approve, amend, or revoke PTTW. However, using the PTTW as a prohibition tool would only be considered after all other feasible management options have been assessed as being insufficient in protecting the municipalities' drinking water supply. The Ministry could consider a phased approach for some takings with the requirement for appropriate monitoring and information-sharing to assess impacts before the permit is fully approved.

Where consumptive water takings may not be able to be adequately addressed by Prescribed Instruments (e.g., takings that are exempt from the PTTW process), the Part IV tools (i.e., Prohibition, Risk Management Plans, together with Restricted Use) may be an option to meet the source protection plan objectives. The Part IV tools may be applicable in an area around existing or planned municipal wells or in areas where municipal water supply systems are available or elsewhere in the WHPA-Q where activities are exempted from the Prescribed Instrument.

Municipal land use planning policies could be considered a tool to address consumptive water use activities. However, land use planning tools are untested as a means to address water takings. Consumptive water use and availability could be considered by the Province when allocating growth through provincial planning tools such as the Growth Plan, particularly where municipal comprehensive reviews and expansion of urban boundaries may be required as a result of growth forecasts and targets set out by the Province. In the implementation of the Growth Plan population and employment targets, municipalities could consider the Tier 3 information as a component of the Official Plan update process.

Additional policies addressing water consumption could also be addressed through policy within Official Plans, e.g., specific restrictions in certain areas of the municipality or by the type of development and/or water taking. The need for additional

restrictiveness of the land use policies may vary depending on existing municipal land use policies and the geographic setting of the vulnerable areas. For example, the policy may include a list of the types of hydrological or hydrogeological studies required as part of a complete application for development proposals. Municipalities could establish Official Plan policies to provide direction as to which circumstances for development applications that required high water use would be considered. Policies could also provide direction on the types of land uses that are not permitted within the community due to consumptive water use concerns. Municipalities may also include policies requiring all new development to be directed to settlement areas on full municipal services to help manage water consumptive use and consistency with municipal water supply master plans, if applicable.

Policies could also be written for municipalities to incorporate the long term sustainability of the municipal water supply into their decisions about water services when approving growth and development. This could be achieved by requiring an approved PTTW where the MOECC has determined that the proposed taking does not become a significant drinking water quantity threat.

The specify action tool could also be valuable in addressing existing and future consumptive use activities through the development of locally-specific policies. For example, policies could focus on:

- ensuring that municipal water management plans and/or water conservation plans are developed or updated;
- developing joint water resource management systems to provide collaboration and cooperation between the province, Source Protection Authority and municipalities to manage local water resources to protect drinking water sources;
- that Tier 3 information is used in making informed decisions and that Tier 3 models are provincially funded and maintained on an ongoing basis; and
- ensuring that existing and future municipal water demands are met before allocating water to other users in the WHPA-Q and IPZ-Q. This would mean shifting to a “priority of use” concept instead of the current “first in time, first in right” approach.

Threat 20: Recharge Reduction

Perhaps the most effective tools to address recharge reduction threats are municipal land use planning policies and implementation of best management practices as part of updated municipal practices and development approval requirements. Policies could be developed to require the local planning authority to manage new developments by including criteria for approval that ensure the proposed activity does not become a significant drinking water threat. The restrictiveness of the policies may vary depending on existing municipal land use policies and the geographic setting of the vulnerable area. For example, policies could be specific by directing municipalities to require new

development for lands to implement best management practices (BMPs) to maintain predevelopment recharge.

Recharge reduction activities could also be addressed through Prescribed Instrument policies, specifically Environmental Compliance Approvals (ECA) such as sewage works projects being used for low-impact development, storm water ponds, etc.

Softer tools such as education and outreach and incentive programs can be used to promote source protection policies in general and focus on promoting BMPs, as well as low impact development (LID) in specific areas where feasible. Outreach programs could target specific sectors in the vulnerable area.

Policy Legal Effect

As defined in the CWA, the Source Protection Plan policies will have to identify who will be responsible for implementation. The legal effect describes whether there is an obligation for the responsible party to implement the policy. The Legal Effect Policy Matrix as presented in Appendix D outlines the obligations of provincial, municipal, local board, source protection authority or other body to implement a policy using a specific tool. For example, for the “softer” tools (i.e., education and outreach) a policy could direct a municipality to comply with the policy where a Provincial Ministry would only have to adhere to the policy.

9. Next Steps

Lake Erie Source Protection Region is committed to a collaborative process working with municipalities and stakeholders during water quantity policy development. After completion of the discussion paper and release by the Lake Erie Region Source Protection Committee (anticipated in June 2018), policy approaches will be drafted by the Guelph-Guelph/Eramosa Water Quantity Policy Development Study Project Team with feedback and support from the Implementing Municipalities Group (IMG) and Community Liaison Group (CLG). Municipalities will be able to identify policy options that best suit their needs based on specific circumstances and resources available. The drafting of water quantity policies is expected to occur in the fall 2018.

Draft policy options developed by the Project Team with support from the IMG and CLG are expected to be presented to the Lake Erie Source Protection Committee (SPC) in the fall 2018. The SPC has the decision making authority regarding the policies to be included in the Source Protection Plan, and with direction from the SPC, Lake Erie Region staff will incorporate the water quantity policies into an updated Grand River Source Protection Plan. Formal public consultation is a mandatory component prior to the updated plan being submitted to the MOECC for review and approval and is

expected to occur in the spring 2019. Municipalities affected by the plan updates will be asked to endorse the plan amendments prior to formal public consultation.

Appendix A

Guelph-Guelph/ Eramosa WHPA-Q and IPZ-Q

Location of Identified Water Quantity Threat

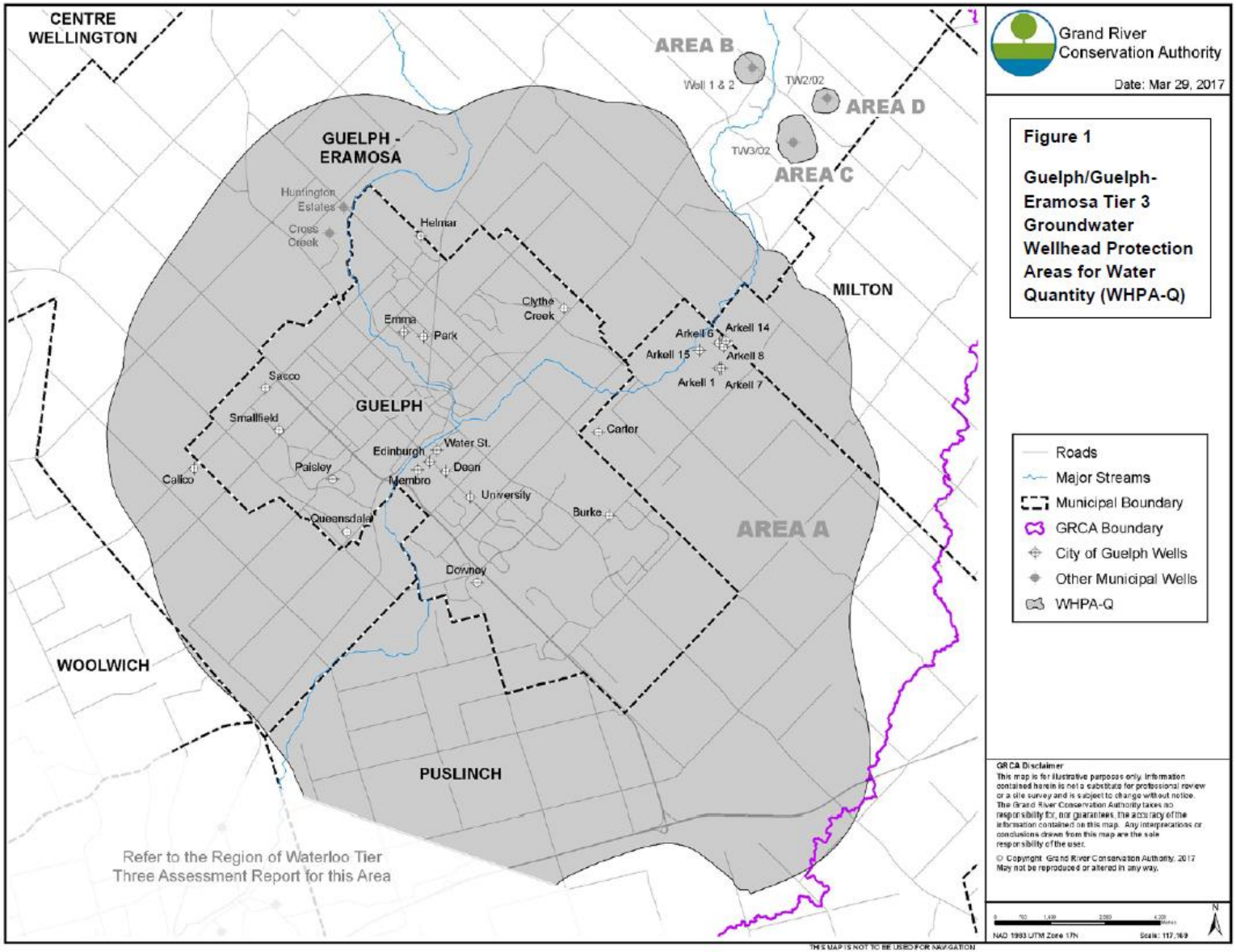

Figure 1: Guelph-Guelph/ Eramosa Tier 3 Wellhead Protection Area A Water Quantity (WHPA-Q)

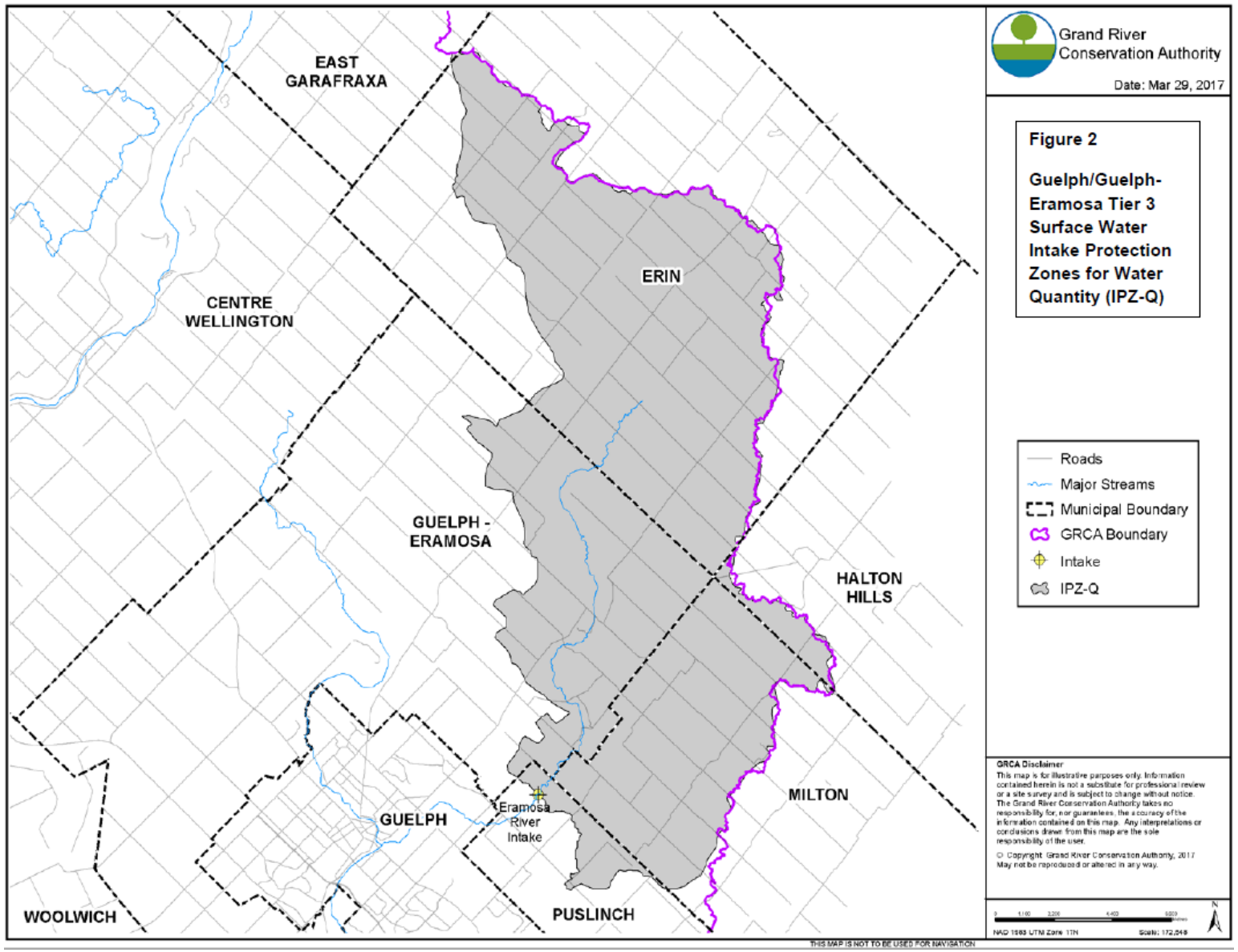

Figure 2: Guelph-Guelph/ Eramosa Tier 3 Intake Protection Zone Water Quantity (IPZ-Q)

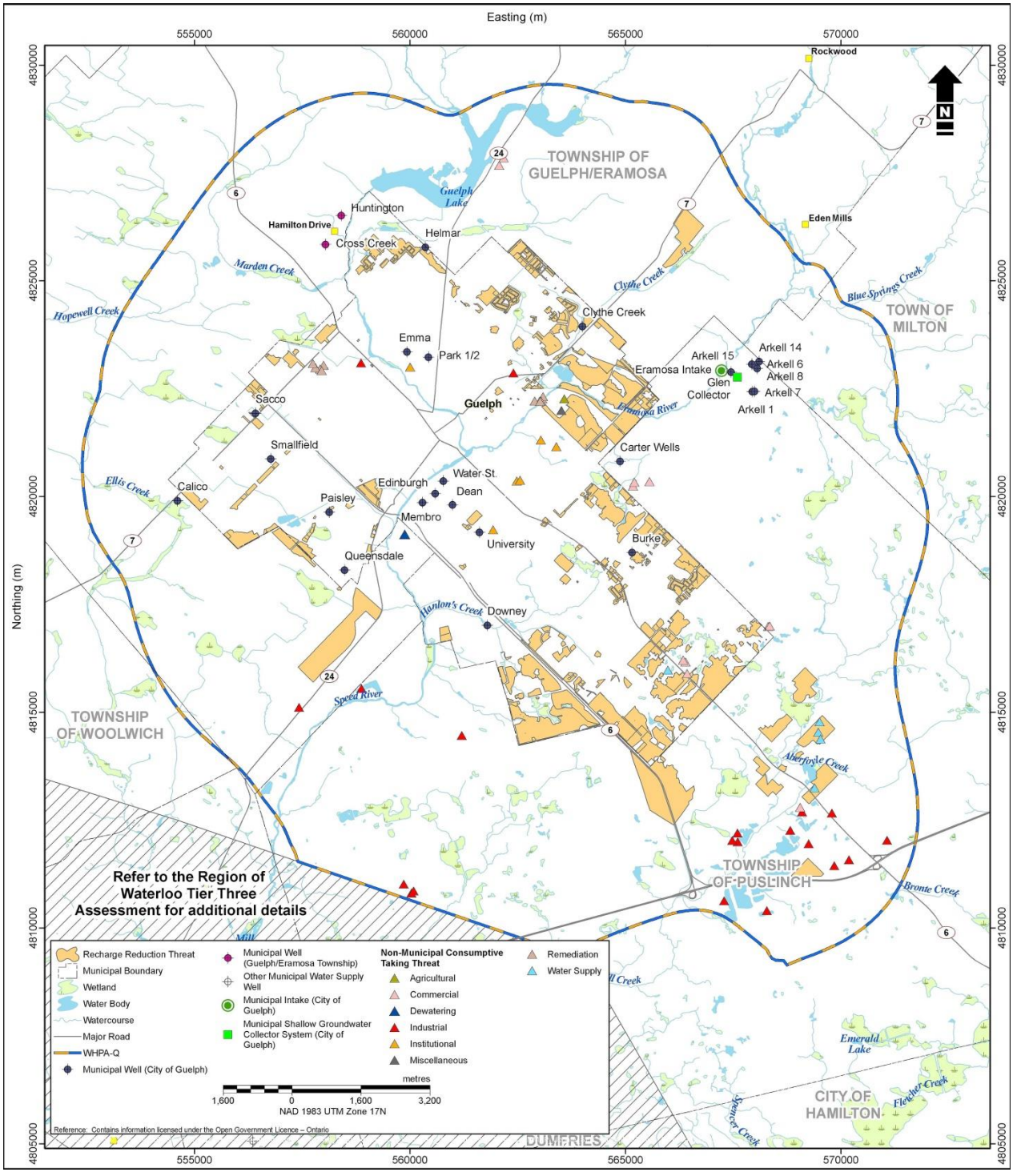

Figure 3: Guelph-Guelph/ Eramosa Tier 3 Wellhead Protection Area A Water Quantity (WHPA-Q) Threats

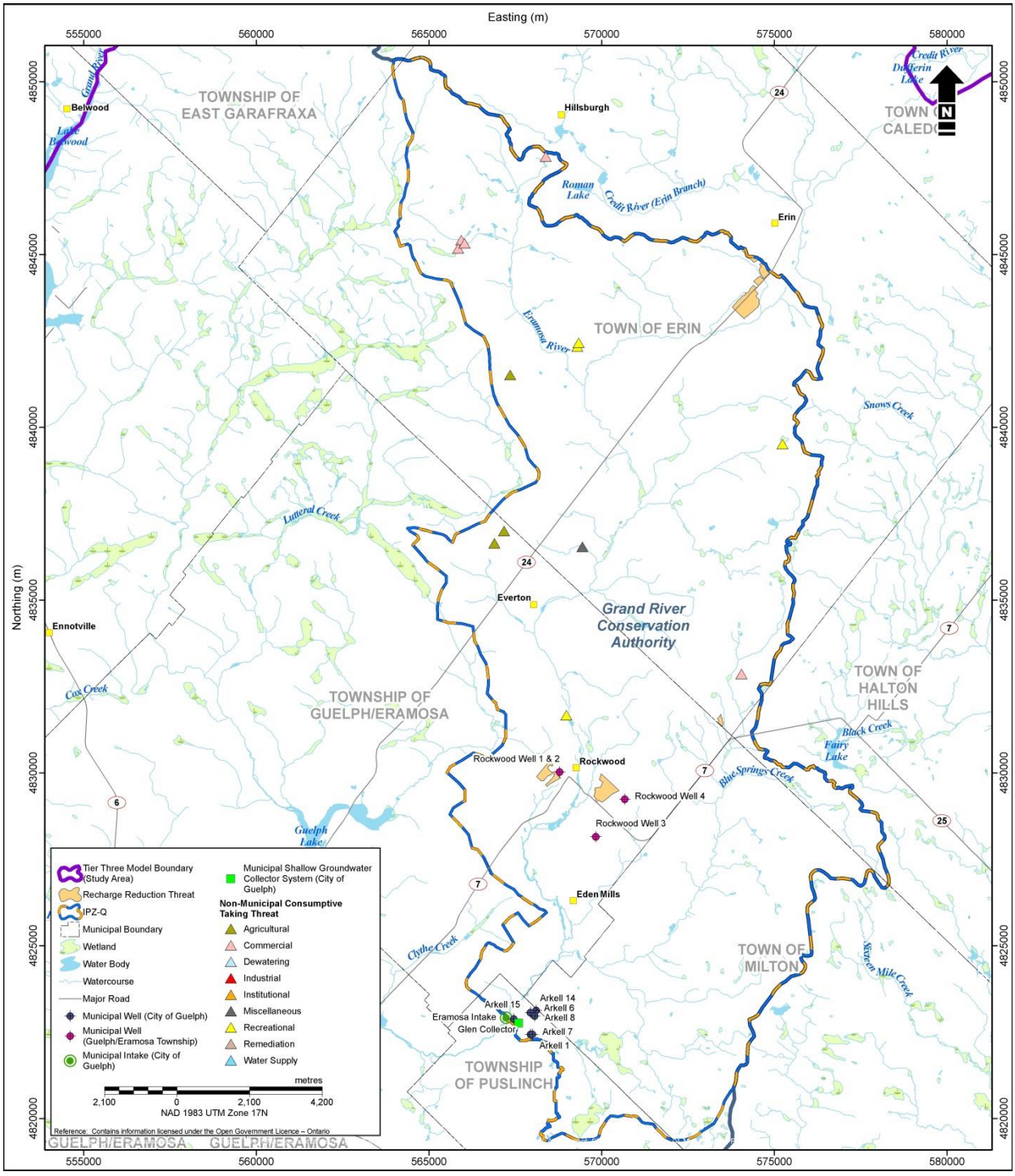

Figure 4: Guelph-Guelph/ Eramosa Tier 3 Intake Protection Zone Water Quantity (IPZ-Q) Threats

Appendix B

Existing Legislation, Policies and Other Programs

The following legislation, policies and programs are in place to address consumptive water taking activities and recharge reduction.

Federal

This section has been included to provide context for water management in Canada. Water management in Canada is a joint responsibility of indigenous peoples, federal and provincial governments, municipalities, conservation authorities, and all water users. Aboriginal rights and treaty rights, including certain customs and practices, became constitutionally protected in 1982; and these rights may take priority over all other uses. Canada's approach to water law varies significantly from province to province, but has a basis in English common law. The *Constitution Act, 1867* (& *Constitution Act, 1982*) lays out the split in responsibilities with respect to water resources between the federal and provincial governments.

Great Lakes Water Quality Agreement (GLWQA)
The GLWQA includes annexes on groundwater and climate change that speak to increasing understanding of groundwater resources, and coordinating with water quantity management actions taken by the International Joint Commission (IJC).

Canadian Environmental Assessment Act
This Act focuses on potential adverse environmental effects that are within federal jurisdiction.

Federal Water Policy (1987)
The policy encourages the management and use of freshwater in a wise, efficient, and equitable manner consistent with the social, economic, and environmental needs of present and future generations.

International Boundary Water Treaty Act and International River Improvement Act
The federal government is responsible for waters that have inter-provincial or international boundary considerations. Two main federal acts regulate use of waters along the Canada-United States (US) border: the International Boundary Waters Treaty Act and the International River Improvement Act. Within Canada, a number of inter-jurisdictional water boards have been established to focus on specific water issues that have implications for more than one province or territory.

Fisheries Act
This Act is the principal federal statute conserving and protecting Canadian fisheries resources.

Species at Risk Act
This Act works on protecting and saving indigenous Canadian species and distinct populations from becoming extirpated or extinct.

Navigation Protection Act
This Act prohibits the dewatering of any navigable water.

Provincial

Ontario Water Resources Act, 1990
To protect the sustainability of the Province of Ontario's water resources, the Ontario Water Resources Act requires those taking greater than 50,000 litres per day to obtain a Permit to Take Water (PTTW) with exceptions for residential use, livestock watering, frost protection and firefighting (less than 379,000 litres per day). No permit can be issued for more than ten years.

The purpose of the Permit to Take Water (PTTW) program is to ensure the conservation, protection and wise use and management of the waters of the province. The chief considerations in the review of PTTW applications are the potential for impacts to other users and the natural and built environment. There are currently 23 municipal residential PTTWs in the Guelph-Guelph/Eramosa Tier 3 WHPA-Q .

Clean Water Act, 2006
The *Clean Water Act, 2006* enables the protection of existing and future sources of municipal drinking water through source protection plans, which contain policies to address activities identified as threats to municipal drinking water sources. The Act identifies two threats to water quantity: an activity that reduces the recharge of an aquifer, and 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. Under this Act, PTTWs are provincial prescribed instruments that can be used to manage activities that take water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body. There is no provincial instrument prescribed under this Act that is available to be used in source protection plan policies to address recharge reduction.

Additionally, where a Wellhead Protection Area (WHPA)-Q has been assigned a significant water quantity risk level, the Risk Management Measures Catalogue can be used as part of a RMMEP to help select and evaluate preferred measures to manage water quantity threats and inform the policy development process. A variety of tools are available under the Act to address water taking and recharge reduction, including Part IV tools, prescribed instruments (water taking only), land use planning, incentives, and education and outreach (see section 4).

Planning Act, 1990

Requires that the Minister of Municipal Affairs, Ontario Municipal Board and other planning bodies across Ontario have regard to various matters of provincial interest, including but not limited to the protection of ecological systems, conservation and management of natural resources, and the efficient use and conservation of energy and water. The Act provides for and supports the control of land use and development throughout Ontario. The Provincial Policy Statement, 2014 (PPS), which is issued under section 3 of the Planning Act, applies province-wide. Its policies set out the government's land use vision for how land and resources are managed, and all decisions affecting land use planning matters "shall be consistent with" the PPS. The PPS requires wise use and management of resources, including water.

The Act requires that planning authorities (e.g. municipalities) ensure the long-term protection of natural heritage and water resource systems, as well as the conservation and management of natural resources, and the efficient use and conservation of energy and water. Under the Provincial Policy Statement (PPS), planning authorities are required to protect, improve or restore the quality and quantity of water and designated hydrologic functions or features; plan efficient and sustainable water use; and use water conservation practices. Municipalities use the PPS to develop their official plans and to guide and inform decisions on other planning matters. Using the Planning Act, municipalities control planning and development through a variety of tools

Places to Grow Act, 2005

Growth Plan for the Greater Golden Horseshoe, 2017

Mandates population and employment forecasts which must be conformed to as part of the next municipal comprehensive review process. The Places to Grown plan is about accommodating forecasted growth in complete communities. The Plan contains specific targets (e.g., greenfield densities, residential intensification, affordable housing) for growth and implementing policies to ensure that the growth forecasts and complete community objectives are achieved. In Wellington County, approved local allocations of the County forecast that is contained in the Places to Grow plan is included in the County Official Plan (OP). As the growth forecasts are mandated by the Province and must be conformed with, the decision to not accommodate growth to manage the risk associated with this threat is not an option. The Plan contains specific policies regarding planning for new and expanded infrastructure, including municipal water systems. These water system-related policies provide direction for the protection, conservation, enhancement and restoration of quality and quantity of water within a watershed. Specific water resources policies relate directly to recharge in Significant Groundwater Recharge Areas (SGRA) and Highly Vulnerable Areas (HVA) in the Assessment Reports to which planning decisions must conform and which have been in effect since July 1, 2017. A Natural Heritage System has been issued under the Places to Grow

plan for which there are policy directions that indirectly relate to protection of cold water streams that are also the subject of the Tier 3 Assessment work. The Places to Grow plan also includes climate change policies.

Municipal Act, 2001

Provides municipalities with broad powers to provide “any service or thing that the municipality considers necessary or desirable for the public” and they have broad powers to pass by-laws concerning the “economic, social and environmental well-being of the municipality” and the “health, safety and well-being of persons” as long as they do not frustrate provincial acts and regulations. Municipalities have powers to regulate tree cutting and site alteration which can affect the control of recharge, they can also use offer programs that encourage or incentivize recharge. The City of Guelph regulates tree cutting and site alteration through the development approval process and through related supporting by-laws.

Building Code Act, 1992

Objectives of the Building Code include limiting the probability that the design or construction of buildings, or supporting infrastructure will cause a resource to be exposed to unacceptable risk of depletion. A number of changes regarding water conservation/reuse where made in 2014 that promote water efficiency.

Ontario Environmental Assessment Act, 1990

Provides for the protection, conservation and wise management of the environment, generally requiring an environmental assessment of any major public or designated private undertaking. Common and/or important issues identified in Environmental Assessments related to water projects include fish and fish habitat, water levels and flows, and competing or complementary interests of nearby land owners, water-resource users and water-related natural resource users.

The Act also establishes a “Class Environmental Assessment” process for planning certain municipal projects. For water projects, the purpose of the municipal class environmental assessment is to ensure that projects will be "undertaken to address problems affecting the operation and efficiency of existing water systems, to accommodate future growth of communities, or to address water source contamination problems". Relating to source water protection, once an Environmental Assessment is complete for a planned municipal water supply source, the well/intake is defined as a “planned source” under the *Clean Water Act, 2006*; meaning it must be included in the Assessment Report and Source Protection Plans.

Ontario Low Water Response (OLWR)

This program is a mitigation strategy, intended to reduce the effects of low water or drought periods. Under OLWR, watershed-based water response teams (WRT)

coordinate local activities, with these teams consisting of local water users and local and provincial water managers.

Environmental Protection Act, 1990
This Act is the primary pollution control legislation in Ontario. Under Part II.2 of the Act – Water Taking Regulation (O. Reg. 63/16) under the Environmental Protection Act, a registration process has been established for certain lower risk water takings through the Environmental Activity and Sector Registry (EASR). These include takings for construction site dewatering or road construction purposes.

Water Opportunities and Water Conservation Act, 2010
The Lieutenant Governor in Council may, by regulation, require public agencies to prepare water conservation plans. These plans will allow the Minister of the Environment and Climate Change to require municipalities to develop water conservation plans. Further the Minister can establish performance indicators and targets for municipal water, wastewater and stormwater services and operations.

Conservation Authorities Act, 1990
Allows the formation of Conservation Authorities by municipalities, in order to protect and manage natural resources, other than gas, oil, coal and minerals, on a watershed scale. The Act enables conservation authorities to regulate activities that may interfere with a watercourse or wetland, and regulate development in areas prone to water-related hazards (floodplains, shorelines) for impacts to the control of flooding, erosion, dynamic beaches, pollution or conservation of land.

Endangered Species Act, 2007
Works to protect and save species at risk and their habitat in Ontario. Consumptive water taking and recharge reduction activities that damage or destroy such habitat may be prohibited under this Act.

Public Lands Act, 1990
Authorizes the Ministry of Natural Resources and Forestry to acquire land for their purposes while also guiding disposition of Crown land resources via a permitting process (e.g., peat, vegetation removal, etc.).

Conservation Land Act, 1990
Authorizes private land owners to grant easements or enter into a covenant with one or more conservation bodies for the protection of water quality and quantity, including protection of drinking water sources and for watershed protection and management.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
OMAFRA supports programs for the agricultural sector that assist in maintaining potable water supplies, supporting the use of efficient irrigation and drainage methods.

OMAFRA also works with Agriculture and Agri-Food Canada on the Environmental Farm Plan (EFP) program, which is delivered by the Ontario Soil and Crop Association.

Environmental Bill of Rights, 1993 and Environmental Registry
Serves to notify the public of important environmental decisions and to solicit public comment. Through the EBR, the public has the right to request reviews of inadequate laws, regulations, policies or instruments as well as to comment on proposed legislation and regulations.

Provincial Water Quality Objectives, 1994
The Ontario Ministry of Environment and Energy issued the Provincial Water Quality Objectives in 1994, which gives direction on the management of the province's water resources. The inter-relationship of and between surface and ground water quality and quantity is to be recognized in water management decision making processes. The guidelines speak to water quantity management principles including: avoiding interference between users, water conservation, and protection of significant infiltration areas.

Lakes and Rivers Improvement Act, 1990
Regulates the public and private use of Ontario's lakes and rivers, and the land under them, including for the construction, repair and use of dams. It empowers the Ministry of Natural Resources (MNRF) to regulate the construction and operation of water works, and requires that new water works be approved.

Drainage Act, 1990
Allows for the construction of drains to serve as a communal drainage system for an area of landowners.

Tile Drainage Act and Tile Drainage Installation Act, 1990
Both acts enable improvement of agricultural land productivity via drainage systems. While drainage may allow for increased surface recharge, it can also lessen the amount of water available for taking, through drainage of surface and groundwater.

Great Lakes Strategy, 2012
Lays out a vision for drinkable, swimmable and fishable Great Lakes.

Great Lakes Protection Act, 2015
Reflects the goals and principles of the Strategy. The Act supports: economic opportunities and innovation through environmentally sustainable use of natural resources; and allows public bodies to target actions on priority issues and problem areas through the Great Lakes Guardian Community Fund.

Assessment Act, 1990
The Assessment Act sets out eligibility criteria for lands that can receive property tax exemptions under the Conservation Land Tax Incentive Program (CLTIP) and the Managed Forest Tax Incentive Program (MFTIP). Under the CLTIP, provincially significant conservation lands, such as wetlands and community conservation lands, are eligible for property tax relief.

Municipal

At the local level, municipalities and local bodies such as conservation authorities also have discrete water management responsibilities, many which have been mandated or delegated to them by the province, such as through the Municipal Act, Planning Act, regional planning initiatives, *Clean Water Act, 2006*, *Building Code Act*, and *Conservation Authorities Act.* Other initiatives and programs undertaken at local levels can include: integrated watershed management, watershed planning, local drought contingency projects and planning, and stewardship and education/outreach initiatives.

City of Guelph

Water Efficiency Strategy Update, 2016
Includes a number of programs, initiatives and strategies, that work together to help protect the City's water supply by reducing water demand on a daily basis to ensure that water is available for future use and meet the targets of the 2014 Water Supply Master Plan. From 2006 to 2014, the City's water efficiency programs have reduced demands by about 6.6 million litres per day with about 42 percent of this savings (2.8 million litres per day) attributable to the City's water loss reduction program.

Water Supply Master Plan, Updated in 2014
The Water Supply Master Plan aims to ensure the long-term water supply capacity to allow for growth within the City of Guelph. The Plan evaluated water needs associated with community growth over a 25-year planning period and identified a series of preferred water supply projects to meet the City's future community water supply requirements. Through this detailed Master Plan, water capacity reclaimed through water conservation and efficiency was identified as the most cost–effective and immediate source of available water supply. While the City's overall water demands will continue to increase because of the growing population, per capita demands are projected to decline on an annual basis due to effective water conservation programming and changes to the building code.

Water and Wastewater Servicing Master Plan, 2008
The Plan identifies preferred servicing strategies and related system improvements for water distribution/ storage and wastewater conveyance and identifies the need for the

development of a water distribution hydraulic model to assist water loss management. The Plan assesses each system to enhance reliability, efficiency and capability to service existing and new city residents. Additional recommendations included a study of a large scale wastewater reuse initiative. The 2009 Wastewater Treatment Master Plan identified water conservation initiatives as a key component of the master plan and as a non-expansion, source control alternative.

Stormwater Management Master Plan

To satisfy the first phases of an Environmental Assessment and to create a framework for the future development, the City of Guelph has prepared a Master Plan for stormwater management. The Stormwater Management Master Plan is a long-term plan for the safe and effective management of stormwater runoff from existing urban areas, while improving the ecosystem health and ecological sustainability of the Eramosa and Speed Rivers and their tributaries. The Plan's overall objective is to integrate flood control and stormwater drainage with opportunities to improve and protect groundwater and surface water quality and the natural environment. Three key areas are addressed in the plan. These include management of stormwater runoff as it related to aquifer recharge, low impact development to increase the efficient use of outdoor water and water sensitive urban design to minimize impacts to water quality.

Urban Forest Management Plan, 2012

Ensures a healthy urban forest which cleans air, conserves energy, decreases water use, increases property values and makes Guelph's neighbourhoods more beautiful and enjoyable.

Official Plan

Establishes a statement of goals, objectives and policies for growth and development for the next 20 years. The Official Plan is focused on sustainability and establishes policies that have a positive effect on the social, economic, cultural and natural environment of the city. It includes policies for the protection of water resources including the City's drinking water sources, as well as, surface water and groundwater features.

The City of Guelph has current Official Plan policies recognizing the entire City as a recharge area. For newly developing communities, a secondary plan process is undertaken by the City, as is currently underway for the Clair Maltby Area. This secondary plan process includes an assessment of infrastructure including stormwater to inform the policies for development within the area.

Natural Heritage Action Plan

Looking at potential opportunities for review and update of existing subwatershed plans. As part of development approvals, the City requires pre to post water balance on site as

the minimum stormwater management criteria unless subwatershed studies provided alternative targets. For any development applications which are proximate or within the Natural Heritage System, an environmental impact study is required. “Sensitive ground water features” identified to date include those areas to support recharge/discharge as identified through subwatershed studies relating to streams and wetlands or significant landform as set out within the Natural Heritage System.

Outside Water Use Program

The Outside Water Use Program (OWUP) was created in 2002 in response to the Ontario Low Water Response Plan. The OWUP program objectives are to conserve Guelph’s groundwater supply and protect against the impact of drought during the hot, dry summer months. The Program has three levels that affect residential outside water use. These levels are triggered by dry weather and local watershed conditions, and range from every other day lawn watering (level blue and yellow) to banning of lawn watering during drought conditions (level red) along with other water uses. A large education and outreach component of this program is the Healthy Landscapes Program. This program provides a method in which the City can communicate with water customers about their outdoor water use while showing them how to improve their landscaping to ensure it is water efficient and suitable for the City’s climate and soil conditions. This includes the promotion of trees to assist with the urban tree cover, the planting of non-invasive plants and best irrigation practices. Further, the program forges relationships with the community and local businesses.

Water Conservation Program

The City has undertaken and implementation an extensive water conservation program as outlined in the Water Efficiency Strategy. The program has achieved a benefit of approximately $2.70 for each dollar they spent on their water efficiency programming between 2006 and 2014. While the potential to save money by deferring or downsizing infrastructure expansion projects is often one of the primary drivers for communities to implement water efficiency programs, there are also many other co-benefits to municipalities such as reducing operational costs (i.e., energy costs) and greenhouse gas emissions.

The City’s water conservation program is also considered in the MOECC’s application review process for a new or renewed PTTW. Not maintaining a robust conservation program could jeopardize the City of Guelph’s ability to obtain new water supplies. Furthermore, if the PTTW is approved, the City of Guelph conservation programs become a regulatory requirement of the PTTW upon issuance. Any revisions to current conservation programs will need to be incorporated in renewals to PTTWs in ensure ongoing compliance.

Incentive Programs

The City of Guelph offers a number of incentive programs for residential, multi-residential, industrial, commercial and institutional sectors as outlined in the Water Efficiency Strategy. Examples of incentive programs include: the Royal Flush Rebate Program, Water Efficient Landscaping Incentives, Multi-residential Audit Program and Sub-metering programs, Industrial, Commercial, and Institutional Capacity Buyback Program and, the Water Loss Management Program. Additionally, the City of Guelph have developed a credit program for industrial, commercial, institutional (ICI) and multi-residential properties of six units or more where land owners who reduce stormwater runoff on private property can obtain a credit towards the stormwater service fee they are required to pay as outlined in the Stormwater Master Plan.

Municipal Facility Upgrades Program

The City will continue to make water saving upgrades in City buildings and conduct pilot and research projects within municipal facilities (e.g., rainwater harvesting and wastewater reuse). Funding and program details are provided in the Water Efficiency Strategy.

Water Loss Management Program

The Program's goal is to achieve and maintain distribution system leakage at the lowest economically viable level. The City utilizes District Metered Areas and a leak detection program (sounding and correlation of water mains) where possible to manage system leakage. The City will continue its current leak detection and sounding programs and it has commissioned an additional 20 district metered areas between the years of 2016-2018, bringing the total number to 27.

Public Outreach/Education Programs

The City provides public education programs/activities to support and facilitate a number of program initiatives as outlined in the Water Efficiency Strategy. These include the Mobile Water Engagement Application which allows users to track their water consumption data, school presentations, and the Outdoor Water Use Program which ensures community members are aware of the summer outdoor water use by-law and how they can reduce their outdoor water use.

Research

There are a number of ongoing and planned studies the City is engaged in related to water management and conservation. A few examples of these studies include: Distribution System Pressure Management, Water Conservation and Rebound Effects, Water Softener Pilot, Automated Meter Reading and, Municipal Upgrades Best Practices.

Wellington County

Official Plan

Section 4.9 of the Wellington County Official Plan pertains to Water Resources and includes policies on watershed planning, surface and groundwater protection, source water protection and specific policies on the protection of the Paris and Galt Moraine. The Wellington County Official Plan has been amended to conform with all five Source Protection Plans in the County. The County Official Plan serves as the local Official Plan for the Townships of Guelph/Eramosa and Puslinch. The Paris and Galt Moraine is protected through Policy Area policies in Section 4.9.7 and shown on Schedules B-2, 3 and 7.

Township of Puslinch

Municipal Servicing Feasibility Study

In 2017, the Township of Puslinch initiated a feasibility study for municipal servicing (water and wastewater) within the GGET Tier 3 study area. More information can be found at www.puslinch.ca as the study is ongoing.

Puslinch Groundwater Monitoring Network

The Township has been measuring sixteen groundwater monitoring wells for quality and quantity since 1994. These wells provide ambient groundwater conditions unassociated with development within the Township. The groundwater monitoring network includes overburden wells completed in the Paris Moraine, Galt Moraine and the Aberfoyle Outwash deposits. The network also includes wells drilled into the Guelph and Gasport bedrock aquifers. The results of the monitoring can be found at www.hardenv.com\mill_creek.html.

The monitoring program provides the Township of Puslinch with quarterly groundwater levels and annual groundwater quality and is used to evaluate impacts from major water takings in the Township including that from the City of Cambridge and the City of Guelph.

Guelph/Eramosa Township

Water Conservation

The Township of Guelph/Eramosa municipal water system has a water supply that relies heavily upon the use of groundwater. As a result, the Township has established outside water use restrictions to balance demand with the available water supply. Restrictions are in place for residents using the Municipal Water Supply. The Township also operates a toilet rebate program for Rockwood residents that upgrade their toilets to approved high efficiency (3.0L and 4.8L) and dual flush (3/4.8L or 3/6L) models.

Other Programs

Integrated Watershed Management (IWM)

Establishes a process of managing human activities and natural resources in an area defined by watershed boundaries. It is an evolving and continuous process through which decisions are made for the sustainable use, development, restoration and protection of ecosystem features, functions and linkages. While yet to be formally adopted in Ontario, it is firmly established in the initiatives of conservation authorities and within the limited scope of drinking water source protection planning.

Appendix C

Policy Tool Review Tables

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Part IV: Prohibition	Prohibit consumptive water takings	• Removes threat completely • Very effective • Potential to delineate smaller zones within vulnerable areas where prohibition may be justified • Prohibit and move existing takings to the municipal system where municipal water services are available	• Difficult to justify when used broadly across vulnerable areas • Province may not support prohibition for existing takings • Restricts all water takings • Impact to water taker high	• Combine with Part IV Restricted Land Use • Consider where municipal water services are available • Potential to delineate smaller zones within vulnerable areas where prohibition may be justified • Consider using other vulnerable area boundaries or screening tool (e.g., SGRA) to delineate smaller zones	• Difficulty justifying prohibition when Tier 3 results indicate capacity for increased takings • Public acceptance for WHPA-Q-wide prohibition may be low • The science is well-founded and precautionary but there is some uncertainty incorporated into the assessment
Part IV: Risk Management Plans (RMP)	Require a RMP that manages consumptive water takings	• Could apply to water takings where there is a PTTW exemption • Property specific and flexible	• Potentially high level of resources required for administration and enforcement • Potential for public	• Combine with Part IV Restricted Land Use • Could apply to water takings where there is a	• If too broadly applied may impair economic development • Potentially high level of resources

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		• Addresses specific activity • Opportunity to apply municipal water conservation programs through RMPs	or stakeholder opposition as there are current exemptions to PTTW • Implementation and legal challenges (e.g., appeals to Environmental Review Tribunal (ERT) if application of RMP is not consistent and/or locally justified.	PTTW exemption • Could be applied to smaller takings, i.e. below PTTW threshold • Terms and conditions in RMP could ensure monitoring data is submitted to municipalities or to confirm water taking is below exemption threshold	required for administration and enforcement
Part IV: Restricted Land Use	Used in conjunction with either Part IV: Prohibition or Part IV: Risk Management Plans to act as a screening	• Allows for an activity to be managed without restricting an entire land use • Would be useful process tool to link to Planning Act process if the decision is made	• Applies to existing land use only when the activity is changing or expanding • Activity may not be flagged through a building permit or other development application	• Able to provide exemptions to specific land use (e.g., residential) • Integration with existing municipal development review process • Would be useful process tool to link	• Must be combined with Part IV RMP • Land uses named in the policy must match the names that appear in local official plans or zoning bylaws

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
	tool for development applications (planning or building) that may trigger a Part IV policy.	to use either prohibition or RMP as a tool		to Planning Act process if the decision is made to use either prohibition or RMP as a tool	
Prescribed Instruments	Regulate a permitted consumptive water taking through a prescribed instrument (Permit To Take Water - PTTW).	• Science-based, pre-cautionary, transparent and involves peer reviewed process • Broad powers to collect information and to require studies • Relatively well understood compared to other tools • Opportunity to strengthen Ontario Low Water Response through PI, especially for private permits	• Not all consumptive water takings are captured under the Ontario Water Resource Act; i.e. not equitable, if not used in conjunction with other policy tools • Financial impact to property owners from new requirements • Lack of control regarding how the MOECC implements the instrument • If PIs are used too	• Opportunity to assess cumulative effects if a Tier 3 model is available • Maximum 10-year PTTW period allows for adaptive management • Can limit water takings (volume) to ensure too much water is not being taken. • Potential to use this tool along with prioritization of use • Potential to use this tool to implement water	• Creates new SDWT which then needs to be managed • Staff resources for administration and enforcement • Financial impact to property owners from new requirements • Cumulative effects are currently not considered and are difficult to assess • If used incorrectly, the opportunities listed may become weaknesses • Permitted future

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		• Many water takings are already managed through PTTW (uses existing legislation) • Ability to set timelines in plan policies for reviews of existing PTTW (e.g., adaptive management) • Potential for new data collection and assessments through improved monitoring requirements. • Ability to "roll back" takings if permitted rates are not being used • Ability to not renew or cancel permits	often and/or too harshly to prevent water takings, challenges to PIs will be taken to the Environmental Review Tribunal (ERT) and high-level ERT decisions may not be appropriate for local communities • Lack of clear scientific direction on water quantity limits and impacts often makes ERT arbitration decisions and restrictions to be seen as subjective • May be ineffective without other supportive changes (e.g. assessments of cumulative impacts, the	charges	takings risk further depletion of the resource and unsustainable implications

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
			creation of new monitoring standards) • Lack of clear data as to how much water is available and existing water takings may be over-allocated • Need for improved clarity and consistency regarding expectations and outcomes of permitting process • Need for improved monitoring – there is no central database • All permits are treated the same regardless of how the water is used, i.e. if some of it is returned to the		

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
			watershed or if it all leaves the watershed		
Land Use Planning	Regulate new development through land use planning processes and documents by establishing conditions that must be met	• Does not apply to existing threats		• Established municipal tool; Planning Act processes are in place • Policies can be tailored to specific areas with specific restrictions • Water taking can be considered a land use and can therefore be regulated through land use planning (e.g., through Official Plans) • The new Growth Plan includes efforts to ensure there is adequate water supply available for	• Addresses future threats only • Use of Land use planning tools untested to address water takings • Insufficient enforcement powers • There is a lack of guidance for how to ensure growth areas reflect water supply service capacity • Attempts to regulate water taking through land use planning could result in challenges at the LPAT. This is a body that is not familiar with water issues, and may

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
				• populations • Opportunity for municipalities to provide their intention for the long-term	make uninformed rulings that cannot be overturned • Policies may be interpreted differently across municipalities, e.g., water taking requirements for dry industrial vs wet industrial zoning
Education and Outreach (E&O)	Continue and/or expand water conservation outreach and develop new outreach materials to be shared across the region for both residents and business	• Provides information and options to landowners (opportunity to increase awareness in the industrial sector) • Learn from best practices within Ontario by sharing more research, communications plans, programs, strategies and	• Communications about water quantity are generally poor • People do not understand the complex water process, e.g., conveying messaging about drought response • Time and cost for program could be high • No guarantee that	• Same as existing	• Same as existing

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		campaigns • Can be combined with other tools • Achieved high water use awareness in City of Guelph • Opportunity for large users to improve engagement with the community • Can reduce cost of the water supply by reducing water use through effective programming	threat will be reduced without the development of targets and metrics • Need more discussion around the use of technical language and what it means, e.g., "threat" and "risk" • Need for increased E&O at the residential level • Requires stakeholder by- in		
Incentives/Stewardship Programs	Provide incentives, grants or tax incentives for consumptive water use reduction actions	• Reduces financial burden to applicant • BMPs are effective • Opportunity to reach industry, condominiums, and multi-	• May not be sufficient to effectively address significant threats on its own • Requires continuous funding • Effectiveness relies	• Same as existing	• Same as existing

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		residential properties as these programs are not often implemented or at capacity, and can produce large return on investment • Municipal water reduction program working well • Find and share good examples of incentive and stewardship programs in Ontario jurisdictions that can be replicated (e.g., Guelph Energy Efficiency Retrofit Strategy (GEERS), a greywater financing model)	in voluntary participation • Ensuring compliance with municipal water saving programs • Some incentive and stewardship programs have started to see diminishing returns • Need to ensure fairness in implementing charges, and avoid perceptions of providing advantages to industry through incentives • Difficult to incentivize industry and connect with industry		

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		• Can motivate water conservation behaviours at little cost to the municipality when compared to the cost of producing water, completion of new infrastructure programs and maintaining or expanding infrastructure			
Pilot Programs/Research	Example: Complete studies to determine existing impacts and/or future BMPs	• Fill data gaps • Target specific areas • Pilot different technologies in most sensitive areas • Pilot programs to focus on long-term outcomes • Improve well and energy	• Costs may outweigh the benefits • Difficult to achieve public buy-in • Challenge to find participants • Limited impact	• Same as existing	• Same as existing

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		optimization • Opportunity for industry to partner with and help municipalities			
Specify Actions	Establish specific action(s) to help manage water takings	• Tool is flexible with opportunity to engage stakeholders in implementation of the policy • Ability to require or encourage specific action that helps reduce risks, e.g., maintenance of Tier 3 models, consider water servicing in growth forecasts, prioritizing consumptive water use or improving low-water response consistency	• Potential implementation cost may be high • Coordination may be difficult between all parties involved due to overlapping jurisdictions at municipal, provincial, Conservation Authority level • Not enough teeth to ensure compliance	• Could work with other regulating bodies (e.g., MOECC) with existing expertise to identify proper actions • Expand education and outreach initiatives through these actions • Opportunity for more engagement from non-municipal water takers	• Potential implementation cost may be high • Coordination may be difficult between all parties involved due to overlapping jurisdictions at municipal, provincial, Conservation Authority level • Not enough teeth to ensure compliance

Threat 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					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		across the watershed • Opportunity to affect change within broader water management framework • Provides options for local situations (i.e. water management at a regional or local level)			

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Part IV: Prohibition	Prohibit recharge reduction activities	• Potentially removes threat completely • Potentially effective	• Restricts all activities that reduce recharge • Difficult to implement retroactively under existing conditions • Impact to property owner potentially very high	• Could be very effective in completely removing the threat • Potential to delineate smaller zones within vulnerable areas where prohibition may be justified • Could be used in concert with the other Part IV tools • Consider as a valuable tool when development is not able to meet a recharge value target/threshold • Consider using RMP to maintain water quantity when a certain threshold is met through the development	• Cumulative impact of recharge reduction may justify prohibition in some areas, while in other areas it may be difficult to justify because reduction in recharge threats are not contributing significantly to significant risk level • The science is well-founded and precautionary but there is some uncertainty incorporated into the assessment

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
				application. This should include requirements for monitoring. If threshold is not met, then prohibit.	
Part IV: Risk Management Plans (RMP)	Require a RMP that implements measures to restore or maintain pre-development recharge	• Property specific and flexible • Ability to include monitoring program and measure implementation success • Potential opportunity to impose RMP (though this is a challenge as threat inspection is required), especially on land that is zoned but not developed. This could be implemented through a	• Ownership and collection of monitoring data (e.g. condominium board or residential development) falls to municipality • Implementation may be ineffective; need to monitor and ensure actions are sustained over the long term (e.g., operation and maintenance of green infrastructure such as infiltration gallery) • Recharge is not monitored • Significant resource	• Proactive tool • Ability to require water balance for subdivision (individual lot level) • Can occur through land use • Can occur on multi-residential properties • Can help ensure ongoing performance beyond initial planning approval • Could implement RMP for gravel pit approval then require monitoring (by Risk	• Staff resources to implement may be high, e.g., to complete follow-ups, addressing challenges related to non-conformity • Cost of program delivery may be high

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		stormwater management model.	and time effort	Management Official, RMO) of pit for set times • Must demonstrate to the RMO that the RMP and site plan are being adhered to	
Part IV: Restricted Land Use	Designate land uses where recharge reduction could occur and where RMP or prohibition would be required.	• Allows for an activity to be managed without eliminating an entire land use • Alerts all jurisdictions involved that permissions are needed for modifications to development • May be useful for areas identified through the planning process (e.g. greenfield areas)	• Applies to land use only when the activity is changing or expanding	• Able to provide exemptions to specific land use (e.g., residential) • Integration with existing municipal development review process • May allow development that does not pose a significant drinking water threat to be established in a designated area	• Must be combined with Part IV Prohibition or RMP • Land uses named in the policy must match the names that appear in local official plans or zoning bylaws
Prescribed	Regulate	• Science-based,	• Staff resources for	• Same as existing	• Same as existing

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
Instruments	recharge reduction activities through a Prescribed Instrument (Environmental Compliance Approval – ECA)	pre-cautionary, transparent and involves peer reviewed process • Potential for new data collection and assessments through improved monitoring requirements.	administration and enforcement may be high • Financial impact to property owners from new requirements may be high		
Land Use Planning	Regulate new development through land use planning processes and documents by establishing conditions that must be met	• Does not apply to existing threats		• Municipalities already have the Planning Act in place • Policies can be tailored to specific areas with specific restrictions • Strengthen pre/post development water balance • Include water balance assessment requirements for	• Addresses future threats only • Appeals to the LPAT could result in this body that is not familiar with water issues making uninformed rulings that cannot be overturned • Push for growth areas does not consider water quantity recharge needs • Unclear where land

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
				development applications • Bylaws for stormwater management, for the maintenance of Low Impact Development (LID) systems • Provincial Policy Statement supports protecting water quality and quantity • Environmental Impact Statement can be used to require multi-year monitoring period (through municipalities) for site plan approval • Require developers to use the Tier 3 model to validate recharge	use could apply to recharge • Unclear what would be regulated on industrial sites, and how site planning would address drainage

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
				and increase protection of recharge areas • Update and improve land use plans to require subwatershed plans on a cyclical basis (not only when triggered by development)	
Education and Outreach	Continue and/or expand outreach initiatives about maintaining recharge and develop new outreach materials to be shared across the region for both residents and business	• Provides information and options to landowners (increases awareness) • Can encourage best management practices • Can be combined with other tools • Retrofits could reverse, i.e. increase recharge in built up areas	• Self-motivated program • Time and cost for program could be high • Typically requires long-term and extensive investment to be successful • Retrofits to increase recharge more difficult after development built • Increased recharge in built up areas	• Education programs can be effective and can be used in combination and to support other tools	• Typically requires long-term and extensive investment to be successful

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
			may not be appropriate (e.g. road salt impacts) • No enforcement		
Incentives/Stewardship Programs	Provides grants or tax incentives for actions to maintain or increase pre-development recharge	• Reduces financial burden to applicant • Could prove useful and effective when combined with other tools • Strengthen incentives to further water quantity protection objectives (e.g. stormwater credits)	• May not be sufficient to effectively address significant threats on its own • Requires continuous funding • Effectiveness relies in voluntary participation • May be perceived as rewarding those with poor management practices	• Same as existing	• Same as existing
Pilot Programs/Research	Example: Complete studies to determine existing impacts and/or future BMPs	• Fill data gaps • Target specific areas • Partner with local researchers • Should be used in conjunction with a stewardship/incent	• Costs may outweigh the benefits • Challenge to find participants	• Same as existing	• Same as existing

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		ive program • Can work well and support other tools			
Specify Actions	Establish specific action(s) to help manage recharge reduction activities	• Tool is flexible • Ability to require or encourage specific action that helps reduce risks • Opportunity to affect change within broader water management framework • Provides options for local situations • Can be linked with other policy tools including RMPs • Could work with other regulating bodies (e.g., MOECC) with existing expertise to identify proper actions • Ability to require	• Cost to municipality may be high • Coordination may be difficult between all parties involved • Unclear how to obligate municipalities to follow best management practices • Create new specify actions: provide municipalities with best management practices for water quantity sustainability, but provide more detailed and specific guidance for how to implement those best practices in	• Same as existing	• Same as existing

Threat 20: An activity that reduces the recharge of an aquifer					
		Existing Threats		Future Threats	
Tool	Tool Description	Potential Strength/ Opportunity	Potential Weaknesses/ Challenge	Potential Strength/ Opportunity	Potential Weakness/ Challenge
		maintenance of Stormwater management infrastructure	communities		

Appendix D

Legal Effect Policy Matrix

Appendix D: Legal Effect Policy Matrix			
Responsible Party:	Provincial	Municipality, Local Board or Source Protection Authority	Other Bodies
SIGNIFICANT THREAT POLICIES- ACTIVITIES			
Part IV Tools (1)	Comply	Comply	Comply
Prescribed Instruments	Must Conform	N/A	N/A
Land Use Planning Approaches	Comply	Must Conform	
Education and Outreach/ Incentive Programs	Strategic Action	Comply	Strategic Action
Other (2)			
MONITORING POLICIES			
All Policy Tools	Comply	Comply	Comply

(1) Part IV Tools include Section 57 Prohibition, Section 58 Risk Management Plans and Section 59 Restricted Land Uses

(2) Other approaches authorized by the regulation include: specify the action to be taken to implement the source protection plan or to achieve the plan's objectives; establish stewardship programs; specify and promote best management practices; establish pilot programs; and govern research.

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-04 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Progress Report Grand River Assessment Report and Source Protection Plan Update**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-04 – Progress Report Grand River Assessment Report and Source Protection Plan Update – for information.

REPORT:

This report provides an update on progress of technical studies in the Grand River watershed. Progress reports and results of technical studies will be presented to the Source Protection Committee as they are completed with recommendations to update the Grand River Assessment Report and Source Protection Plan. In addition, Source Protection Plan policies are being developed (water quantity) or revised (water quality), where needed. Lake Erie Region staff will return to the Source Protection Committee with updated timelines as needed.

Technical Studies

St. George (Brant County) / Lynden (City of Hamilton)

Both the communities of St. George and Lynden have constructed new municipal supply wells to meet capacity needs. A new groundwater model, hydrologic model, and WHPAs were developed for the two communities in one project. The study was completed in June 2018 and the results are recommended to be included in the draft updated Grand River Assessment Report. Details on the study are presented in Reports SPC-18-06-06, St. George Water Quality Technical Study and SPC-18-06-05, Lynden Water Quality Technical Study.

Guelph-Eramosa (Hamilton Drive, Rockwood), Bethel (Brant County) and Mt. Pleasant (Brant County)

Provincial funding was received to update quality-related WHPAs and vulnerability assessments for municipal wells located in Tier 3 study areas. The objective is to provide continuity in the models used to delineate both quality and quantity WHPAs. Tier 3 models represent the best currently available data, whereas some of the older quality WHPAs were mapped based on now outdated geological interpretations. Both the Guelph-Eramosa and Bethel study are currently underway and are expected to be completed in summer/fall 2018. The Mt. Pleasant study will be commencing shortly.

Bright (Oxford County)

Wellhead Protection Areas (WHPAs) and vulnerability scores for two wells in the community of Bright were updated using the Whitemans Creek Tier 3 model. The study was completed in May 2018 and the results are recommended to be included in the draft updated Grand River Assessment Report. Details on the study are presented in Report SPC-18-06-08, Bright Water Quality Technical Study.

Centre Wellington WHPA and Issue Contributing Area Delineation

WHPAs are being re-delineated for the Centre Wellington municipal wells using the recently peer reviewed Tier 3 groundwater flow model. The model represents significant geological updates to the Township based on mapping by the Ontario Geological Survey. Chloride Issue Contributing Areas are also being developed for two municipal wells where chloride has been identified as a drinking water Issue. The project recently started this spring and will be completed in late fall 2018.

Whitemans Creek Tier 3

In 2014, EarthFX Inc. commenced the Whitemans Creek Tier 3 Water Budget project to consider risks to the municipal water supplies in the Village of Bright and the Town of Paris Bethel well field. The risk assessment was completed in May 2018 and details on the study are presented in Report SPC-18-06-10, Whitemans Tier 3 Water Budget and Local Area Risk Assessment.

Guelph-Guelph/Eramosa Water Quantity Policy Development Study

Two components of the Guelph-Guelph/Eramosa (GGET) Water Quantity Policy Development Study, technical work (Risk Management Measures Evaluation Process (RMMEP)) and the development of a water quantity discussion paper, are complete. See Report SPC-18-06-03 – Guelph-Guelph/Eramosa Threats Management Strategy and Water Quantity Policy Discussion Paper, for details.

Centre Wellington Scoped Tier 3 Water Budget study

The Centre Wellington Scoped Tier 3 Water Budget Study began in August 2016 to assess potential risks to the Centre Wellington municipal drinking water system. The project is managed by the GRCA on behalf of the Township of Centre Wellington. The study is being completed in coordination with the Township's Water Supply Master Plan which began earlier this year.

The project consultants have completed the groundwater flow model and Numerical Groundwater Flow Development and Calibration Report. The report has been reviewed by the Provincial peer review team and was presented to the Community Liaison Group (CLG) on May 15. The report will be finalized follow the CLG commenting period which closes on June 29. A project update was provided to Township council on May 22. The project is now beginning the risk assessment phase, beginning with scenarios that can be completed using existing data. Additional risk assessment scenarios will be evaluated as projected water demand information comes available from the Water Supply Master Plan.

Information about the Centre Wellington study including reports, CLG presentations, and meeting summaries are available at www.sourcewater.ca/CW-Scoped-Tier3

Prepared by:

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Prepared by:

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Prepared by:

Sonja Strynatka, P.Geo.
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Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-05 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Lynden Water Quality Wellhead Protection Area Technical Study

---

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-05 – Lynden Water Quality Wellhead Protection Area Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the results of the Lynden Water Quality Wellhead Protection Area Technical Study into the Draft Updated Grand River Watershed Assessment Report.

SUMMARY:

The Rural Settlement Area of Lynden is a small community within the City of Hamilton, with a population of approximately 400 residents. The Lynden municipal water supply consists of one communal production well, FDL-01.

A second municipal well, FLD-03, was drilled in 2015 to meet increased capacity needs.

In 2016, a study was initiated by the City of Hamilton, in partnership with the Grand River Conservation Authority, to generate wellhead protection areas (WHPAs) for FDL-03 and update the existing WHPA for FDL-01. In addition to the updates to the WHPAs, vulnerability scores, threats, and a drinking water issues assessment were completed for the Lynden system.

Results from this study are recommended to be incorporated into the draft updated Grand River Assessment Report in later 2018.

REPORT:

System Description

The Rural Settlement Area of Lynden is a small community within the City of Hamilton, with a population of approximately 400 residents. The Lynden municipal water supply consists of one communal production well, FDL-01.

In 2002, a Servicing Master Plan for Lynden identified the need for an additional water supply, and more recently in 2017, the Master Plan was re-evaluated through a Schedule ‘C’ Municipal Class Environmental Assessment, which concurred that upgrading the existing system was the preferred alternative.

In 2015, a new production well, FDL-03 was drilled 230 m to the south of FDL-01. Both wells are screened in a confined overburden aquifer between 50 and 55 metres below ground surface. Neither well meets the requirements to be considered groundwater under the direct influence of surface water (GUDI). Land use in the area surrounding the municipal wells is predominantly agricultural.

With the addition of FDL-03, the system has a capacity of 518.4 m^3/day. The raw water passes through a two-stage treatment process to remove naturally occurring hydrogen sulphide and provide disinfection.

Wellhead Protection Areas

A numerical groundwater flow model and a hydrologic model for the Fairchild Creek subwatershed were developed for this project. The objectives of the models were to:

1. Improve recharge estimates in the subwatershed in comparison to the existing GRCA GAWSER hydrologic model.
2. Generate WHPAs for both the Lynden municipal wells and the St. George wells, which are located approximately 10 km to the west of Lynden (refer to report SPC-18-06-06)

The GRCA's GAWSER model currently classifies all exposed bedrock as impervious, which is incorrect given the often highly fractured or karstic nature of bedrock in southern Ontario. Exposed and shallow bedrock is a key area of groundwater recharge in the watershed, which needed to be recognized in the hydrologic model. The hydrologic model developed as a part of this project provided groundwater recharge estimates which accounted for the fractured shallow bedrock in the Fairchild Creek subwatershed. These recharge estimates were then applied to the groundwater flow model.

To begin the development of WHPAs for the Lynden wellfield, the maximum permitted combined average daily pumping rate for both wells was identified to be 6 L/s with a 2:1 ratio of using FDL-03 over FDL-01. Therefore pumping rates assigned to simulate WHPAs were 2 L/s for FDL-01 and 4 L/s for FDL-03.

Aquifer vulnerability was mapped using the Surface to Well Advection Time (SWAT) method which utilizes the groundwater flow model by tracking particles forward in the model to estimate their time of travel from ground surface to the municipal wells. Vulnerability was assessed as low throughout the entire WHPA. A thick confining clay till unit overlays the municipal aquifer that affords it protection from surficial inputs. No preferential pathways were identified within the WHPAs that could increase the vulnerability scores. Private wells within the WHPAs were reviewed based on the MOECC's Water Well Information System, and 15 were identified as installed prior to 1990 and the establishment of the Ontario Regulation 903 (wells) under the Ontario Water Resources Act. These wells were identified as potential preferential pathways until field verified at a later date.

The resulting WHPAs and vulnerability scores are shown in **Figure 1**. WHPAs are oriented in a north/south direction corresponding with the local direction of groundwater flow in the overburden sediments.

Figure 2 compares the updated WHPAs with the older WHPAs. The new WHPAs have a rounder shape because of revisions to the local geologic understanding, but are oriented in the same direction as the older WHPAs.

Drinking Water Issues

No pathogenic or chemical issues were identified for FDL-01 and FDL-03. Elevated turbidity and sulphide/hydrogen concentrations have been observed at the wells, however these are naturally occurring and therefore not considered an issue. The Lynden treatment facility is equipped to remove hydrogen sulphide from the raw water.

Drinking Water Threats

As the vulnerability within the WHPAs is uniformly low, significant chemical and pathogen threats can only occur within the WHPA-A.

A desktop evaluation of drinking water threats within the Lynden WHPAs resulted in the identification of 26 significant drinking water threats, 5 moderate threats, and 33 low level threats. The 26 significant threats are located on 7 properties. A summary of land use associated with significant threats is as follows:

Significant threats (26 threats):

- Fifteen threats related to the application of agricultural source material, fertilizer, pesticides and the presence of livestock
- Six threats related to the handling and storage of fuel
- Five threats related to the presence of domestic septic systems

No drinking water threats related to conditions were identified within the Lynden WHPAs.

Next Steps

Results from the technical study will be incorporated into the draft updated Grand River Assessment Report, based on acceptance of the report by the Source Protection Committee.

Prepared by:

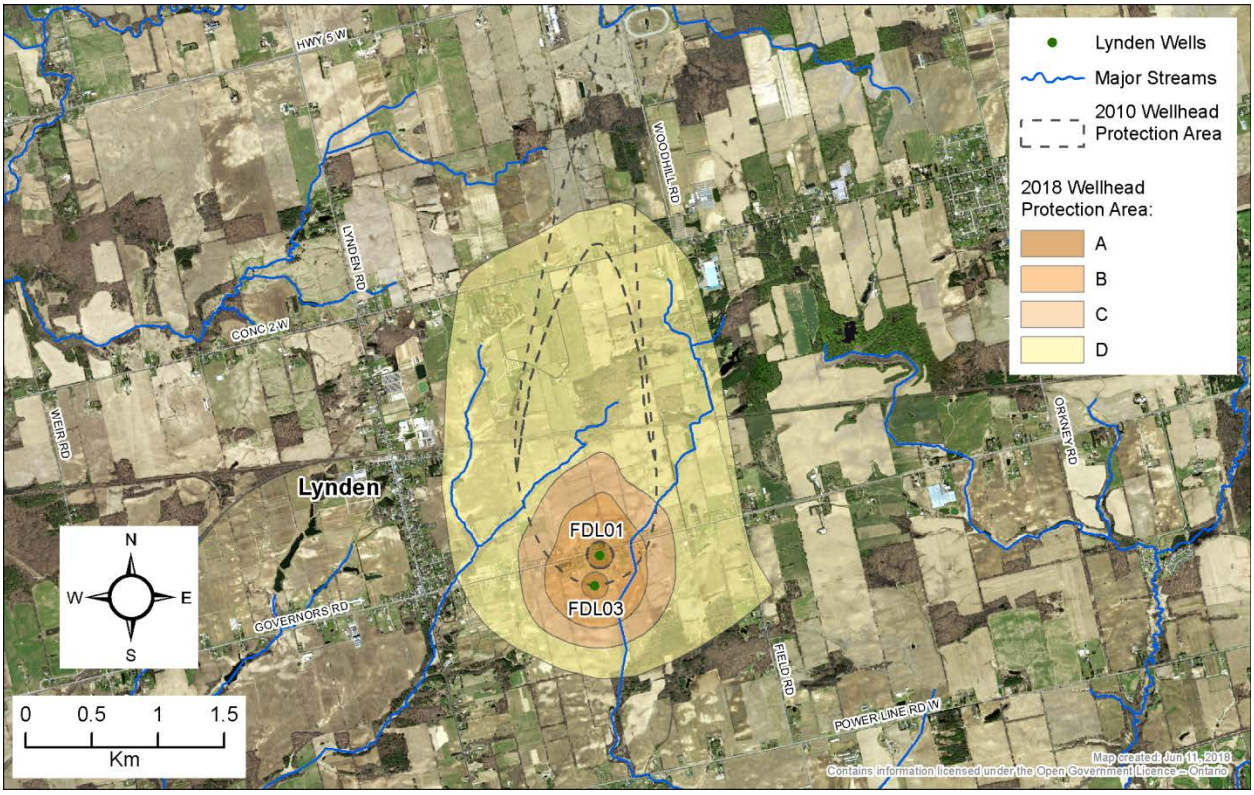
Sonja Strynatka, P.Geo.
Senior Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Figure 1: Vulnerability scores within Lynden Wellhead Protection Areas

Figure 2: Lynden Wellhead Protection Areas



LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-06 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: St. George Water Quality Wellhead Protection Area Technical Study

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RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-06 — St. George Water Quality Wellhead Protection Area Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the results of the St. George Water Quality Wellhead Protection Area Technical Study into the Draft Updated Grand River Watershed Assessment Report.

SUMMARY:
The community of St. George is located in the County of Brant, approximately 10 km to the north of the City of Brantford. The St. George municipal supply system currently consists of three production wells. The need for additional supply was identified through a Class Environmental Assessment for St. George Water Servicing for redundancy and future growth. This was addressed by the construction of two new bedrock wells located to the northwest of the town center.

In 2016, a study was initiated by the Grand River Conservation Authority in partnership with the County of Brant, to generate wellhead protection areas (WHPAs) for the new municipal supply wells and update WHPAs for the existing wells. In addition to the updates to the WHPAs, vulnerability scores, threats, and a drinking water issues assessment were completed for the St. George system.

Results from this study are recommended to be incorporated into the draft updated Grand River Assessment Report in later 2018.

REPORT:

System Description

The existing St. George municipal water supply system consists of three productions wells: Well 1, Well 2, and Well 3, all screened in an overburden aquifer from 15 to 23 metres below ground surface. The wells are centrally operated out of a single pump house. The wells service approximately 1,268 residences, 155 commercial accounts, and one bulk truck-fill station. Land use in the vicinity of the wells is residential and commercial, with one park.

The community requires an additional water supply for redundancy and to support future growth. A Class Environmental Assessment for St. George Water Servicing identified the preferred alternative to be the construction of new bedrock test wells at a previous monitoring site located to the northwest of the community centre. The new wells are cased through 57 m of overburden and completed as open holes in the bedrock. A 65 hour pumping test indicated that the two wells were capable of producing 45 L/second (or 22.5 L/s per well). The bedrock wells

are not considered groundwater under the direct influence of surface water. Land use surrounding the wells is predominantly agricultural.

Wellhead Protection Areas

A numerical groundwater flow model and hydrologic model for the Fairchild Creek subwatershed was developed for this project. The objectives of the models were to:

1. Improve recharge estimates in the subwatershed in comparison to the existing GRCA GAWSER hydrologic model.
2. Incorporate the geology from the Ontario Geological Survey's Brantford-Woodstock area surficial deposits three-dimensional mapping.
3. Generate WHPAs for both the St. George municipal wells and the Lynden wells located approximately 10 km to the east of St. George (refer to report SPC-18-06-05)

The GRCA's GAWSER hydrologic model currently classifies all exposed bedrock as impervious, which is incorrect given the often highly fractured or karstic nature of bedrock in southern Ontario. Exposed and shallow bedrock is a key area of groundwater recharge in the watershed, which needed to be recognized in the hydrologic model. The hydrologic model developed as a part of this project provided groundwater recharge estimates which accounted for the fractured shallow bedrock in the Fairchild Creek subwatershed. These recharge estimates were then applied to the groundwater flow model.

To develop WHPAs, three pumping scenarios were used to develop a composite WHPA of the existing overburden and new bedrock wells fields.

Aquifer vulnerability was mapped using the Surface to Well Advection Time (SWAT) method which utilizes the groundwater flow model by tracking particles forward in the model to estimate their time of travel from ground surface to the municipal wells. Since the wellfields are located in different aquifers (overburden versus bedrock) the vulnerability was assessed independently for each wellfield. The vulnerability was then combined into the composite WHPA. Where vulnerability scores between the two wellfields overlapped, the higher of the two vulnerability scores was assigned to the WHPA.

No preferential pathways were identified within the WHPAs which could increase the vulnerability scores. Private wells within the WHPAs were reviewed based on the MOECC's Water Well Information System. Nine wells were identified as installed prior to 1990 and the establishment of the Ontario Regulation 903 (wells) under the Ontario Water Resources Act that could be in connection with the municipal supply aquifer. These wells were identified as potential preferential pathways until field verified at a later date.

The resulting composite WHPAs and vulnerability scores are shown in **Figure 1** where WHPAs are oriented towards the up-gradient direction of groundwater flow.

Figure 2 compares the updated WHPAs with the older WHPAs. The new WHPAs, which were generated using a higher pumping rate than the older WHPAs, are generally larger but are oriented in the same direction as the older WHPAs.

Issue Contributing Area

Nitrate has historically been considered a drinking water issue for the St. George overburden wells. Nitrate concentrations were reassessed as a part of the WHPA update, and nitrate continues to be a concern although concentrations are less than the Ontario Drinking Water Quality Standard (ODWQS) of 10 mg/L. Concentrations range between 3 and 6 mg/L across the monitoring network. Nitrate has not been detected in the bedrock wells. Nitrate monitoring

for the St. George wells is further discussed in SPC Report 18-06-07 entitled Re-evaluating Issues in M. Pleasant, Bethel, and St. George.

An issue contributing area (ICA) had been previously mapped for the St. George overburden wells. The ICA was re-delineated as a part of the current WHPA update to encompass the WHPA-D for the overburden wells only as nitrate has not been detected in the new bedrock wells. The extent of the nitrate ICA is shown on **Figure 3**.

Drinking Water Threats

A desktop evaluation of drinking water threats within the new WHPAs resulted in a total of 216 significant, 30 moderate, and 26 low ranking threats. These threats have not yet been field verified. The results are summarized in **Table 1**. Of the 216 significant threats, 185 were related to the nitrate issue, 1 is related to a pipeline, 2 are related to contaminated sites, and the remaining twenty eight are related to prescribed activities based on the vulnerability score and the WHPA in which the activity is located. Significant threats not related to the nitrate ICA are located on 12 properties within the WHPA-A and WHPA-B.

Table 1: Threats enumeration within St. George WHPAs

Threat		Enumerated Threats		
		Significant	Moderate	Low
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	2	0	0
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	70	2	5
3	The application of agricultural source material to land.	29	0	0
4	The storage of agricultural source material.	17	0	0
5	The management of agricultural source material.	0	0	0
6	The application of non-agricultural source material to land	0	0	0
7	The handling and storage of non-agricultural source material	0	0	0
8	The application of commercial fertilizer to land.	39	0	0
9	The handling and storage of commercial fertilizer.	17	0	0
10	The application of pesticide to land.	6	10	8
11	The handling and storage of pesticide.	4	7	4
12	The application of road salt.	0	1	0
13	The handling and storage of road salt.	0	0	0
14	The storage of snow.	0	0	0
15	The handling and storage of fuel.	12	10	8
16	The handling and storage of a dense non-	3	0	0

Threat		Enumerated Threats		
	aqueous phase liquid.			
17	The handling and storage of an organic solvent.	3	0	0
18	The management of runoff that contains chemicals used in the de-icing of aircraft.	0	0	0
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.	11	0	1
Total		**213**	**30**	**26**

Next Steps

The County will be following up with property owners to verify threats within the WHPAs as well as with property owners within the nitrate ICA to continue to better understand and manage the source of nitrate in the overburden wells.

Results from the technical study will be incorporated into the draft updated Grand River Assessment Report based on acceptance of the report by the Source Protection Committee.

Prepared by:

Sonja Strynatka, P.Geo.
Senior Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Figure 1: Vulnerability scoring for St. Geroge Municipal Wells

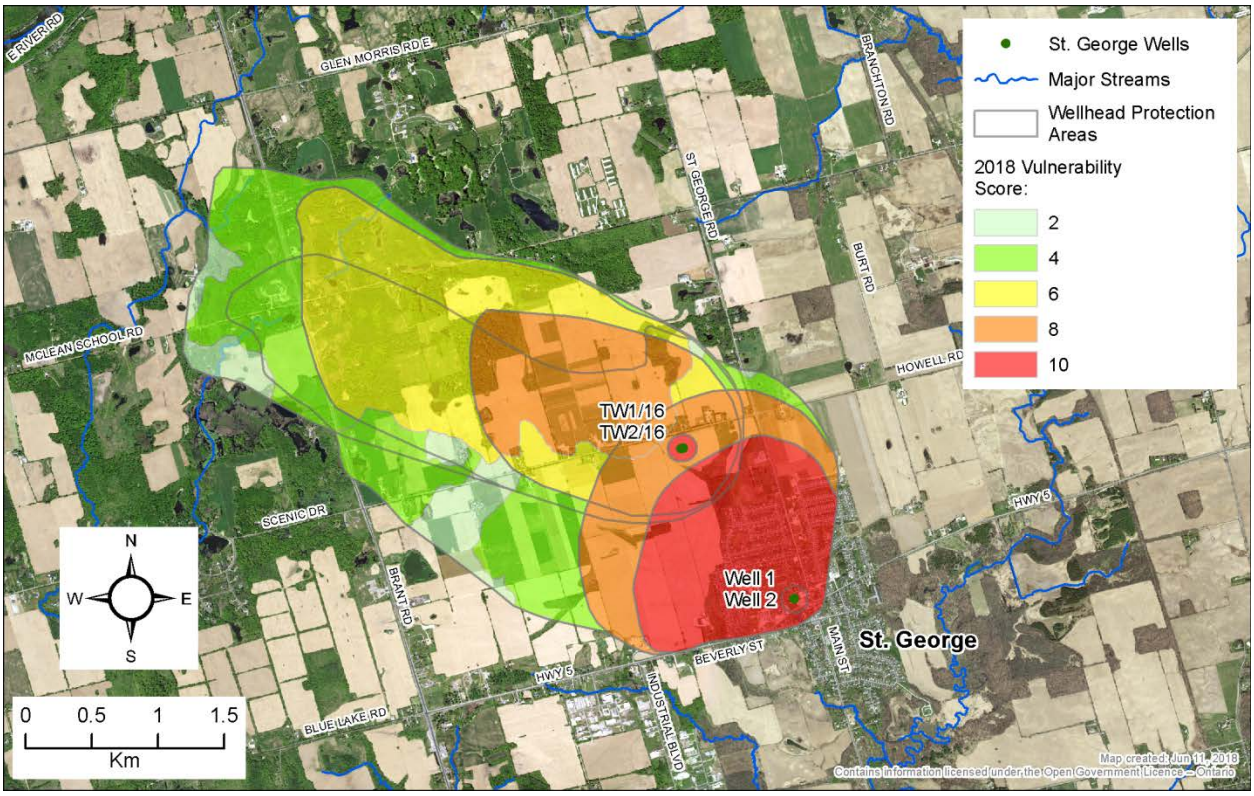


Figure 2: St. George Wellhead Protection Areas

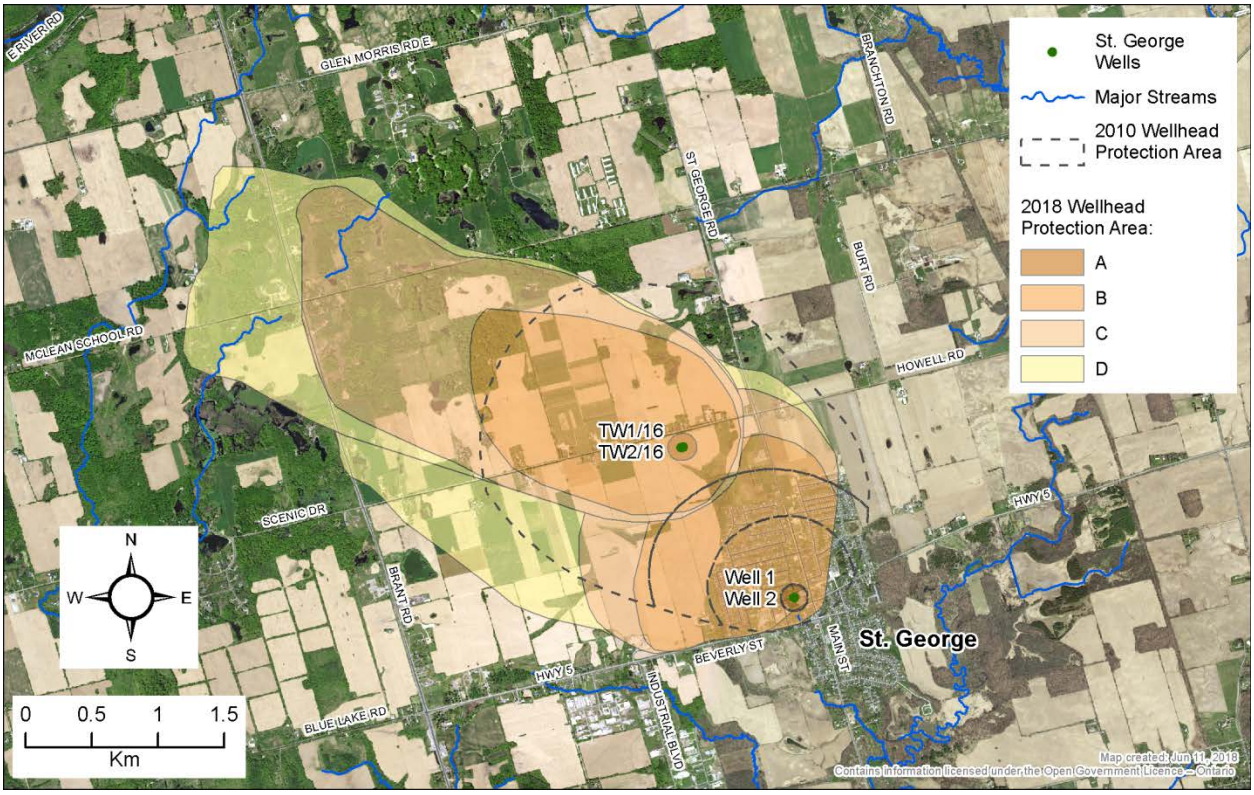
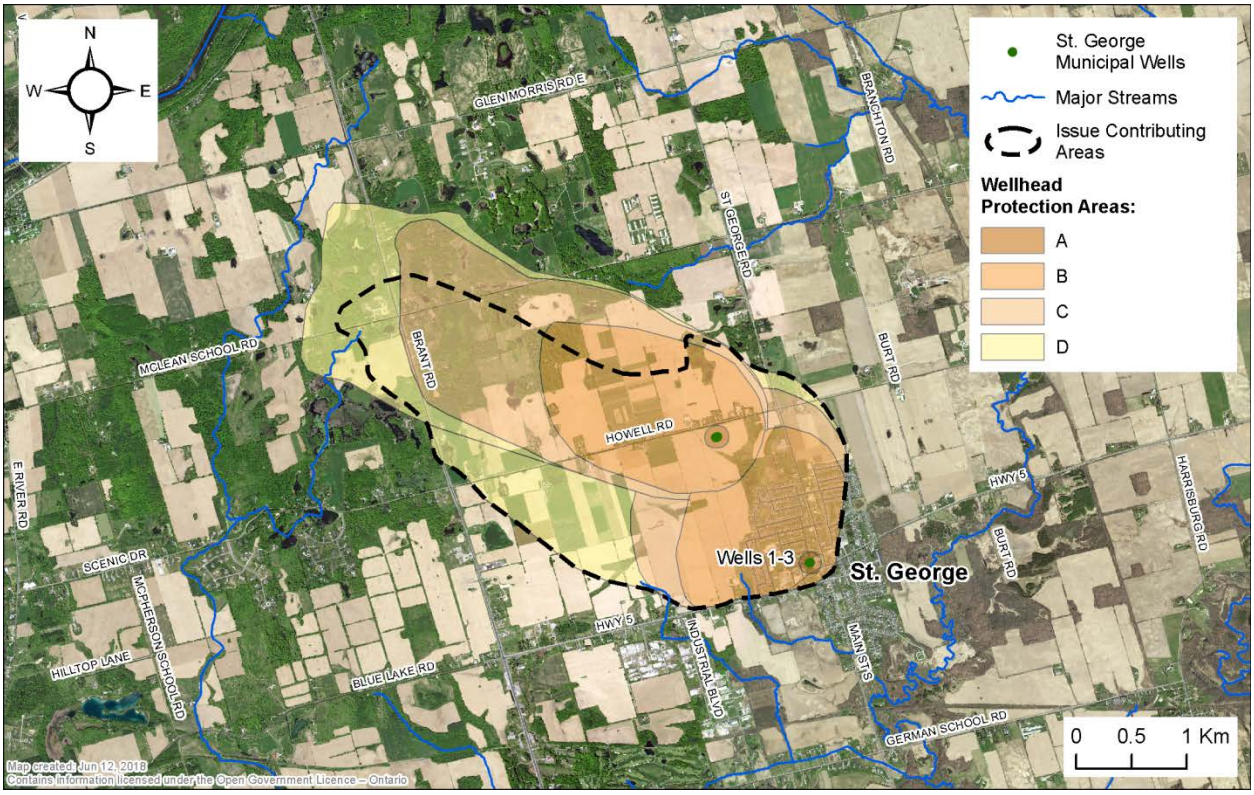


Figure 3: St. George Nitrate Issue Contributing Area



LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-07 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Re-evaluating Issues in Mt. Pleasant, Bethel and St. George

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RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-07 – Re-evaluating Issues in Mt. Pleasant, Bethel and St. George - for information.

AND THAT the Lake Erie Region Source Protection Committee support the staff recommendation to remove the Mt. Pleasant wellfield chloride ICA and the Bethel wellfield nitrate ICA from the Grand River Assessment Report and Source Protection Plan.

AND THAT the Lake Erie Region Source Protection Committee recommends that the County of Brant continue to monitor and report on nitrate concentrations at the St. George wellfield.

SUMMARY:

The Issue Contributing Areas (ICAs) have been re-evaluated for three of the Count of Brant's (County) wellfields: Mt. Pleasant, Bethel Road, and St. George.

The Mt. Pleasant wellfield currently has a chloride ICA due to elevated chloride levels. The likely source of chloride was the salt pile that was stored uncovered in WHPA-B. Chloride concentrations have decreased in the Mt. Pleasant water supply wells approximately six years after the salt was moved to a covered salt dome.

The Bethel Road wellfield currently has a nitrate ICA due to elevated nitrate levels. The likely source of the nitrate is agricultural practices surrounding the area. Nitrate concentrations have decreased and remained stable in the Bethel Road water supply wells. The likely reason for the decrease in nitrate is the land use change from agricultural to industrial as the Brant Business Park was constructed.

The St. George wellfield currently has a nitrate ICA due to elevated nitrate levels. It is still unknown what the source of the nitrate is; however the County is currently taking measures to determine the source. Although nitrate concentrations have decreased in the St. George water supply wells, the concentrations are still variable.

Staff recommends that the ICAs be removed for both the Mt. Pleasant and Bethel Road wellfields and that the County of Brant continue to monitor the nitrate concentrations at the St. George wellfield.

REPORT:

Mt. Pleasant Water Supply System

Background

The municipal groundwater supply system for Mt. Pleasant consists of two overburden productions wells, constructed in 1981 (Well 1) and 1995 (Well 2). Both production wells are constructed in a confined/ semi confined sand and gravel aquifer, with an overlying glacial till aquitard that is variable in thickness. The regional direction in overburden groundwater flow generally occurs from southwest to northeast. Due to historically elevated chloride concentrations at the Mt. Pleasant supply wells, chloride was deemed an Issue. The entire WHPA for the Mt. Pleasant wellfield is included in the ICA for chloride (**Figure 1**). At the time of the chloride ICA delineation it was unknown whether the high chloride concentrations were from road salting activities, a historical landfill site, a salt storage dome or a combination of any of the three.

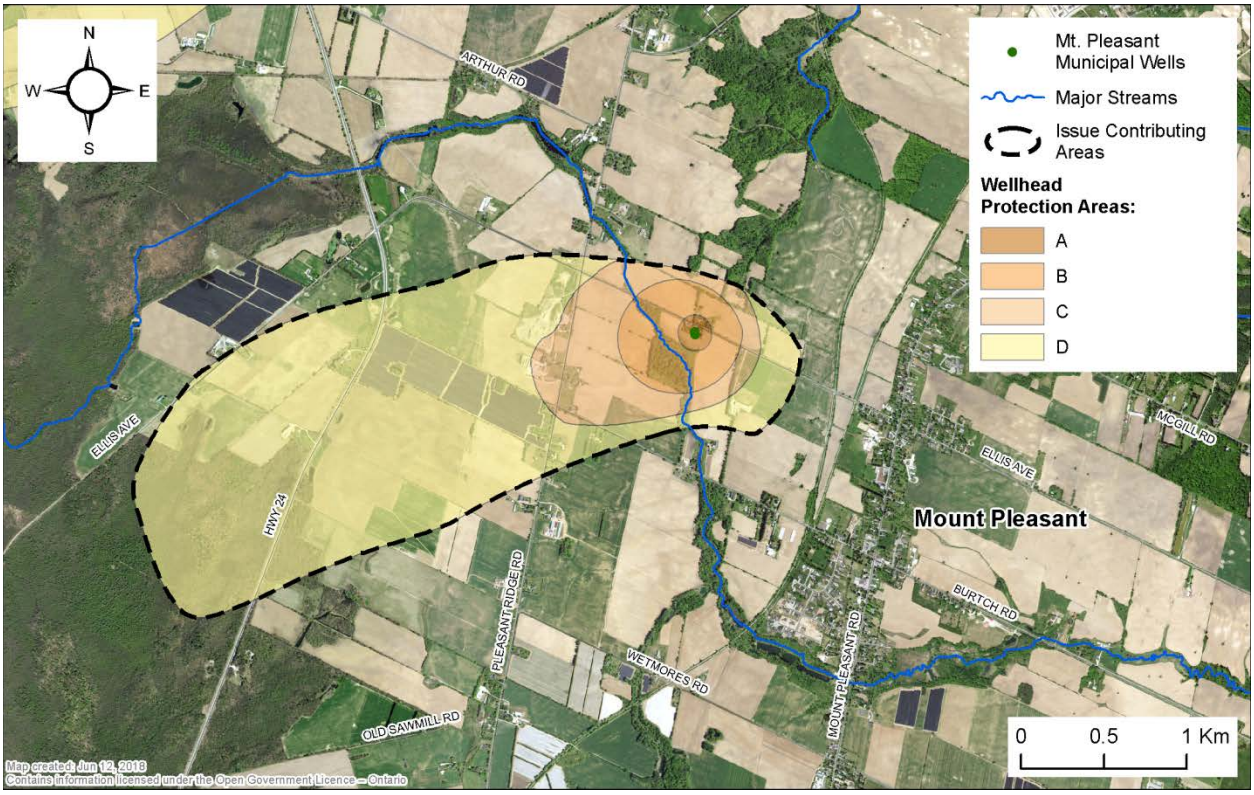

Figure 1: Mt. Pleasant Wellfield Issue Contributing Area for Chloride

Recent discussion with the County provides further insight into the elevated chloride concentrations at the Mt. Pleasant supply wells. Prior to 2006, road salt was stored in a small shed just south east of the wellfield. This area is the lowest part of the former aggregate mine with the ground surface in close proximity to the water table below. There is no aquitard here. When the salt was delivered it was dropped on the ground and then pushed into the shed and most often the shed was too small to store the salt, therefore the salt sat outside directly on the ground with no cover. As the salt was exposed to precipitation, it dissolved and infiltrated into the municipal aquifer below.

In 2006, a salt dome was constructed that is large enough to allow the salt delivery trucks to unload directly in the dome. The new dome is also large enough to store all salt and load the snow plow/sanders for winter control operations. The location of the salt dome is slightly northwest compared to the old location, where it's at a higher elevation.

Review of Chloride Concentrations

Chloride concentrations for the Mt. Pleasant supply wells are illustrated in **Figure 2**. Elevated chloride concentrations at Well 1, near or above the chloride aesthetic objective of 250 mg/L, is observed from 2006 to 2012. At Well 1, a decreasing trend from 2012 (approximately 225 mg/L) to 2014 is observed, with stable chloride concentrations around 120 mg/L to 2017. Chloride concentrations at Well 2 are consistently lower than those observed at Well 1, with concentrations peaking from 2006 through 2012 (approximately 120 mg/L) and declining to a concentration of approximately 70 mg/L in 2015 through to 2017.

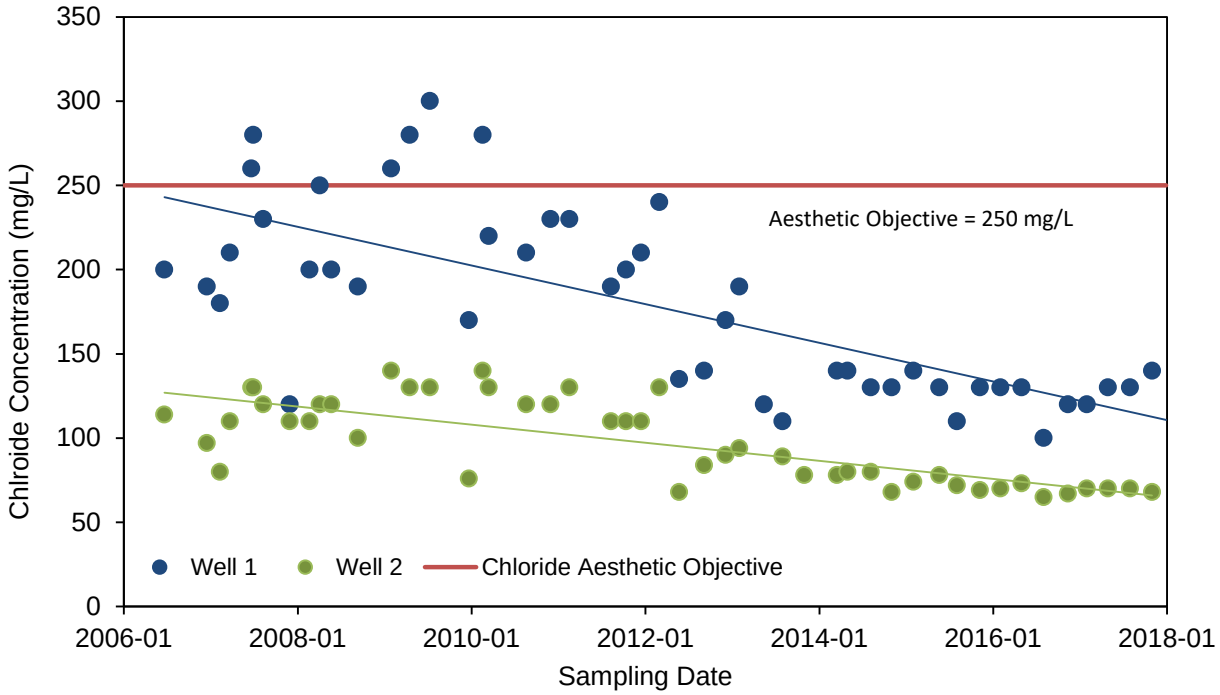

Figure 2: Chloride Concentrations at the Mt. Pleasant Municipal Supply Wells

Next Steps

A decline in chloride concentrations is noted from 2012 onwards, approximately 6 years after the salt storage dome was built for salt storage. The shed where the salt was previously stored is just outside the 5 year time of travel, therefore it can be concluded that the likely source of chloride at the Mt. Pleasant wells was the salt that was stored outside and exposed to dissolution by precipitation.

On the basis of the above, staff recommends that the chloride ICA be removed from the Mt. Pleasant wellfield.

Bethel Water Supply System

Background

The Bethel Road Wellfield, located just south of Paris, Ontario contain three active production wells (P51, P52 and P53) and one new production well that will be online in the near future (P54). The four wells are completed in intermediate to deep overburden sediments and screened in an unconfined aquifer comprised of sand and gravel to approximately 23 to 34 m below ground surface (bgs). Regionally, groundwater flow in the overburden is in an easterly direction towards the Grand River. The entire WHPA for the Bethel Road Wellfield is included in the ICA for nitrate (**Figure 3**). The nitrate ICA was delineated based on elevated nitrate concentrations in the raw water at all Bethel Road wellfield production wells. The monitoring data suggest the possibility of contamination is from agricultural activity in the WHPA.

In 2012, construction of the Brant 403 Business Park began, which over time changed the land use in the area from agricultural to industrial. The industrial landscape included paved parking lots, large buildings and a storm water management pond. In addition to the development of the business park, agricultural activity south of the Bethel Road wellfield has ceased as the area is now an aggregate mine.

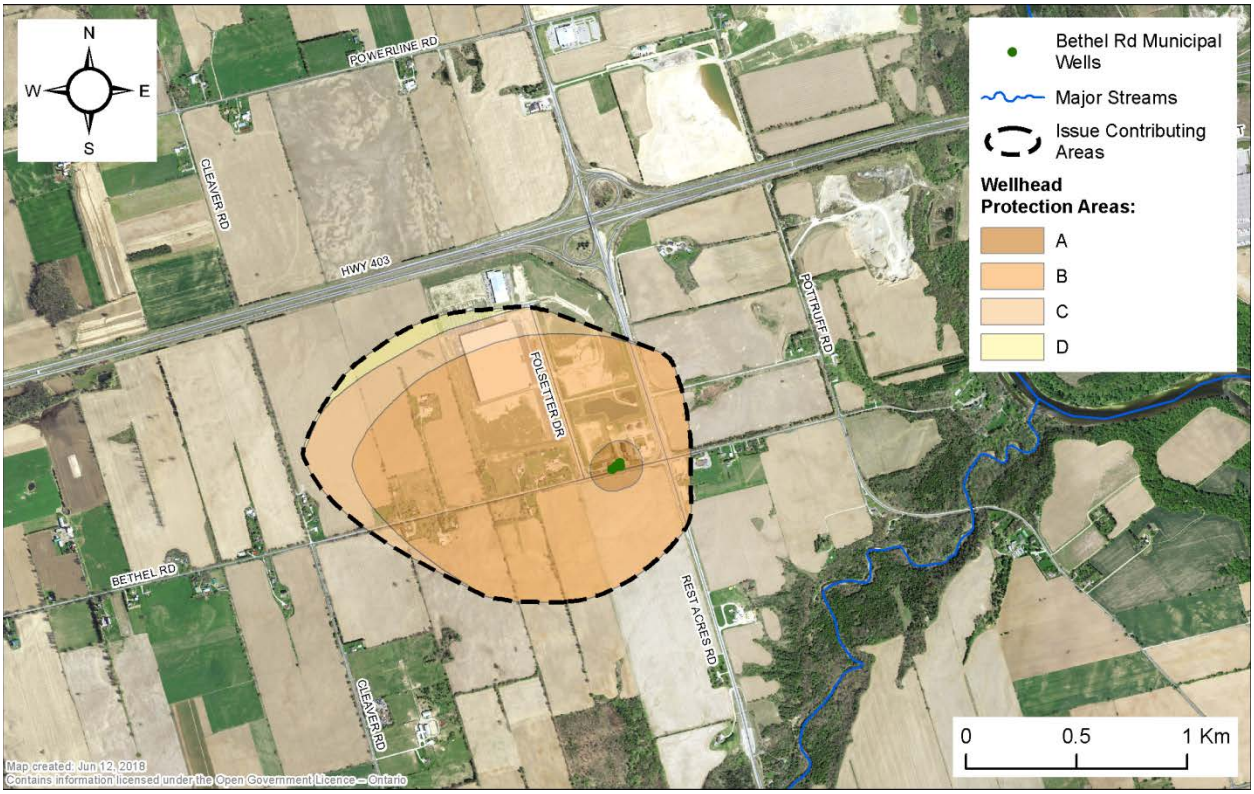

Figure 3: Bethel Road Wellfield Issue Contributing Area for Nitrate

Review of Nitrate Concentrations

Nitrate concentrations for the Bethel Road supply wells are illustrated on **Figure 4**. Elevated nitrate concentrations at P52 (approximately 9 mg/L) began to decrease in 2014, as they continued to decrease to levels below 1 mg/L by the end of 2016, where concentrations have remained stable. Nitrate concentrations in P51, P53 and P54 show a decreasing trend from

2015 (approximately 5 mg/L) to end of 2016 (less than 2 mg/L), where concentrations have remained stable.

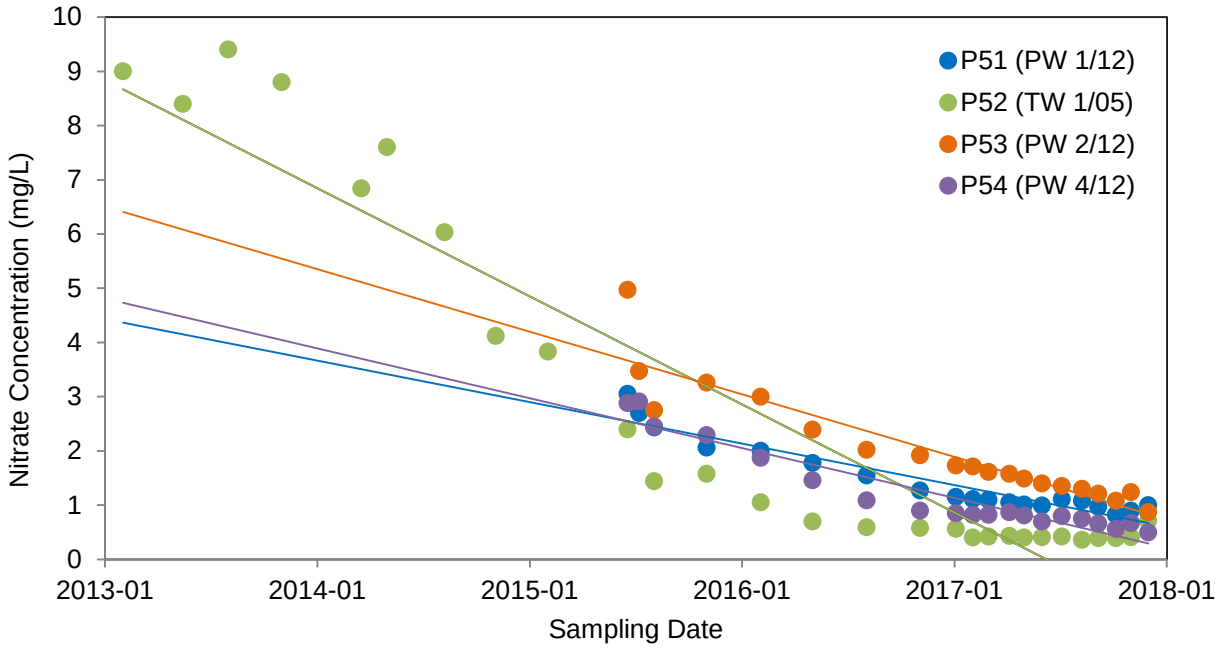

Figure 4: Nitrate Concentrations at the Bethel Road Municipal Supply Wells

Next Steps

Since 2012, areas surrounding the Bethel Road wellfield have experienced a land use change from agricultural to industrial (i.e. parking lots and buildings). The area has been developing over time and as more surfaces are paved the less agricultural practices occur. It is very unlikely that nitrate levels will increase in the area as many of the agricultural lands are no longer there.

On the basis of the above, staff recommends that the nitrate ICA be removed from the Bethel Road wellfield.

St. George Water Supply System

Background

The existing St. George municipal water supply system consists of three productions wells: Well 1, Well 2, and Well 3, all screened in an overburden aquifer from 15 to 23 m bgs. The community requires an additional water supply for redundancy and to support future growth, therefore two bedrock test wells were cased to 57 m bgs with an open hole in the bedrock aquifer. A re-delineation of the nitrate ICA was done as part of the technical work completed for the existing overburden St. George wells. The WHPAs and nitrate ICA are presented on **Figure 5**. The monitoring data and surrounding land use suggest the possibility of contamination from agricultural activity within the WHPA.

In 2008, the County made efforts to educate local farmers within the WHPAs of the use of Agricultural Best Management Practices. At this time the County is unaware if the local farmers are using new technology to achieve best management practices. The County is currently working on speaking with landowners and farmers directly to learn about their farming practices

prior to and after 2008. This information will help gain an understanding of where the nitrate is being applied and the impacts to the production wells.

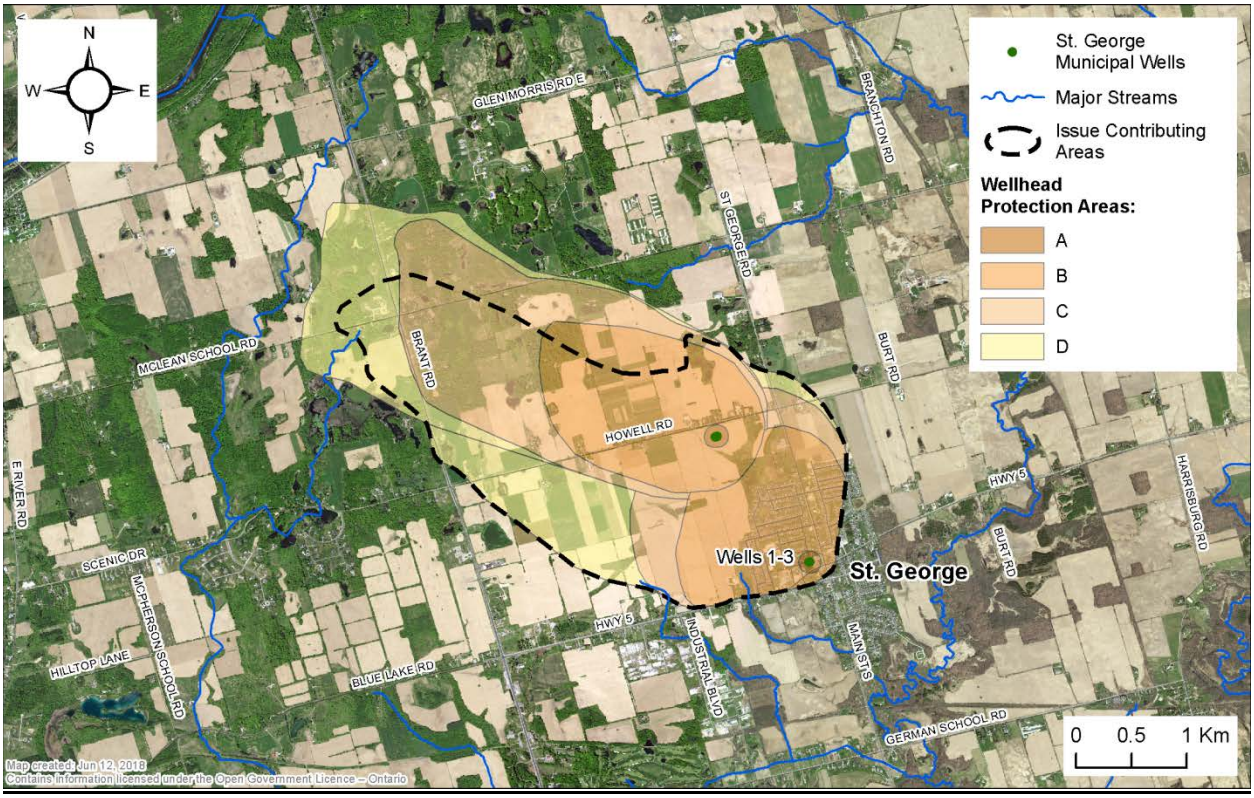

Figure 5: St. George Wellfield Issue Contributing Area for Nitrate

Review of Nitrate Concentrations

Nitrate concentrations for the St. George supply wells are illustrated on **Figure 6.** Elevated nitrate concentration in the three overburden wells have slowly declined from approximately 6 mg/L in 2008 to lower, but variable concentration from 2014 to 2018 (ranging from 4 to 5 mg/L).

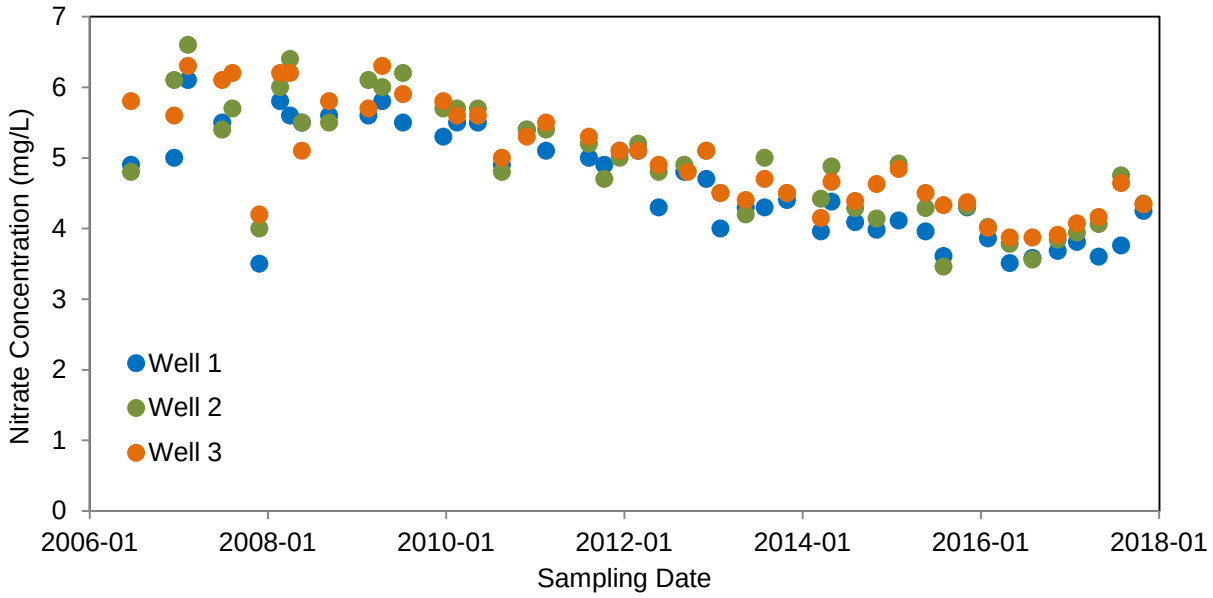

Figure 6: Nitrate Concentrations at the St. George Municipal Supply Wells

Next Steps

Although nitrate concentrations at the St. George wellfield have decreased overtime, it is still unclear as to why this is occurring. Further work and monitoring is required to determine the cause of the nitrate concentration decreases.

Staff recommends that the County continue to monitor, evaluate and report on nitrate concentrations at the St. George wellfield.

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Reviewed by:

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Senior Hydrogeologist

Approved by:

Martin Keller, M.Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-08 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Bright Water Quality WHPA Update Technical Study

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-08 – Bright Water Quality WHPA Update Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the results of the Bright Water Quality WHPA Update Technical Study into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

SUMMARY:

Two groundwater supply wells provide municipal water to the community of Bright, within the County of Oxford. Wellhead Protection Areas (WHPAs) were last delineated for the municipal wells in 2010 using a circa-2001 local-scale groundwater flow model. Since that time, the Whitemans Creek Tier 3 groundwater flow model has been developed, which represents the most current science and conceptual understanding of the area. The objective of the current technical study is to delineate WHPAs and assign vulnerability scores for the Bright municipal wellfield using the Whitemans Creek Tier 3 groundwater flow model.

Results are recommended to be incorporated into the update to the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

REPORT:

System Overview

The community of Bright is located within the Whitemans Creek Subwatershed, approximately 30 km northeast of Woodstock and approximately 25 km southwest of Kitchener, within the County of Oxford. The Bright municipal wellfield consists of two overburden wells, Wells 4A and Well 5. The wells are screened from 20.57 to 26.67 metres below ground surface (m bgs) and 24.9 to 25.9 m bgs, respectively and screened within the Waterloo Moraine aquifer. Both wells are considered not to be groundwater under direct influence of surface water (GUDI) by as per the criteria outlined in MOECC (2001), according to the County of Oxford Water Systems Drinking Water Quality Management System Operational Plan.

Wellhead Protection Areas

The Bright wellfield falls within the study area of the Tier 3 Water Budget and Risk Assessment for the Whitemans Creek subwatershed (Earthfx, 2018). As part of the Tier 3 study, a detailed analysis of the local geology surrounding the Bright wellfield was completed.

The Bright municipal supply wells are screened in the Waterloo Moraine Aquifer. The aquifer is between 5 and 30 m thick in the wellfield vicinity and confined by the poorly drained, low permeability Port Stanley Till. Below the Waterloo Moraine Aquifer, the Maryhill Till aquitard, and the older Catfish Creek Till aquitard provide vertical confinement for the deeper overburden aquifers.

Locally, high groundwater levels are observed in the overburden to the east of the Bright municipal wellfield, where high recharge is believed to occur. Here, groundwater flow in the overburden fans out in multiple directions and causes groundwater flow through the municipal wellfield to be from the northeast to the southwest.

Bright WHPAs were simulated with a cumulative municipal pumping rate that was equivalent to the maximum permitted rate of the wellfield (3.78 L/s). A continuous rate of 3 L/s was applied to Well 4A and a rate of 0.78 L/s was applied to Well 5.

The resulting WHPAs are shown on **Figure 1** along with the previous WHPAs. WHPA-D extends approximately 1.4 km to the northeast following the general direction of local groundwater flow patterns in this area. Differences between the 2010 and 2018 WHPA shape, size and direction result from a number of factors including:

- new municipal wells with updated pumping rates,
- revised hydrostratigraphic conceptualization, and
- revised recharge rates and distribution developed from the Tier 3 study.

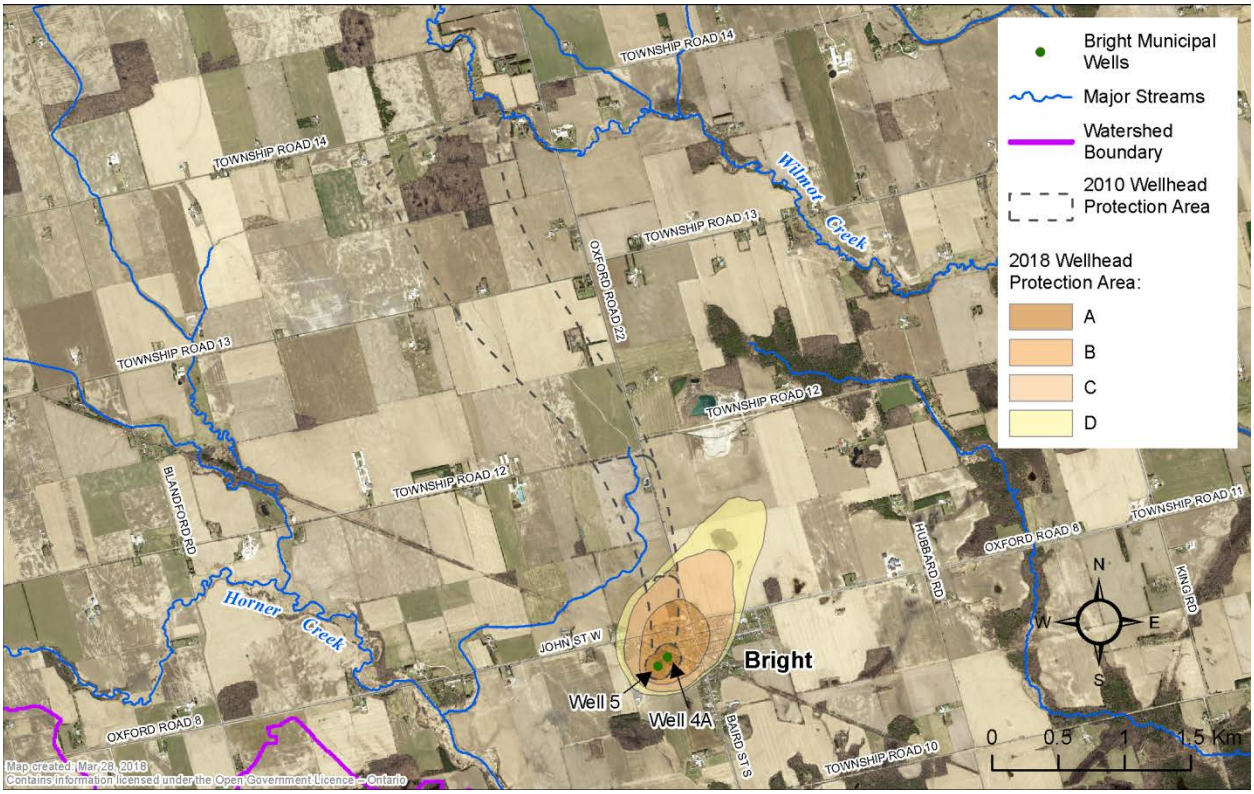

Figure 1: Bright WHPAs. Dashed lines represent previous WHPAs.

Well 4A and Well 5 are both classified as non-GUDI and hence a WHPA-E was not delineated. Delineation of a WHPA-F was not required based on the absence of a WHPA-E.

Vulnerability Scoring

The surface to well advective time (SWAT) method was used in this study to delineate areas of low, medium and high vulnerability within the WHPAs. Resulting vulnerability scores within the Bright WHPAs are summarized in **Table 1.**

Table 1: WHPA Vulnerability Scores – SWAT

	Surface to Well Advective Time (SWAT)		
	High (0 to 5 years)	Medium (5 to 25 years)	Low (>25 years)
WHPA – A	10	10	10
WHPA – B	10	8	6
WHPA – C	8	6	2
WHPA – D	6	4	2

Potential transport pathways were reviewed as part of this study, the results of which included two sources of potential pathways: 1) wells identified within MOECC's Water Wells Information System constructed prior to 1990 and 2) aggregate extraction pits. In both cases the vulnerability scores were not adjusted to account for these potential transport pathways. It is recommended that the vulnerability not be increased for presence of non-municipal wells until a well inventory is completed to verify their location and status. Two properties licensed for aggregate extraction were identified just outside the WHPA-D; therefore vulnerability was not adjusted to account for their presence. If these areas of extraction were to expand into the WHPA in the future, the vulnerability scoring should be re-evaluated.

The resulting map with vulnerability scores within the new WHPAs is shown on **Figure 2**.

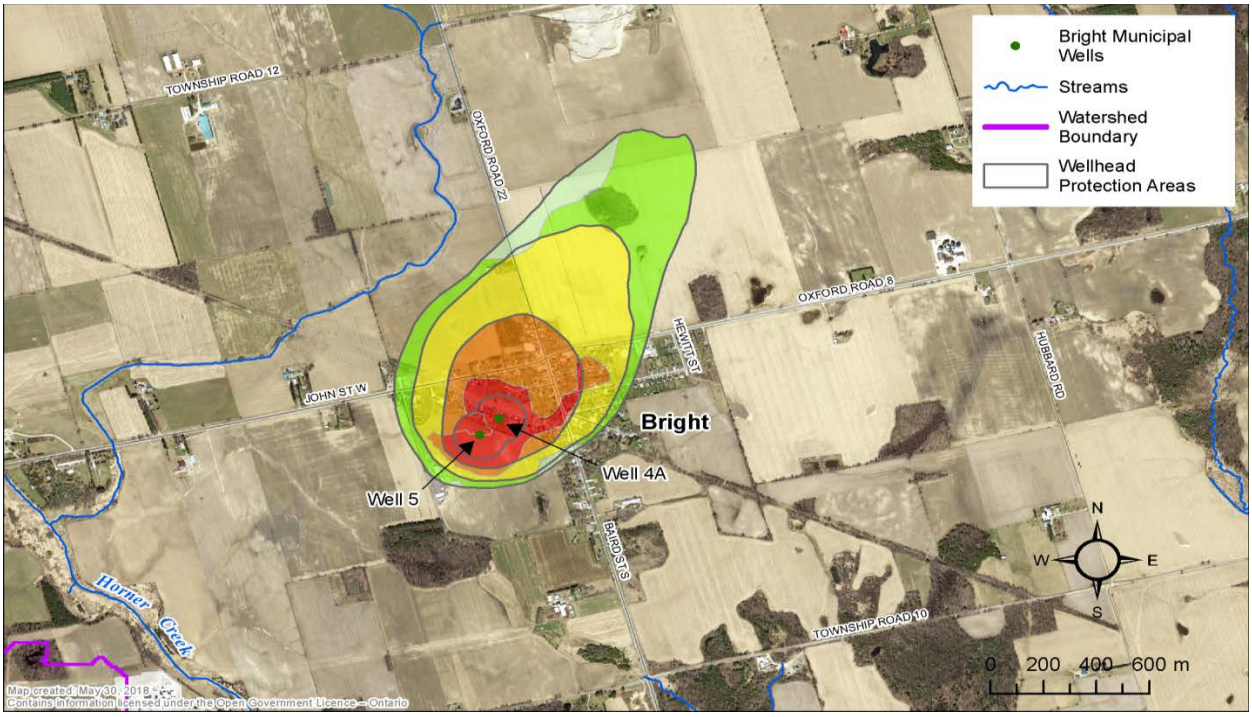

Figure 2: Vulnerability scoring within Bright WHPAs

Next Steps

The results of this study are recommended to be incorporated into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

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Reviewed by:

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Senior Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-09 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Region of Waterloo Water Quality WHPA Technical Study

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RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-09– Region of Waterloo Water Quality WHPA Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the updated Region of Waterloo WHPAs into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

SUMMARY:

Updated water quality WHPAs for the Region of Waterloo's 26 municipal groundwater supply systems were delineated based on the Region of Waterloo (the Region) Tier 3 groundwater model. In general, the new WHPAs are larger than the existing, specifically longer and narrower, and cover a larger portion of the Region; however, this does not directly translate into new requirements on property owners as most of the policies in the outer WHPAs are for education and awareness building to reduce impacts to municipal wells.

Results of the technical study are recommended to be incorporated into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

REPORT:

Background

The Region of Waterloo completed a Tier 3 Water Budget and Water Quantity Risk Assessment project (Tier 3 Assessment) that was presented at the April 2017 Source Protection Committee meeting (report no. SPC-17-04-03). The results of the Tier 3 Assessment concluded that the Region's municipal wells were predicted to be able to meet future water supply demands to 2031, consequently the four WHPA-Q's in the Region of Waterloo were assigned a "low" risk level.

The Tier 3 Assessment groundwater flow model involved comprehensive and well-specific refinements which improved the interpretation of groundwater flow to the wells. As a result, the refined Tier 3 groundwater model was used to delineate updated water quality WHPAs for the Region of Waterloo municipal supply wells.

Water Quality Wellhead Protection Areas

The current WHPAs in the approved Grand River Source Protection Plan and Assessment Report are presented on **Figure 1**, with the updated WHPAs delineated using the Tier 3 groundwater model presented on **Figure 2.**

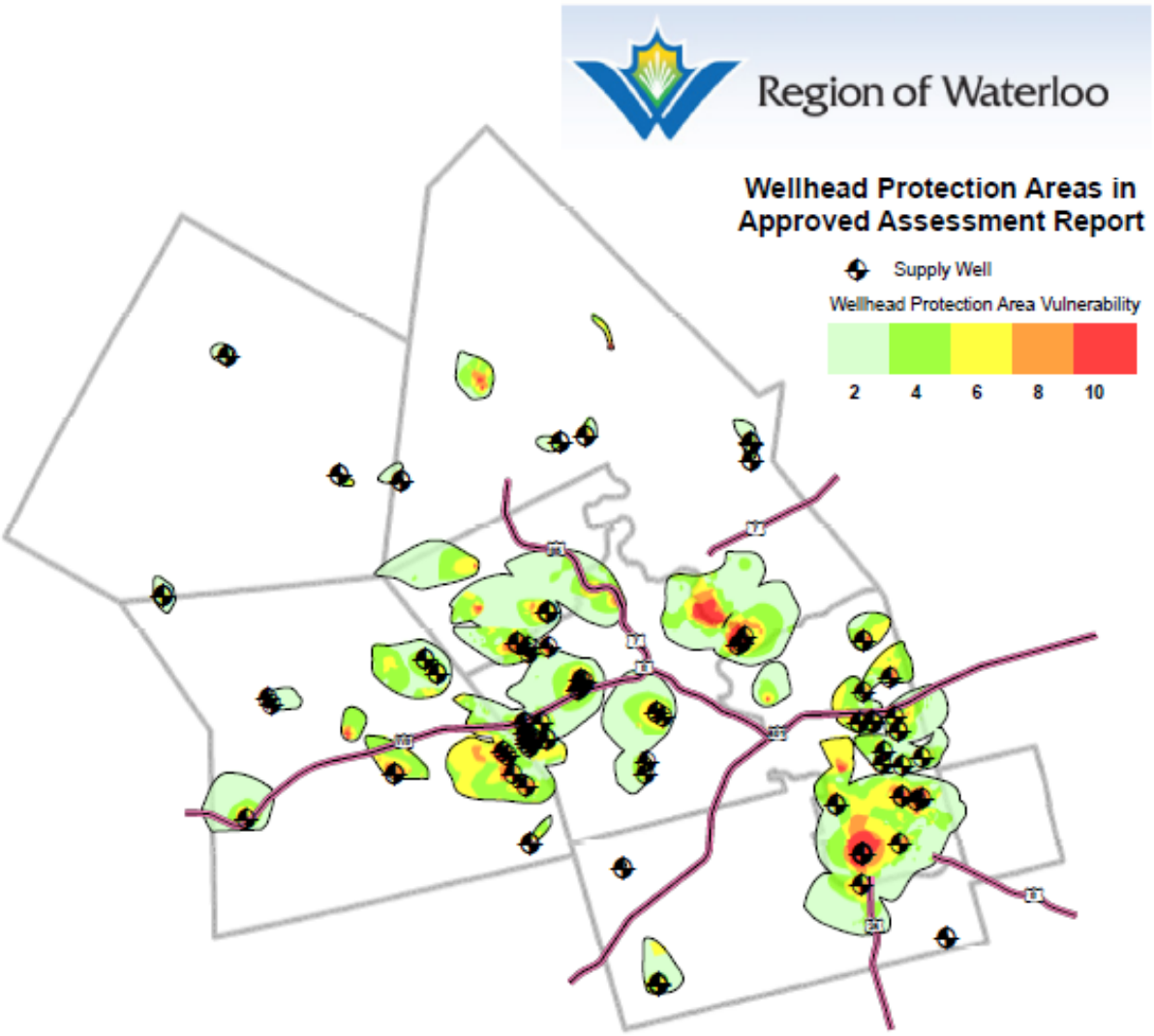


Figure 1: Region of Waterloo Wellhead Protection Areas in Approved Assessment Report

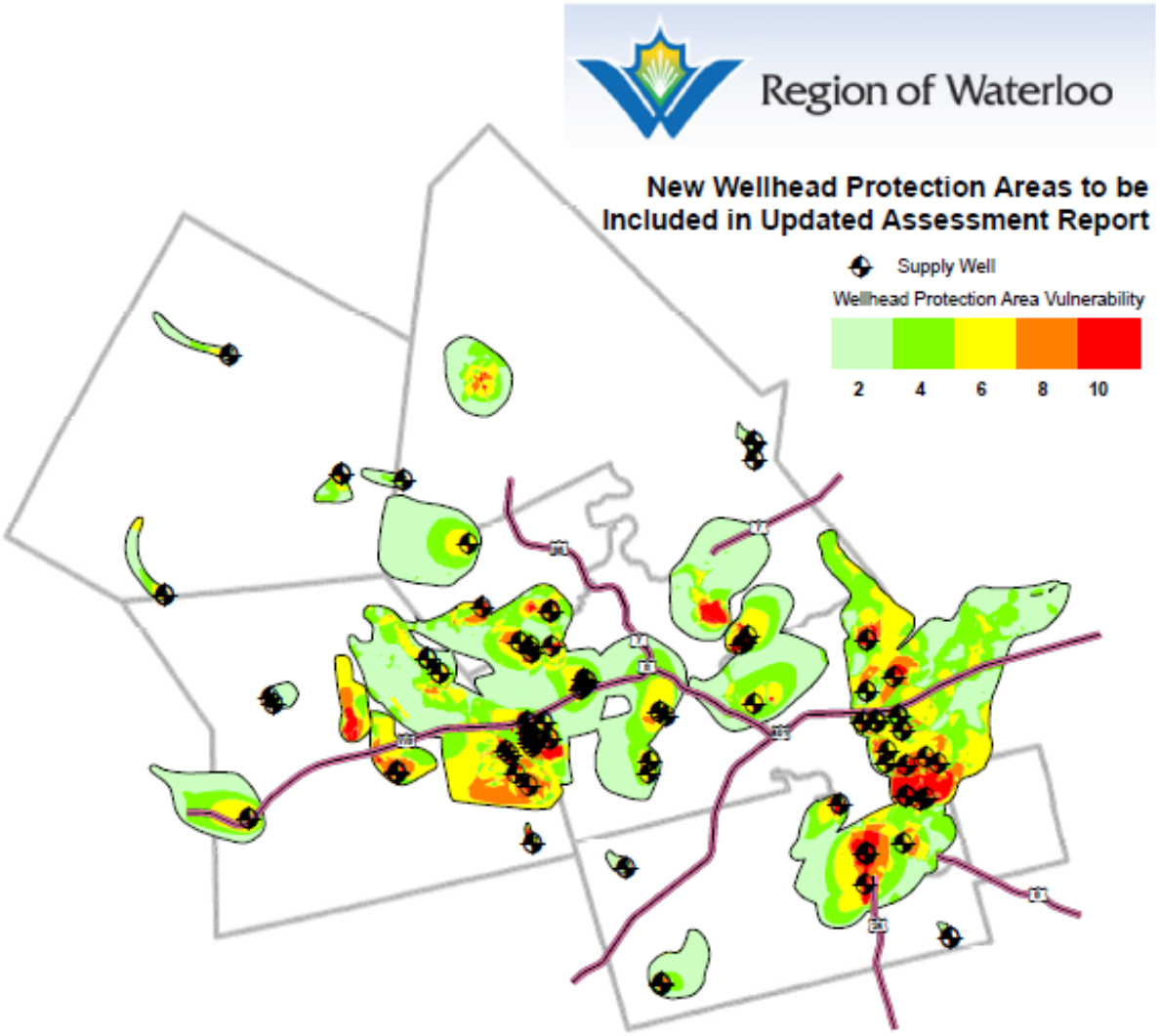


Figure 2: Region of Waterloo Wellhead Protection Areas to be Included in Updated Approved Assessment Report

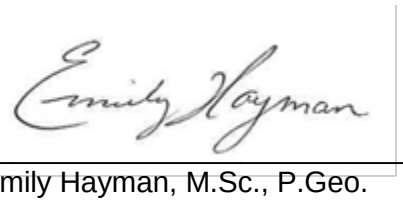
The updated WHPAs are generally larger (narrower and longer), particularly in the Cambridge area. The updated Cambridge WHPAs extend into the adjacent Wellington County and almost to the Guelph boundary, while the updated New Hamburg WHPAs extend further into Perth County. Overall, there is a 46 percent increase in area and a five percent increase in the number of properties where the WHPAs overly. It is important to note that these increases do not directly translate into new requirements on property owners as most of the policies in the outer WHPAs are for education and awareness building to reduce impacts to municipal wells. Differences between the current and updated WHPAs can be attributed to the following:

- Changes in pumping rates for many of the wells, which is based on sustainable rates derived from the Region of Waterloo Water Supply Master Plan;
- Removal of WHPAs due to planned decommissioning of supply wells;
- New WHPAs due to the addition of supply wells within the Region of Waterloo; and
- Improvements in the Tier 3 model with regards to local hydrogeology.

Next Steps

The results of this study are recommended to be incorporated into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

Prepared by:



Emily Hayman, M.Sc., P.Geo.
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Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-10 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Whitemans Tier 3 Water Budget and Local Area Risk Assessment

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RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the components of the report entitled *Whitemans Creek Tier Three Local Area Water Budget and Risk Assessment (Earthfx Inc. May 2018)* into an Updated Grand River Source Protection Area Assessment Report.

SUMMARY:

The Whitemans Tier 3 Water Budget and Local Area Risk Assessment report (May 2018) prepared by EarthFX Inc. has been peer reviewed and finalized in accordance with the Technical Rules under the Clean Water Act, 2006. The risk level assigned to water quantity wellhead protection area (WHPA-Q) for the Bright Wells in Oxford County was low with low uncertainty and for the Bethel Wells in Brant County was significant with high uncertainty. Further work is proceeding on policy development discussions with Brant County and the Ministry of the Environment and Climate Change.

REPORT:

Background

On February 19, 2010, the Ministry of Natural Resources and Forestry confirmed their acceptance of the Grand River Source Protection Area Tier 2 Water Budget and Water Quantity Stress Assessment Report. The Tier 2 Assessment indicated that under drought conditions Bright well 4, in Oxford County, may have insufficient water to continue pumping. As a result of this finding and per the technical rules, the Whitemans Creek subwatershed was assigned a moderate potential for hydrologic stress for groundwater resources. A result of the moderate stress identification is that municipal water supply systems located in the subwatershed are further assessed under a Tier 3 Water Budget and Water Quantity Risk Assessment. In the Whitemans Creek subwatershed, this included the community of Bright wells in Oxford County and the then newly commissioned Bethel Well Field in Brant County.

A Tier 3 Water Budget study is completed in three phases. First, the area of study is characterized and a conceptual model is built to increase the understanding of hydrologic and hydrogeologic processes in the area. Then a complex numerical model is built based on the conceptual model to simulate hydrologic processes. Finally, a Water Quantity Risk Assessment (WQRA) is completed using the numerical model to identify any risk to the long term sustainability of the municipal water supply. These steps are sequential and require peer review and peer reviewer sign-off prior to work moving on to the next phase. The Whitemans Tier 3 Water Budget project was initiated in 2014. The conceptual model was presented to the peer

review team in October 2015, the numerical model in November 2016 and the Water Quantity Risk Assessment in October 2017. Final signoff of the Water Quantity Risk Assessment was completed in May 2018.

Modeling

The hydrologic and hydrogeologic conditions in the Whitemans Creek subwatershed are highly variable. There is significant interaction between the groundwater and surface water systems. In addition, the area has very high seasonal water use to support agricultural irrigation. To address this complexity, a fully-integrated surface and groundwater numerical modeling approach was used. The numerical model covered the entire area of the subwatershed and included the movement of water between the surface and groundwater systems in addition to movement within these systems. To better understand high seasonal water use, an irrigation demand model was developed that incorporated crop type, irrigation methods, irrigation source water and soil moisture accounting. The irrigation demand model was integrated into the surface and groundwater model to allow for changes to irrigation water use to be simulated with changes to climate conditions.

Water quantity wellhead protection areas (WHPA-Q) were delineated for both the Bright municipal wells (see **Figure 1**) and the Bethel Well field (see **Figure 2**). The simulated drawdown for the Bright well field was smaller than the established drawdown threshold and as such the Local Area was delineated as a 100m radius around each well. The Bethel WHPA-Q was delineated based on drawdown from the municipal well field and anticipated recharge reduction from nearby development.

Bright and Bethel Well Field Risk Assessment Results

The risk assessment scenarios predicted that the County of Oxford municipal wells servicing the community of Bright are capable of meeting existing and future water demands for current and future land use during both average climate and drought conditions. Based on the results of the risk assessment modelling scenarios, the WHPA-Q was classified as having a low risk level with low uncertainty.

The results of the risk assessment scenarios predict that the Bethel wellfield is capable of meeting existing water demands for current and future land use during average climate and drought conditions. However, the risk assessment scenario suggests that the wellfield may not be able to meet future demand under drought conditions. Consequently, the WHPA-Q was assigned a risk level of significant. The Bethel system was given high tolerance because of redundancy within the Paris water supply and distribution system to meet peak demands. The Town of Paris is serviced by three well fields and has a large storage reservoir. The significant risk level was given a high level of uncertainty due to the lack of long term history of operations of the well field resulting in only a short period of record available to calibrate the numerical model.

For water quantity wellhead protection areas with a significant risk level, all existing and new water takings located within the area that draw water from the municipal aquifers or activities that reduce groundwater recharge are classified as Significant Drinking Water Quantity Threats (significant threats). Since the Tier 3 Assessment assigned a significant risk level for the Bethel wellfield, all water takings that could potentially impact the municipal systems were identified as well as areas that may have reduced recharge. A total of 19 consumptive demand threats were identified, including both permitted and non-permitted takings, and a total of 243 ha of recharge reduction activities associated with future land development. The significant threats for the

WHPA-Q are shown in **Figure 3**.

Next Steps

Source Protection Authority staff are in early stage discussions with the Ministry of Environment and Climate Change and County of Brant regarding policy development for the identified water quantity threats for the Bethel Well Field. The need for policy development, including any future study needs, will be determined through these discussions.

On the basis of the peer reviewer sign-off of this Water Quantity Risk Assessment report, staff are asking the Lake Erie Region Source Protection Committee for their direction to include the components of the Whitemans Tier 3 Water Budget and Local Area Risk Assessment into the Draft Updated Grand River Watershed Assessment Report.

In the near future, the complete Whitemans Tier 3 Water Budget and Local Area Risk Assessment reports will be posted on the Lake Erie Source Protection Region website for public viewing.

Prepared by:

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Approved by:

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Source Protection Program Manager

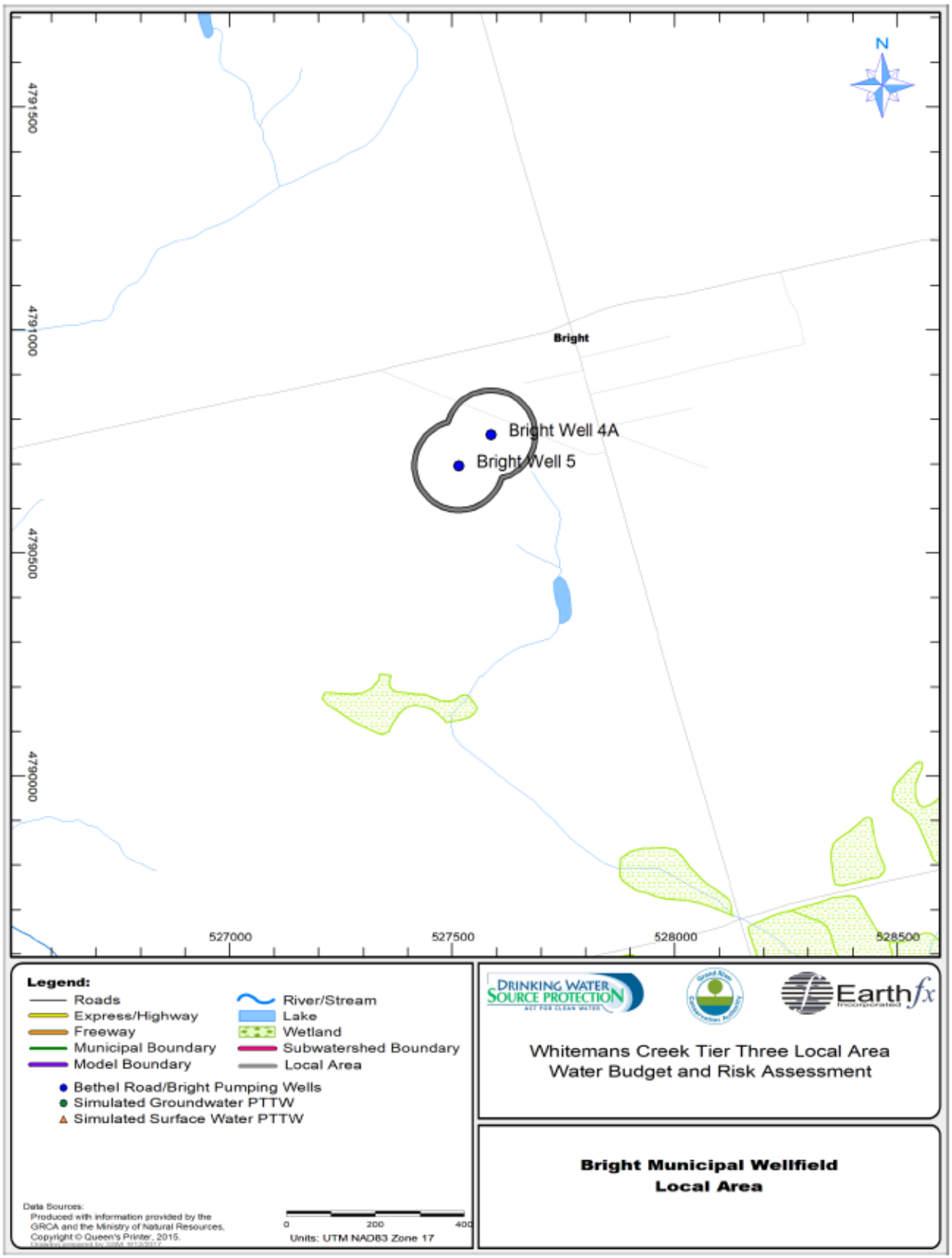

Figure 1. Bright Wellhead Protection Area for Water Quantity (WHPA-Q)

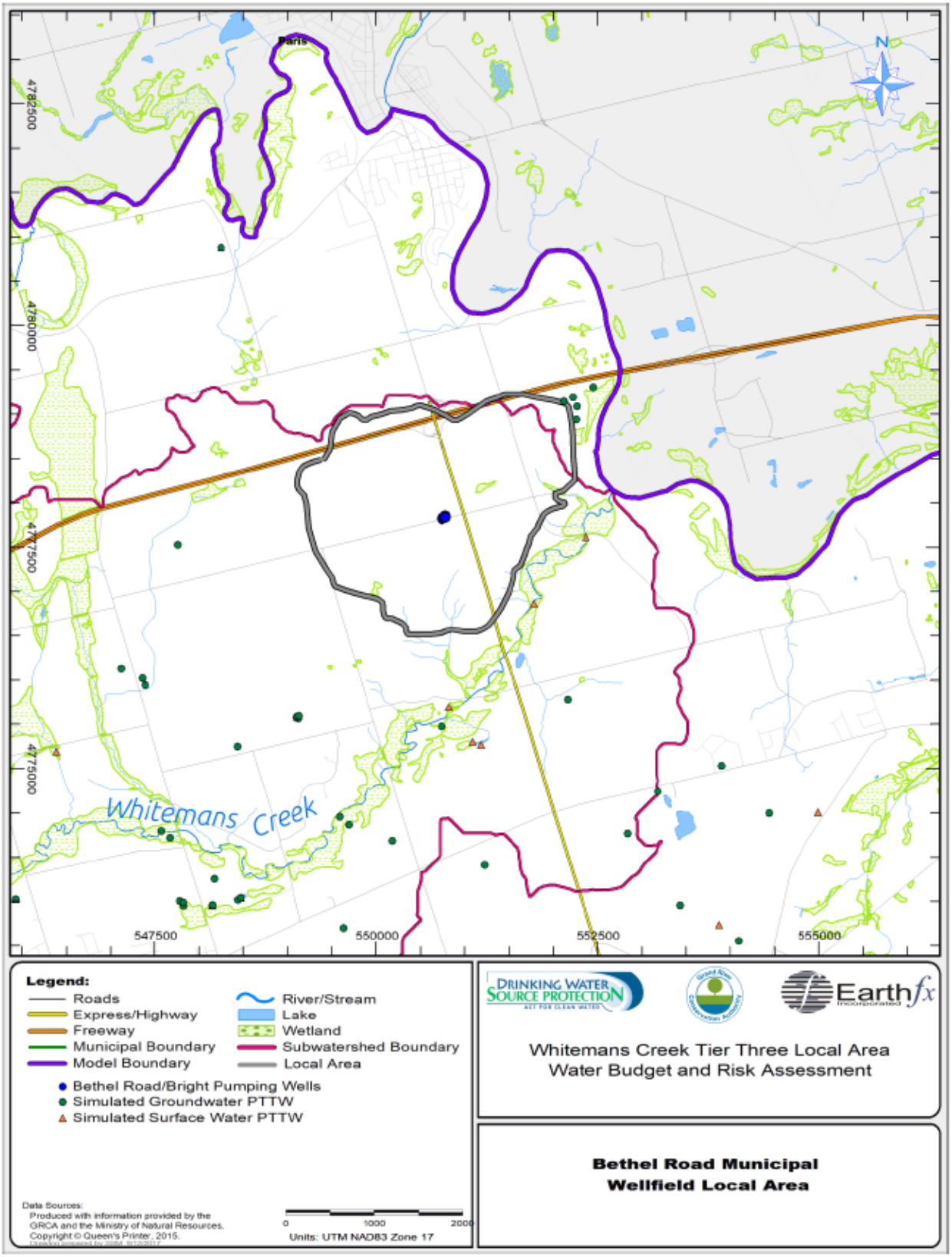

Figure 2. Bethel Well Field Wellhead Protection Area for Water Quantity (WHPA-Q)

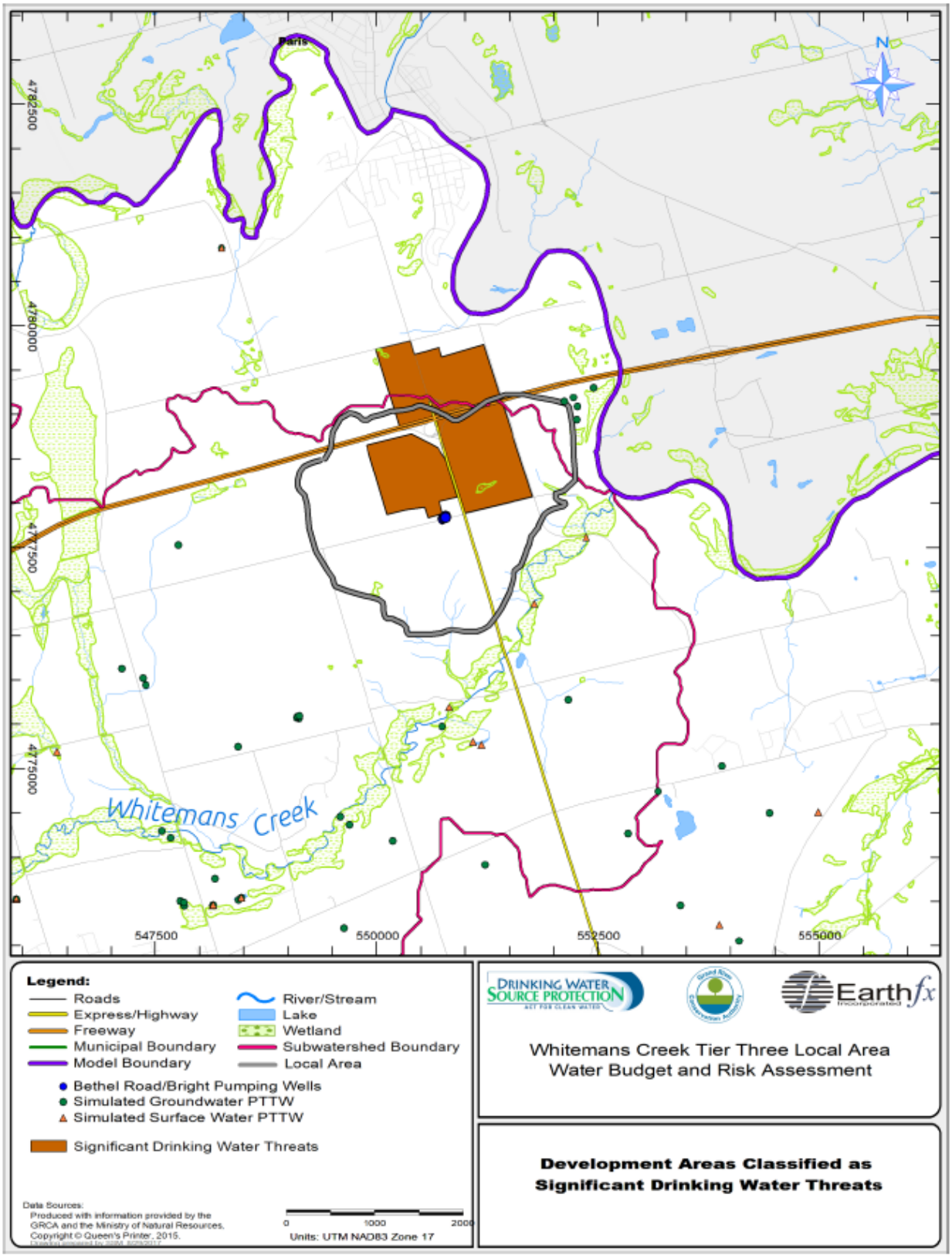

Figure 3. Bethel Well Field WHPA-Q and significant water quantity threats

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-11 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Draft Updated Grand River Assessment Report: Region of Waterloo Tier 3 Water Budget and Local Area Risk Assessment**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-11 – Draft Updated Grand River Assessment Report: Region of Waterloo Tier 3 Water Budget and Local Area Risk Assessment – for information.

REPORT:

Update to the Assessment Report

Technical work for the Region of Waterloo Tier 3 Water Budget and Local Area Risk Assessment (Tier 3 Assessment) was completed and presented to the SPC on April 6, 2017 (Report 17-04-03). The Tier 3 Assessment concluded that the Region of Waterloo's municipal wells were predicted to be able to meet future water supply demands to 2031 under all drought and urban growth scenarios. In addition, reductions in groundwater discharge to sensitive cold-water streams were predicted to be less than 10 percent. Consequently, the four Wellhead Protection Areas (WHPA-Q) delineated within the Region of Waterloo were assigned a low risk level. No water quantity policies needed to be developed as a result of the low risk level.

As part of a S.34 update of the Grand River Source Protection Plan, the Tier 3 Assessment has been incorporated into a new draft section 20 of the updated Grand River Assessment Report. The write up of the new section was led by Region of Waterloo staff. Further work on the Tier 3 section will be necessary, e.g., content revisions and the addition of maps. The Region of Waterloo Tier 3 section includes the following:

- Introduction;
- Groundwater and Surface Water Topography;
- Risk Assessment;
- Risk Management Measures Evaluation;
- Section Summary; and
- References

In addition to updated content, the structure of the assessment report has been revised, notably moving water quantity technical work from the beginning of the document, to newly established sections near the end, e.g., section 20, Region of Waterloo Tier 3. Subsequently, water quality

risk assessments and each municipal water quality section have been renumbered.

Please see **Appendix A** for the new draft section 20 of the assessment report, Region of Waterloo Tier 3 Water Budget and Local Area Risk Assessment.

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Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

Draft Assessment Report, Section 20: Region of Waterloo Tier 3 Water Budget and Local Area Risk Assessment

20.0 TIER 3 WATER BUDGET AND RISK ASSESSMENT

This section describes the Region of Waterloo Tier 3 Water Budget and Local Area Risk Assessment (Tier 3 Assessment) completed for the municipal drinking water systems of the Cities of Kitchener, Waterloo and Cambridge and rural communities of New Dundee, Conestogo, and Elmira, respectively (**Map 10-1**). This project was undertaken to evaluate the current and future sustainability of the water supply wells, and to identify potential threats to the drinking water supplies from a quantity perspective.

20.1 Introduction

Tier 3 Assessments aim to determine if a municipality is able to meet their current and future water demands. Specifically, Tier 3 Assessments estimate the likelihood that a municipal drinking water aquifer or surface water feature (i.e., river or lake) can sustain pumping at their future pumping rates, while accounting for the needs of other water uses such as cold water streams, or other permitted water takers in the area. Tier 3 Assessments consider current and future municipal water demand, future land development plans, drought conditions, and other water uses as part of the evaluation.

Specific tasks completed for the Region of Waterloo's (Region) Tier 3 Assessment included the:

1. Development of detailed numerical models to predict whether or not municipal drinking water aquifers could meet current and future municipal water demands;

2. Evaluation of whether municipal drinking water sources can reliably pump their future (Allocated) pumping rates, while maintaining the requirements of other water uses (e.g. ecological requirements and other water takings);

3. Mapping of water quantity vulnerable areas (areas that contribute water to municipal drinking water systems) and assigning risk levels to those areas; and

4. Identification of water quantity threats that may influence the Region's ability to meet its future (Allocated) rates.

The MOECC released a set of Technical Rules that require Tier 3 Assessments be completed in subwatersheds that have a moderate or significant water quantity stress where there are municipal drinking water supplies. The Tier 2 Assessment for the Grand River Watershed completed by the GRCA identified that a Tier 3 Assessment was required for the Central Grand River Subwatershed (cities of Kitchener, Waterloo and Cambridge) as well as the rural communities of New Dundee, Elmira and Conestogo.

As previously discussed in Section 8 and Table 8-1, the Region of Waterloo operates a total of twenty six (26) municipal drinking water systems that serve a total population of approximately 513,445 residents (2009). The Integrated Urban System (IUS) is comprised of six municipal drinking water systems. It is an interconnected network of wells and a surface water intake on the Grand River in Kitchener (the Hidden Valley Surface Water Intake) which supplies the Mannheim Water Treatment Plant, reservoirs, and pumping stations. The IUS supplies water to approximately 488,342 (2009) people living in the communities of Cambridge, Kitchener, Waterloo, Elmira, Baden, New Hamburg and St. Jacobs. Fourteen (14) smaller water supply systems provide water to settlement areas not connected to the IUS, and which are located in the rural townships (**Table 8-1**). There are three additional drinking water systems that are

currently not active. In all, groundwater is currently extracted from 122 wells throughout the Region and one surface water intake. Together these sources are capable of supplying approximately 269,000 cubic metres of water a day. It is recognized however that this number of wells may change in coming years as wells are decommissioned.

The following sections outline the steps taken in the Tier 3 Assessment to characterize the groundwater systems, develop and calibrate numerical modelling tools, and complete a water quantity risk assessment for the municipal groundwater supplies for the Region of Waterloo.

20.2 Groundwater and Surface Water Characterization

20.2.1 Topography and Physiography

The Waterloo Moraine is a topographic feature present within the western portions of the Region. The Grand River valley lies in the central and eastern portions of the Region and also forms a prominent topographic feature in the area.

The physiography of the Tier Three Assessment study area was shaped by glacial advances and re-advances that ceased approximately 10,000 years ago. Fluvial erosion has also been active in shaping the landscape, especially along the Grand and Speed rivers. Five dominant physiographic regions exist within the Tier 3 Assessment area as described by Chapman and Putnam (1984):

Waterloo Sand Hills (Waterloo Moraine) - the Waterloo Sand Hills lie in the central and western part of the Tier 3 Assessment area. The surface is composed of well drained hills of sandy till or sand and gravel filled kames or kame moraines, with thick sequences of outwash sands occupying the intervening hollows.

Guelph Drumlin Field - the Guelph Drumlin Field is located in the eastern portion of the Tier 3 Assessment area, on the east side of the Grand River, and is characterized by till drumlins fringed by gravel terraces and separated by swampy valleys.

Horseshoes Moraines - this region covers the southeastern portion of the Tier 3 Assessment area and is characterized in this area by the Galt and Paris moraines, and old spillways with broad gravel and sand terraces and swampy floors.

Oxford Till Plain - this region is located in the northern portions of the Region, west of the Grand River, and on the northern reaches of the City of Waterloo and is characterized as a slightly undulating, loam till plain.

Stratford Till Plain - this region is located in the northwestern and southwestern portions of the Region and is described as a level to slightly undulating silty-clay till or silt till plain that slopes gradually to the southwest.

20.2.2 Surface Water Features

From a hydrologic perspective, several large tributaries of the Grand River flow through the Region, including the Conestogo, Speed and Nith Rivers, as well as numerous smaller tributaries such as Alder Creek, Laurel Creek, Schneider Creek, Canagagigue Creek, Hunsberger Creek, Hopewell Creek and Mill Creek.

20.2.3 Geology and Hydrogeology

Geologic Overview

Bedrock beneath the Region consists of limestone, dolostone and shale Paleozoic bedrock formations that overlie deeply buried Precambrian basement rocks (Armstrong and Dodge 2007). The Paleozoic bedrock formations dip regionally to the southwest (Johnson et al. 1992) and in most of the western portions of the Region outside Cambridge, the bedrock is deeply buried beneath thick Quaternary-aged overburden sediments. Paleozoic bedrock outcrops in the Cambridge area along the banks of the Grand River valleys, and in the southeast corner of the Region in the Rockton area.

Paleozoic bedrock formations that underlie the Region are listed in **Table 10-2**, with the youngest Formations listed at the top of the table and the oldest deposits at the bottom. Researchers at the Ontario Geological Survey (OGS) studied the bedrock formations within the Region (Brunton 2008; Brunton 2009), and re-interpreted the depositional environment under which the formations were laid down. **Table 10-2** outlines the current understanding of the Paleozoic bedrock beneath the Region.

Table 10-2 Paleozoic Geology Beneath the Region of Waterloo

Previous Conceptualization		Revised Conceptualization		Lithology Description
Formation	**Member**	**Formation**	**Member**	
Bois Blanc Fm.		Bois Blanc Fm.		Grey-brown, cherty, thin- to medium-bedded and fine- to medium-grained fossiliferous limestone
Bass Island Fm.		Bass Island Fm.		Grey-buff, dense dolostone
Salina Fm.		Salina Fm.		Interbedded dolostone, mudstone and shale with lenses of evaporates
Guelph Fm.		Guelph	Hanlon	Cream coloured, medium- to thick-bedded, fossiliferous grainstones, wackestones, and reefal complexes
			Wellington	
Amabel	Eramosa	Eramosa	Stone Road	Cream coloured, coarsely crystalline dolostone
			Reformatory Quarry	Light brown-cream, thickly bedded, coarsely crystalline dolostone
			Vinemount	Grey-black, thinly-bedded, fine crystalline dolostone with shaley beds
	Wiarton / Colpoy / Lions Head	Goat Island	Ancaster	Grey, cherty, fine crystalline dolostone
			Niagara Falls	Fine crystalline, cross-laminated crinoidal grainstone with small reef mounds
		Gasport	Gothic Hill	Cross-bedded crinoidal grainstone-packstone with reef mounds and shell beds
		Rochester		Calcareous shale with carbonate interbeds
		Irondequoit		Thick-medium bedded crinoidal limestone
		Rockway		Green-grey fine crystalline argillaceous dolostone with shaley partings

Previous Conceptualization		Revised Conceptualization		Lithology Description
Formation	**Member**	**Formation**	**Member**	
		Merritton Fm.		Pinkish-brown, fine crystalline dolostone with shaley partings
Cabot Head / Reynales Fm.		Cabot Head Fm.		Grey-green non-calcareous shale interbedded with sandstone and limestone
(after Brunton 2008, 2009)				

Overburden units deposited during the Quaternary period (2 million to 10,000 years ago) detail a record of repeated ice advance and retreat of ice lobes that originated from the Huron-Georgian Bay and the Erie-Ontario lake basins (Bajc and Shirota 2007). The overburden sediments within the Region range from Mid-Wisconsinan age fine and coarse textured tills to recently deposited coarse-grained sands and gravels along the banks of the Grand, Speed and Nith rivers. The overburden units, as interpreted and outlined in Bajc and Shirota (2007), are listed in **Table 10-3** (from youngest to oldest). In the naming convention used by Bajc and Shirota (2007), the first two letters identify if the unit is interpreted as an aquitard (AT) or an aquifer (AF), while the latter two characters correspond to the sequence of the units, with A (and 1) as the youngest grouped sequence and F (and 3) as the oldest.

Descriptions of the geologic units within the Tier 3 Assessment area on a regional scale are described in Bajc and Shirota (2007), summarized in the Physical Characterization Summary Report (AquaResource 2009e), and discussed on the well field scale in the well field characterization reports (Blackport 2012a, 2012b; Golder 2011a, 2011b, 2011c; Stantec 2009, 2012a, 2012b, 2012c).

Table 10-3 Overburden Geology within the Waterloo Moraine

OGS Layer Name	Interpreted Units	Predominant Materials
ATA1	Whittlesey clay	Silt and Clay
AFA1	Whittlesey sand	Very fine to coarse sand
ATA2	Wentworth Till (may contain abundant stratified drift)	Stony, sandy till
AFA2	Outwash deposits (mainly Grand River valley outwash)	Coarse sand and gravel
ATA3	Fine-grained deposits in the Grand River valley (beneath AFA2)	Sandy silt and silt
ATB1	Upper Maryhill Till, Port Stanley, Tavistock, Mornington and Stratford Tills	Silty to clayey till
AFB1	Upper Waterloo Moraine Stratified Sediments and equivalents	Fine sand, some gravel
ATB2	Middle Maryhill Till and equivalents	Silty to clayey till, silt, clay
AFB2	Middle Waterloo Moraine Stratified Sediments and equivalents	Fine sand, some gravel
ATB3	Lower Maryhill Till and stratified equivalents	Silty to clayey till, silt,

OGS Layer Name	Interpreted Units	Predominant Materials
		clay
AFB3	Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash	Sand, some gravel
ATC1	Upper / Main Catfish Creek Till	Stoney, silty to sandy till
AFC1	Middle Catfish Creek Stratified Deposits	Sand and gravel
ATC2	Lower Catfish Creek Till	Stoney, silty to sandy till
AFD1	Pre-Catfish Creek coarse-grained glaciofluvial/lacustrine deposits	Sand and gravel
ATE1	Canning Drift (till and fine-textured glaciolacustrine deposits)	Silty to clayey till, silt, clay
AFF1	Pre-Canning coarse-textured glaciofluvial/glaciolacustrine deposits	Sand and gravel
ATG1	Pre-Canning coarse-textured till	Stony, silty to sandy till
(after Bajc and Shirota 2007)		

Hydrogeologic Overview

The delineation of hydrostratigraphic units based on lithologic descriptions listed on borehole logs is a rough approximation; however, the available information is used in conjunction with interpretations of the regional and local spatial distribution of geologic units and other available hydraulic data. Units composed primarily of coarser grained overburden materials (e.g., sands and gravels) or highly transmissive bedrock units are referred to as aquifers and units composed of lower permeability overburden (e.g., clay or fine tills) or poorly transmissive bedrock units are referred to as aquitards.

The Region contains overburden water supply aquifers that are primarily associated with coarse-grained sand and gravel deposits, and bedrock water supply aquifers that include the upper fractured bedrock horizon as well as the Guelph and upper to middle Gasport Formations. Aquitard units in the Region include fine-grained glacial tills and poorly transmissive bedrock units such as the Vinemount Member of the Eramosa Formation and the Cabot Head Formation.

Table 10-4 lists and describes the hydrostratigraphic units identified within the Region. Aquifer units listed are defined solely on the basis of the estimated ability of the unit to yield water and do not consider water quality or vulnerability to surficial contamination.

Table 10-4 Hydrostratigraphic Units in the Tier 3 Assessment Area

Layer Type	Unit Type	Interpreted Units	Predominant Materials
Overburden	Aquitard	Whittlesey clay (surficial geology) [ATA1]	Silt and clay
	Aquifer	Whittlesey sand [AFA1]	Very fine to coarse sand
	Aquitard	Wentworth Till (may contain	Stony, sandy till

Layer Type	Unit Type	Interpreted Units	Predominant Materials
		abundant stratified drift) [ATA2]	
	Aquifer	Outwash deposits (mainly Grand River valley outwash) [AFA2]	Coarse sand and gravel
	Aquitard	Fine grained deposits in Grand River valley [ATA3]	Sandy silt and silt
	Aquitard	Upper Maryhill Till, Port Stanley Till, Tavistock Till, Mornington Till, etc [ATB1]	Silty to clayey till
	Aquifer	Upper Waterloo Moraine Stratified Sediments and equivalents [AFB1]	Mainly fine sand, some gravel
	Aquitard	Middle Maryhill Till and equivalents [ATB2]	Silty to clayey till, silt, clay
	Aquifer	Middle Waterloo Moraine Stratified Sediments and equivalents [AFB2]	Mainly fine sand, some gravel
	Aquitard	Lower Maryhill Till and stratified equivalents [ATB3]	Silty to clayey till, silt, clay
	Aquifer	Lower Waterloo Moraine Sediments or Catfish Creek Till Outwash [AFB3]	Sand, some gravel
	Aquitard	Upper/ Main Catfish Creek Till [ATC1]	Stoney, silty to sandy till
	Aquifer	Middle Catfish Creek Stratified Deposits [AFC1]	Sand and gravel
	Aquitard	Lower Catfish Creek Till [ATC2]	Stoney, silty to sandy till
	Aquifer	Pre-Catfish Creek coarse-textured glaciofluvial/ lacustrine deposits [AFD1]	Sand and gravel
	Aquitard	Canning Drift (till, associated fine-textured glaciolacustrine deposits) [ATE1]	Silty to clayey till, silt, clay
	Aquifer	Pre-Canning coarse-textured glaciofluvial/ glaciolacustrine deposits [AFF1]	Sand and gravel
	Aquitard	Pre-Canning coarse-textured till [ATG1]	Stony, silty to sandy till
Bedrock	Contact Zone Aquifer	Fractured bedrock and overlying basal unconsolidated deposits	Coarse-grained deposits on weathered bedrock
	Aquifer	Bois Blanc Fm.	Grey-brown, cherty, thin- to medium-bedded and fine- to medium-grained fossiliferous limestone
	Aquifer	Bass Island Fm.	Grey-buff, dense dolostone
	Aquifer/ Aquitard	Salina Fm.	Interbedded dolostone, mudstone and shale with lenses of evaporites
	Aquifer	Guelph Fm. and Stone Road Mbr, Eramosa Fm	Medium to thick bedded fossiliferous dolostone

Layer Type	Unit Type	Interpreted Units	Predominant Materials
	Aquifer/ Aquitard	Eramosa Fm; Reformatory Quarry Mbr	Thickly bedded, coarsely crystalline dolostone
	Aquitard	Eramosa Fm; Vinemount Member	Thinly, shaley bedded, fine crystalline dolostone
	Aquifer/ Aquitard	Goat Island Fm.	Chert-rich, fine crystalline dolostone and crinoidal grainstone
	Aquifer	Upper Gasport Fm.	Cross-bedded grainstone-packstone with sequences of reef mound and coquina lithofacies
	Aquifer	Middle Gasport Fm.	Cross-bedded grainstone-packstone with reef mounds and coquina lithofacies; High transmissivity
	Aquifer/ Aquitard	Lower Gasport Fm.	Cross-bedded grainstone-packstone with sequences of reef mound and coquina lithofacies

Stratigraphic units immediately below the Gasport include the Rochester, Irondequoit, Rockway and Merritton units which comprise a regional aquitard (< 5 m thick); this is further underlain by the Cabot Head Formation, which is considered to be a very low hydraulic conductivity shale unit. These units were excluded from the model; little exchange of water between the Gasport Formation and the underlying low hydraulic conductivity formations were interpreted.

The conceptual hydrostratigraphic framework presented in **Table 10-4** was used as the basis for the development of the groundwater models used in the Tier 3 Assessment. Further details are provided in Matrix and SSPA (2014).

Local Characterization

Considerable work has been conducted in the Region over the last 40 plus years to refine the understanding of the geology and water resources. Historically, geological information from borehole logs was used to build or refine a conceptual geological model. In previous studies, the details regarding the depositional environments and/or structure of the Quaternary sediments throughout the Region were not examined in full detail. Key geologic units such as the Maryhill Till or the Catfish Creek Till were often used as “marker” units to attempt to interpret the vertical hydrostratigraphic location of sand and gravel (aquifer) units. These aquifer units were then laterally “connected” based on whether they were found above or below the more regional till units.

The geologic model evolved into a multi-aquifer system of aquifers separated by aquitards. The complexity of the multi-aquifer system was refined at individual well fields, usually by drilling several boreholes and installing numerous observation wells in different geologic units. Pumping tests or well field shut down tests were conducted, depending on operational constraints, and transmissivity and storage coefficients were estimated using the results of the pumping tests. Additional data on hydraulic conductivity values of various geologic units were obtained through response testing of monitoring wells, and in some cases local groundwater flow models were developed. In the last 10 to 15 years from when most of the work for this assessment was

completed, broader-area models were developed to refine the conceptual geologic interpretation on a more regional scale.

As previously discussed, the basis for the conceptual model used in the Regional Numeric Model was the three-dimensional geologic model developed by the OGS (Bajc and Shirota 2007). The OGS developed their hydrostratigraphic layer structure based on new and archived subsurface geologic and geophysical data, published information on the Quaternary geology, re-logging of selected archived core, examining available sediment exposures, drilling and logging additional cores and geophysical techniques. These data were used to develop a three-dimensional overburden model of the Region containing 18 hydrostratigraphic units. The OGS hydrostratigraphic interpretation was incorporated as developed into the Regional Numeric Model; however, the Tier 3 Assessment reduced the number of overburden layers to twelve (AquaResource 2010b). **Table 10-5** describes the overburden layer designations used in the Regional Model.

The bedrock stratigraphic understanding developed by the OGS (Brunton 2008, 2009) was similarly used as the basis for characterizing the hydrogeologic conditions throughout the Cambridge area model. **Table 10-5** describes the bedrock layer designations used in the Cambridge Model.

Table 10-5 Hydrostratigraphic Units in the Tier 3 FEFLOW Models

<table>
<tr><th rowspan="2">OGS Name</th><th rowspan="2">Interpreted Units</th><th colspan="2">Regional Model</th><th rowspan="2">Cambridge Model</th></tr>
<tr><th>Waterloo Moraine</th><th>Cambridge Area</th></tr>
<tr><td></td><td>Surficial Geology</td><td>Layer 1</td><td>Layer 1</td><td>Layer 1</td></tr>
<tr><td>ATA1</td><td>Whittlesey clay</td><td rowspan="5">Units not present in the Waterloo Moraine area.</td><td rowspan="3">Layers 2 and 3</td><td rowspan="3">Layer 2</td></tr>
<tr><td>AFA1</td><td>Whittlesey sand</td></tr>
<tr><td>ATA2</td><td>Wentworth Till (may contain abundant stratified drift)</td></tr>
<tr><td>AFA2</td><td>Outwash deposits (mainly Grand River valley outwash)</td><td>Layer 4</td><td rowspan="2">Layer 3</td></tr>
<tr><td>ATA3</td><td>Fine-grained deposits in the Grand River valley (beneath AFA2)</td><td>Layer 5</td></tr>
<tr><td>ATB1</td><td>Upper Maryhill Till, Port Stanley, Tavistock, Mornington and/or Stratford Tills</td><td>Layer 3</td><td>Layers 6 and 7</td><td>Layer 4</td></tr>
<tr><td>AFB1</td><td>Upper Waterloo Moraine Stratified Sediments and equiv.</td><td>Layer 4</td><td rowspan="3">Layers 8 and 9</td><td rowspan="3">Layer 5</td></tr>
<tr><td>ATB2</td><td>Middle Maryhill Till and equivalents</td><td>Layer 5</td></tr>
<tr><td>AFB2</td><td>Middle Waterloo Moraine Stratified Sediments and equivalents</td><td>Layers 6 and 7</td></tr>
<tr><td>ATB3</td><td>Lower Maryhill Till and stratified equivalents</td><td>Layer 8</td><td rowspan="5">Layers 10 and 11</td><td rowspan="5">Layer 6</td></tr>
<tr><td>AFB3</td><td>Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash</td><td>Layer 9</td></tr>
<tr><td>ATC1</td><td>Upper/ Main Catfish Creek Till</td><td rowspan="3">Layer 10</td></tr>
<tr><td>AFC1</td><td>Middle Catfish Creek Stratified Deposits</td></tr>
<tr><td>ATC2</td><td>Lower Catfish Creek Till</td></tr>
<tr><td>AFD1</td><td>Pre-Catfish Creek coarse-grained</td><td>Layer 11</td><td>Layers 12</td><td>Layer 7</td></tr>
</table>

OGS Name	Interpreted Units	Regional Model		Cambridge Model
		Waterloo Moraine	Cambridge Area	
	glaciofluvial/lacustrine deposits		and 13	
ATE1	Canning Drift- till and fine-textured glaciolacustrine deposits	Layer 12		
AFF1	Pre-Canning coarse-textured glaciofluvial/glaciolacustrine deposits	Layer 13		
ATG1	Pre-Canning coarse-textured till			
Bedrock	Contact Zone	Layer 14	Layer 14	Layer 8
	Bass Islands, Bois Blanc, Salina Formations	Layer 15 to 21	Formations not present	
	Guelph Formation		Layer 15	Layer 9
	Eramosa Fm., Reformatory Quarry Mbr.	Deeply buried beneath Waterloo Moraine (not part of active groundwater flow system; not simulated)	16	Layer 10
	Eramosa Fm., Vinemount Mbr.		17	Layer 11
	Goat Island Fm.		18	Layer 12
	Upper Gasport		19	Layer 13
	Middle Gasport		20	Layer 14
	Lower Gasport		21	Layer 15
	Cabot Head			

* Bedrock layers transition west of the Grand River (in the Cambridge area) to represent different bedrock units west and east of the moraine. In the Cambridge area, the Bois Blanc, Bass Island and Salina Formations are present west of the Grand River (note: Salina is present east of the Grand River in areas north of Cambridge including Breslau). The remaining units in the table are present throughout the model domain but are deeply buried by overburden and bedrock west of the Waterloo Moraine, where active groundwater flow is interpreted to be negligible. Therefore, Layers 14 to 21 represent groundwater flow in the contact zone, Bois Blanc, Bass Island and Salina Formations west of the Moraine, and layers 14 to 21 represent the Guelph, Eramosa, Goat Island and Gasport Formations in areas east of the Moraine.

Hydraulic conductivity values were assigned to the various hydrostratigraphic units based on data collected from pumping tests, response tests and values found in the literature for similar types of geologic materials. Average values were initially assigned to each hydrostratigraphic unit. The hydraulic conductivity estimation processes for the Regional Model and the Cambridge Model are described in Matrix and SSPA (2014).

In addition, the model layer structure was updated as part of the Tier 3 Assessment using additional detailed geologic and hydrogeologic characterization within and surrounding municipal wells (Golder 2011a, 2011b, 2011c; Stantec 2009, 2012a, 2012b, 2012c; Blackport 2012a, 2012b). Cross-sections were generated and interpreted across the well field areas, to refine the OGS model layer interpretations. Geologic, hydrogeologic, geochemical and hydraulic information was used to guide the interpretation of the continuity of the aquifers and aquitards and to refine the model layer structure within the well field areas. Boreholes were categorized into high, medium and low quality data, with geologic picks assigned for the various geologic units in each borehole. Data from high quality boreholes were preferentially used to refine the layer structure for each of the hydrostratigraphic units, with lesser quality data used to fill in areas where high quality data were limited.

The model was calibrated to long-term average annual conditions (steady-state) by reducing the discrepancies between the observed and model simulated groundwater elevations within a reasonable margin of error. Hydraulic conductivity values and/or model boundary conditions were adjusted based on available information to improve the fit between the observed and model simulated groundwater elevations and streamflow values. As part of the calibration, individual borehole logs were examined to identify potential areas where till units, for example, may have interbeds of gravel, sand or silt and may be less dense or competent than expected. In these areas, elevated hydraulic conductivity zones within the till layer were created to help achieve a better match between the observed and simulated groundwater elevations. Both the Regional and Cambridge models were calibrated to regional-scale and well-specific steady state calibration targets, as well as to transient well specific pumping test responses.

In addition to the review of the borehole logs, local aquifer response tests were used to provide information on where the hydraulic conductivity values of a portion of an aquifer or aquitard unit may differ from the average value considered in the conceptual model. Pumping or shut down test data were examined to assess the hydraulic connections between aquifers, and between groundwater aquifers and nearby surface water features. Variability in the hydraulic conductivity zones within the test areas were evaluated using the water level responses in monitoring wells screened in different aquifer units or in surface water features.

Whenever available, water quality data were used to verify or refine the conceptual geologic and hydrogeologic models. Long-term general trends in water quality and local surficial sources of contamination were reviewed as part of this assessment. Knowledge of industrial contamination at some municipal wells was used to validate or help refine the local geologic and hydrogeologic conceptual models. The simulated groundwater flow field and gradients were reviewed to ensure the flow from the source area(s) were consistent with the understanding of elevated contaminant concentrations.

The calibration process and updates to the conceptual geologic and hydrogeologic models are discussed in more detail in Matrix and SSPA (2014), and in the individual technical memoranda that summarize the steady-state and transient model calibration for each well field.

Groundwater Flow

Map 10-2 illustrates the model-simulated groundwater level elevation contours produced in the Regional steady-state groundwater flow model for the upper AFB2 (Middle Waterloo Moraine Sands) aquifer. As illustrated, groundwater level elevation contours generally mimic the ground surface topography, and flow converges toward the higher order streams and wetlands. The simulated groundwater elevation contours compare well with the observed elevation contours presented in AquaResource (2009i).

The largest gradients (tightly spaced contours) occurred at regional discharge locations, which include the Grand and Speed rivers. The lowest gradients occurred on the till plains and areas further from the Waterloo Moraine.

Map 10-3 illustrates the model-simulated deep aquifer groundwater level elevation contours from the Regional steady-state groundwater flow model for the lower AFD1 (Pre-Catfish Creek coarse-grained sediments) aquifer. The deep groundwater level elevation contours were similar but more subdued than the shallow elevations. The groundwater level elevation contours converged along the larger river valleys such as the Grand and Speed Rivers. The simulated

groundwater elevation contours compared well with the observed elevation contours presented in AquaResource (2009i).

As the municipal wells in the Cambridge area are most commonly completed in the bedrock or the contact zone between the overburden and bedrock, the groundwater flow assessment focused on the upper bedrock units.

Map 10-4 illustrates the simulated shallow bedrock groundwater level elevation contours from the Regional steady-state groundwater flow model. The groundwater level elevation contours illustrated a similar north-south pattern, with convergence from both the east and west on the Grand River valley. Modelling to date also simulated a broad area of low groundwater elevations south of the Strasburg Well Field, which may be associated with a buried bedrock valley in that area.

The simulated groundwater level elevations in the Upper Bedrock aquifer (Guelph Formation and Reformatory Quarry) in the Cambridge Model are presented on **Map 10-5**. The general trend of simulated groundwater flow in the Upper Bedrock Aquifer was toward the southwest, and groundwater elevation contours converged along the larger river valleys such as the Grand and Speed rivers. The general trend was consistent with the interpreted groundwater flow direction for the area developed for the Guelph Formation (Golder 2011b).

20.2.4 Water Demand and Other Water Uses

Consumptive water demand refers to the amount of water removed from a surface water or groundwater source that is not returned directly to that source. Estimates of consumptive water demand are necessary in water budget assessments to identify subwatersheds that may be under hydrologic stress. This section summarizes the known consumptive water takers identified in the Study Area, separating them into permitted municipal and non-municipal water takings.

All municipal water supply wells within the Region were considered 100% consumptive as water is pumped from groundwater aquifers and discharged to the Grand River via waste water treatment plants. The exception is the Aquifer Storage and Recovery (ASR) wells located in the Mannheim area. These wells were not simulated in the model as water pumped from the Grand River is injected into the groundwater aquifer and then removed a few months later for use. On an average annual basis, this water taking is considered non-consumptive as it is returned to the same source that it was derived.

The evaluation of water demands within the Study Area also considered non-consumptive water uses, such as groundwater discharge for ecological use, to support waste water assimilation, and/or to support recreational water uses. Only groundwater discharge to streams and leakage from streams to aquifers is represented explicitly in the groundwater flow models in the Tier 3 Assessment. However, other water uses rely on a minimum flow or minimum variation in groundwater elevations from the groundwater and surface water systems, so they are assessed as part of the Risk Assessment. Other water uses are also described in this section.

Municipal Water Supply Systems

For the Region of Waterloo Tier Three Assessment, the municipal pumping rates for the 2008 calendar year were selected as the most representative of existing conditions, as all well fields were in operation in 2008 and pumping at fairly consistent rates. The year 2008 also represents

the calendar year when the well field characterization efforts for the Region of Waterloo Tier 3 Assessment were undertaken. The exception to this are the wells at Shades Mill which weren't operating in 2008. For these wells, 2009 average pumping rates were used for the assessment.

The Region recently initiated a review of its approved 2000 (updated 2007) Long-Term Water Strategy (LTWS) to estimate the demand required from each municipal pressure zone within the Region, and how the existing municipal wells could be utilized to meet that demand. The LTWS considered future environmental, social, economic, technical and political implications for each servicing option. Part of that study included the derivation of municipal well field pumping rates to the year 2031.

Building on the LTWS update, as part of the Tier 3 Assessment, the allocated quantity of water (Allocated Rate) was evaluated for each existing groundwater well to meet projected 2031 water demands. The Allocated Rates for the Local Area were established in accordance with the MOE Technical Rules (MOE 2009) and other provincial guidance (MOE 2013). The 2031 Allocated Rates were estimated based on evaluation of the existing and future committed water demand up to the current lawful PTTW taking (MOE 2013). All of the municipal pumping rates proposed in this project were within the current permitted rates, so there were no Planned Demands (i.e. exceeding permitted rates) in this assessment.

The hydrologic and hydrogeologic responses to increases in municipal pumping associated with the 2031 Allocated Rates were assessed using the Tier 3 FEFLOW models.

The 2008 average annual pumping rates and the 2031 Allocated Rates listed in **Table 10-6** are the rates that were used in the Risk Assessment Scenarios.

Table 10-6 Municipal Pumping Rates Applied in the Water Budget Models

Well	Well Field	PTTW Pumping Rate (m^3/d)	2008 Average Annual Pumping Rate (m^3/d)	2031 Allocated Pumping Rate (m^3/d)
G4	Blair Road	1,901	945	-
G4A	Blair Road	1,901	-	1,728
G16	Clemens Mill	3,283	1,666	2,938
G17	Clemens Mill	4,320	1,997	2,160
G18	Clemens Mill	3,269	1,041	1,296
G6	Clemens Mill	2,160	1,346	864
C3	Conestogo (Plains)	786	70	214
C4	Conestogo (Plains)	786	9	38
P6	Dunbar Rd	Grandfathered	884	0
G9	Elgin Street	Grandfathered	1,002	0
E10	Elmira	6,546	0	0
W6A	Erb Street	5,564	1,614	1,296
W6B	Erb Street	4,582	0	1,296
W7	Erb Street	9,092	6,041	6,048
W8	Erb Street	10,474	3,672	2,592
P16	Fountain Street	1,961	0	0

Well	Well Field	PTTW Pumping Rate (m^3/d)	2008 Average Annual Pumping Rate (m^3/d)	2031 Allocated Pumping Rate (m^3/d)
K1	Greenbrook	Max annual daily average of 17,626 m^3/day	372	0
K1A	Greenbrook		0	1,728
K2	Greenbrook		1,874	0
K2A	Greenbrook		0	1,728
K4B	Greenbrook		3,413	1,728
K5A	Greenbrook		957	1,728
K8	Greenbrook		126	864
H3	Hespeler	1,642	561	864
H4	Hespeler	2,074	0	1,296
H5	Hespeler	1.987	383	864
K41	Lancaster	Grandfathered	0	0
K42A	Lancaster	2,290	0	0
K21	Mannheim East	4,925	2,303	2,592
K25	Mannheim East	6,826	3,813	3,456
K29	Mannheim East	5,210	2,503	2,592
K91	Mannheim East Peaking	3,458	674	2,160
K92	Mannheim East Peaking	4,320	813	2,160
K93	Mannheim East Peaking	4,320	813	2,592
K94	Mannheim East Peaking	4,320	843	2,592
K22A	Mannheim West	6,550	1,252	0
K23	Mannheim West	6,566	2,256	432
K24	Mannheim West	6,566	2,562	2,592
K26	Mannheim West	9,092	6,841	6,048
G1	Middleton	Not Specified	3,491	5,184
G14	Middleton	Not Specified	3,206	2,160
G1A	Middleton	Not Specified	3,994	1,728
G2	Middleton	Not Specified	5,366	6,912
G3	Middleton	Not Specified	3,396	4,752
G15	Middleton (Willard)	6,547	2,143	2,592
ND4	New Dundee	983	2	2
ND5	New Dundee	983	222	222
K31	Parkway	Grandfathered	2,567	2,160
K32	Parkway	Grandfathered	2,270	2,592
K33	Parkway	4,550	2,894	3,024
K70	Forwell/Pompeii	13,700	0	0
K71	Forwell/Pompeii		0	0
K72	Forwell/Pompeii		0	0
K73	Forwell/Pompeii		0	0
K74	Forwell/Pompeii		0	0
K75	Forwell/Pompeii		0	0

Well	Well Field	PTTW Pumping Rate (m^3/d)	2008 Average Annual Pumping Rate (m^3/d)	2031 Allocated Pumping Rate (m^3/d)
G5[1]	Pinebush	4,320	1,641	-
G5A[1]	Pinebush	4,320	0	1,296
P10	Pinebush	Grandfathered	2,945	3,110
P15	Pinebush	5,184	962	1,296
P11	Pinebush	5,184	1,136	1,728
P17	Pinebush	5,184	741	
P9	Pinebush	NS	1,474	1,296
G38	Shades Mill	9,850	0	1,296
G39	Shades Mill	9,850	0	2,592
G7	Shades Mill	Grandfathered	2,306	1,728
G8	Shades Mill	2,292	1,204	864
SA3	St. Agatha	518	8	0 (connected via pipeline to urban systems)
SA4	St. Agatha	691	12	
SA5	St. Agatha	273	52	
SA6	St. Agatha	273	37	
K10A	Strange Street	Not Specified	327	432
K11[1]	Strange Street	Not Specified	199	-
K11A[1]	Strange Street	Not Specified	-	1,728
K13	Strange Street	Not Specified	526	1,296
K18	Strange Street	Not Specified	2,160	1,296
K19	Strange Street	Not Specified	216	1,296
K34	Strasburg	4,582	3,184	2,764
K36	Strasburg	2,290	0	0
W10	Waterloo North	3,142	0	1,296
W1B	William Street	5,237	818	432
W1C	William Street	3,274	14	2,160
W2	William Street	5,246	2,384	1,728
W3	William Street	3,024	0	0
K80	Woolner	11,100	0	0
K81	Woolner	11,100	220	0
K82	Woolner	11,100	1,072	0
WM1 to WM4	West Montrose	238	69	0 (water supplied via pipeline from Conestogo)
		TOTAL	105,904	119,448

Notes: [1] Wells G4A, G5A and K11A were drilled in recent years adjacent to the existing wells to supplement (Wells G4A and G5A) or replace (Well K11A) water demands from Wells G4, G5 and K11.

Not specified: Individual pumping rates for the Strange Street Wells are not specified; however, the PTTW specifies a maximum daily rate from all wells of 16,512 m^3/day and a maximum annual daily average of 10,000 m^3/day. Similarly, for the Middleton Wells individual pumping rates are not specified; however, the PTTW specifies a maximum daily rate from all wells of 24,000 m^3/day and a maximum annual daily average of 24,000 m3/day, with an allowance for increasing the maximum daily rates to 30,000 m^3/day for a maximum of 100 days and 35,000 m^3/day for a maximum of 15 additional days, within a calendar year. Individual pumping rates for the Greenbrook Wells are not specified; however, the

PTTW specifies a maximum daily rate from all wells of 37,361 m^3/day and a maximum annual daily average of 17,626 m^3/day.

Grandfathered: These wells have no PTTWs as they were constructed before the implementation of the Ontario Water Resources Act.

In addition to the groundwater pumping rates specified in **Table 10-6**, the Region also extracts water from the Grand River using a surface water intake located at Hidden Valley. Extracted surface water is pumped to the Mannheim Water Treatment Plant where it is treated to drinking water standards and is pumped to the water distribution system. A portion of the treated drinking water is stored in an underground aquifer utilizing the Region's ASR well system. The ASR system is used to store water when surplus water is available and to recover the stored water from the aquifer when needed to meet water demands and operational requirements. As the withdrawal volume of water does not exceed the injected volume, these takings are considered non-consumptive and were not included in the Tier 3 Assessment. The ASR system and the Grand River intake provide additional flexibility and water supply tolerance to the Region during higher demand and/or drought periods.

Non-Municipal Water Demand

Permitted Water Uses

In addition to the municipal supply wells, a total of 233 non‑municipal permitted groundwater wells (sources) existed within the Regional or Cambridge Model domains in 2008. At that time, the 2008 PTTW database and 2008 Water Taking Reporting System (WTRS) database were the most up-to-date databases containing permit and source names, geographic data, coordinates of permits/sources, period of water taking and daily reported pumping rates.

Where data were not available in the WTRS, water demands were estimated using monthly reported water takings collected by the GRCA between 2002 and 2006 (AquaResource 2009a), or consumptive demands were estimated using consumptive use factors (MOE 2007) applied to the maximum permitted rates and maximum allowable days of pumping recorded in the PTTW database.

Non-Permitted Water Uses

The potential impacts of non-permitted groundwater takings (domestic, agricultural and commercial water wells) on the Region's water supply sources were assessed on a local scale in the well field characterization reports for each of the urban well field areas (Blackport 2012a, 2012b; Golder 2011a, 2011b and 2011c; Stantec 2009, 2012a, 2012b and 2012c). Some wells that are located in serviced areas pre-date the supply of serviced water to these areas. Although these wells may no longer be used for potable supply, they may be used for lawn watering or similar uses. Domestic water takings were not simulated in the groundwater flow models, as the sum of the volume of their takings is minor (< 2%) as compared to the average annual municipal and non-municipal permitted demands, and much of this water is interpreted to be returned via septic systems to the same source from which it is withdrawn (AquaResource 2009a).

Other Water Uses; Coldwater Streams and Provincially Significant Wetlands

The Tier 3 Assessment must identify all other water uses and estimate the water quantity requirements for those uses where possible. Other water uses that are relevant to the Study Area include non-municipal groundwater takings (discussed previously), and aquatic habitat, Provincially Significant Wetlands (PSWs), waste water assimilation, and recreational uses,

which are illustrated on **Map 10-6**. The Province of Ontario introduced the use of thresholds to evaluate other water uses. Thresholds applied in the Region's Tier 3 Assessment are discussed in the following sections.

Aquatic Habitat

A Local Area can be designated as having a higher risk level if an adverse impact to cold water fisheries or wetlands is predicted as a result of pumping a supply well at its Allocated Rate. In Ontario, there has been increasing recognition of the water needs of aquatic ecosystems in legislation and policy. For example, water takings in Ontario are governed by the *Ontario Water Resources Act* (Revised Statutes of Ontario 1990, Chapter O. 40) and O. Reg. 387/04 – *Water Taking*. Section 34 of the *Ontario Water Resources Act* requires anyone taking more than a total of 50,000 L/day from a lake, stream, river or groundwater source (with some exceptions) to obtain a PTTW.

The PTTW application process places an emphasis on environmental considerations, such as the potential impact of proposed takings on surface water features and ecological habitats that depend on the interrelationship between groundwater and surface water, to maintain their function in the ecosystem.

The Province has prescribed specific baseflow reduction thresholds that should be used when assigning a Risk Level associated with predicted impacts to cold water fish community streams due to municipal pumping at the Allocated Rates. Within the Region, a Moderate Risk Level would be applied if pumping at the Allocated Rates resulted in a reduction in groundwater discharge to a coldwater stream by an amount that is at least 10 percent of the existing estimated stream flow that is exceeded 80 percent of the time (Qp80), or at least 10 percent of the existing estimated average monthly baseflow of the stream (MOE 2013; MOE and MNR 2010; MNR and MOE 2011).

Map 10-6 shows fish habitat mapping as mapped by the GRCA and MNR. Streams mapped as cold water communities are subject to the Province's groundwater discharge reduction thresholds. Cold water communities within the Kitchener and Waterloo area include the headwaters of Laurel Creek in northwest Waterloo, Strasburg Creek at the Strasburg Well Field, and the main branch of Alder Creek from the Erb Street Well Field south to New Dundee. Other cold water streams include Airport, Hopewell and Idlewood Creeks, located east of the Grand River and the cities of Kitchener and Waterloo. Within the Cambridge area, cold water streams being examined in the Tier 3 Assessment include Mill Creek from the headwaters in the northeast to the Grand River, Moffatt Creek south of the Shades Mill wells, and Blair and Cedar Creeks on the west side of the Grand River.

Provincially Significant Wetlands

The Technical Rules (MOE 2009) also identify PSWs as other water uses that, if significantly impacted by municipal pumping, would result in an elevated Risk Level for the Local Area. The wetland systems within the Study Area include swamps, marshes, fens and bogs. Evaluated wetlands are classified under a standard methodology, taking into account the biological, hydrological, and socio-economic features and functions of a wetland. Based on this system, wetlands can be identified as PSWs and these are protected under the wetland component of the *Provincial Policy Statement* (OMMAH 2005).

The most pertinent wetland features for the Risk Assessment include swamps and fens as they are partially or entirely reliant on groundwater discharge for their ecological health. The most sensitive wetland features, as identified by the GRCA (2008), and the model applied to evaluate the impact, are summarized in **Table 10-7.**

Table 10-7 Summary of Sensitive Wetland Features and Applied Modelling Tool

Complex	Sub-complexes	Wetland Type	Modelling Tool
Laurel Creek Complex	Sunfish Lake	Open Water, Swamp	Regional
Laurel Creek Complex	Sunfish Lake, Optimist Bog	Bog	Regional
Mannheim Area	Laurentian West	Marsh, Swamp	Regional
Mannheim Area	Middle Alder Creek	Swamp	Regional
Mannheim Area	Upper Alder Creek	Swamp, Marsh	Regional
Roseville Swamp	Cedar Creek Wetland	Swamp, Marsh	Regional
Roseville Swamp	Roseville Swamp	Swamp (Marsh)	Regional
Spongy Lake		Fen, Bog, Marsh,	Regional
Strasburg Creek		Swamp, Marsh	Regional
Beverly Swamp	Beverly Swamp	Swamp, Marsh	Cambridge
East side of Cambridge	Mill Creek Wetland	Swamp, Marsh	Cambridge
East side of Cambridge	Moffat Creek	Swamp, (Marsh)	Cambridge
East side of Cambridge	Sheffield Rockton Complex	Fen, Swamp, Marsh	Cambridge
Ellis Creek Wetlands		Swamp, Marsh	Cambridge
Puslinch Lake and Portuguese Bog	Irish Creek Complex	Swamp, Marsh	Cambridge
	Portuguese Swamp	Swamp	Cambridge
Upper Speed River		Swamp, Marsh	Cambridge

20.2.5 Land Use and Land Use Development

Existing Conditions

The existing land use cover used in the Tier 3 Assessment was very similar to the land uses applied in the Tier 3 GAWSER surface water flow generation model (AquaResource 2009b) with minor updates to the land uses in urban areas. The land cover data used in the original Grand River GAWSER model was based on 1992 imagery, and did not reflect current land use practices, particularly within urban areas. Land use mapping for Kitchener, Waterloo, and Cambridge was obtained from the respective cities and compiled into one consolidated land use mapping file, and this file was used to update the land use within the urban boundaries. Municipal land use mapping was checked against 2006 ortho-imagery to ensure urban lands flagged as developed actually were developed. Road lines were buffered by 10 m and assumed to be 100% impervious.

Updates were made to the land use classifications in the rural communities of Elmira, New Dundee and St. Agatha to accurately represent the developed areas in these communities. In addition, the land use classifications in the urban areas of the Region were also revisited to reflect site-specific knowledge. For example, a large development area classed as commercial was updated to low-density commercial to reflect the knowledge of the existing land use practices in that area.

Future (Official Plan) Land Use

The Risk Assessment scenarios also included an assessment of the impact of future land use development, as specified in Official Plans, on municipal water sources (as of July 4, 2012). This mapping represented the most current and up to date Official Plan and land use mapping within the Region at that time.

Land use development has the potential to reduce groundwater recharge. Region staff reviewed the future land use mapping and updated the land use classifications in some areas where development had occurred since 2008 (existing conditions). For example, areas where the Official Plans specified a residential area (interpreted by Matrix to be moderate density), but a low density residential subdivision was built in 2010, the Official Plan land use mapping classification was updated to low density residential.

Changes in land uses from existing to revised Official Plan land uses were assessed to identify where changes in land use from existing to future conditions were expected. Changes in land use that lead to interpreted decreases in groundwater recharge (due to increases in imperviousness) were applied in the Tier 3 Assessment scenarios.

The groundwater flow model represented the changes in land use development by increasing or decreasing groundwater recharge proportionally to the percentage of impervious area. Each of the land use areas were assigned a perviousness value as described in the GAWSER Model Update Report (AquaResource 2009b). **Table 10-8** summarizes the perviousness values applied to the land use areas that are expected to change in the future. These imperviousness values estimate the expected groundwater recharge reductions arising when a parcel of land is developed. Recharge reductions were assumed to be equal to estimated percent impervious values.

Maps 10-7 and 10-8 illustrate the spatial distribution of reductions in groundwater recharge, between existing and future conditions, for the Regional Model and Cambridge Model, respectively. These distributions illustrate the extent that reductions in recharge are predicted to occur due to future land use development in the Region.

Table 10-8 Land Use Impervious Estimates

Land Use Type	Imperviousness (%)
Agriculture	0%
Open Space	0%
Institutional	32%
Low Density Residential	40%
Medium Density Residential	50%
High Density Residential	80%
Low Density Commercial	60%
Medium Density Commercial	80%
Industrial	80%
Urban Commercial Core	90%

20.3 Risk Assessment

20.3.1 Model Development and Application

The Tier 3 Assessment involved a more detailed level of modelling compared to previous water budget studies, and in some areas involved the collection of additional data near the municipal wells. Detailed characterizations of the surface water and groundwater flow systems were then developed, with particular refinement given to areas where the Region's municipal water supply systems are located. These characterizations were used to create numerical models that simulated the groundwater and surface water flow systems. The models were calibrated so that the simulated groundwater level elevations and groundwater discharge rates in the models matched observed values as closely as possible. Once the models were calibrated, an external team of experts (Peer Reviewers) reviewed the reports and provided comments on how the models or reports should be updated to meet the project objectives.

With the development and refinement of a detailed conceptual model of the geologic, hydrologic, and hydrogeologic systems for the Study Area, the numerical groundwater flow model previously developed for the Tier 2 Stress Assessment using FEFLOW (DHI Water & Environment; DHI 2012a), was updated with more recently collected data. While the entire model domain was updated, greater refinement and attention during calibration was given to the areas where the municipal water supply systems of interest are located.

Three numerical modelling tools were applied in the Region's Tier 3 Assessment. Specifically, one GAWSER hydrologic streamflow generation model was used to simulate surface water partitioning and streamflow generation and two FEFLOW groundwater flow models were used to simulate subsurface (groundwater) flow. Using these models, a combined modelling approach was adopted whereby the recharge (i.e. precipitation that infiltrates down into the groundwater flow system) estimated by GAWSER (as a simulated output) was used as a boundary condition input (i.e., the driving force) for the two FEFLOW models.

Calibration and verification of the GAWSER model was achieved using observed streamflow data from nine Water Survey of Canada (WSC) and GRCA gauges, as well as the observed groundwater levels. The model predicted reasonable water budgets (e.g., runoff, evapotranspiration, groundwater recharge) demonstrating that precipitation was realistically partitioned into the various hydrologic components.

Most natural components of the hydrologic cycle were explicitly included in the GAWSER model (i.e., precipitation, evapotranspiration, snow melt, overland flow, channel flow, unsaturated flow, interflow, and saturated flow), as well as some of the effects of human activity (i.e., land use, irrigation, and water usage). Further details on the GAWSER model development and calibration are provided in AquaResource (2009).

Two consistent FEFLOW models were calibrated and implemented for the Region's Tier 3 Assessment. The first was the Regional Model which focused on the Waterloo Moraine overburden groundwater flow systems that supply the Kitchener-Waterloo municipal wells, but included the entire Region of Waterloo area. The second was the Cambridge Model which focused on the bedrock groundwater flow systems that supply the Cambridge municipal wells, and extended northeastward to include portions of the City of Guelph. These models have consistent layer structure, boundary conditions, and parameter values applied. Applying separate models for these two areas facilitated a greater focus on different water resources in

each area, and facilitated progressing in parallel. The development and calibration of these two models are discussed in detail in Matrix and SSPA (2014).

The Regional and Cambridge groundwater flow models were calibrated together so the models had consistent input values, and each model was able to reasonably replicate observed groundwater level elevations and streamflows. The Cambridge model was also comparted to the Guelph Model to ensure they produced similar results in areas where they overlapped. The groundwater flow models were calibrated at the well field scale to long-term average conditions, as well as time-varying conditions.

The wells used to calibrate the models included high quality water level data collected in the Region's Groundwater Monitoring Program (GMP). The models were also calibrated to groundwater discharge estimates collected from streamflow gauges, groundwater level elevations collected over time in municipal wells and monitoring wells, and to historic gransient pumping test for each supply system. In general, following the model calibration, the hydraulic properties and layer structure from the Cambridge Model were applied in the Regional Model to ensure consistency between the two models.

The groundwater flow models were used to simulate groundwater flow conditions across the Region and to conduct the required Tier 3 Risk Assessment scenarios for the municipal wells in the Local Areas. The following sections describe the risk assessment results.

20.3.2 Risk Assessment Results

Vulnerable Areas

The first step in the Local Area Risk Assessment was the delineation of vulnerable areas. Water quantity vulnerable areas were delineated to protect the quantity of water required by the Region's existing and Allocated Rates. The results of the WHPA-Q1 and WHPA-Q2 area delineations are described in the following sections.

WHPA-Q1

The differences in the model-simulated groundwater level elevations in each aquifer model layer under the non-pumping and pumping conditions were defined to produce drawdown contour maps for each of the model layers. The contour maps were then overlain to produce a composite WHPA-Q1 area that encompassed the full extent of the zone of influence associated with the Allocated Rates.

The average observed seasonal groundwater level elevation fluctuations in monitoring wells completed in the overburden production aquifers of the Waterloo Moraine is approximately 2 m. Therefore, a 2 m drawdown contour interval was selected for use in delineating the WHPA-Q1 because a variation of at least 2 m in observed groundwater water level elevations would be required before considering whether the change was due to increased pumping or seasonal variability. The Regional Model was used to delineate the WHPA-Q1 for the municipal wells located in Kitchener-Waterloo and the surrounding rural well fields that were part of the Tier 3 Assessment.

The Cambridge Model was designed to also include the simulated responses to municipal pumping within the nearby City of Guelph by applying boundary conditions in the Cambridge Model that were representative of pumping groundwater level elevations in the City of Guelph Tier 3 Assessment model. Given the interaction between the two cities, the delineation of the

WHPA-Q1 needed to consider a non-pumping condition within Guelph as well as Cambridge. The northern and northeastern specified head boundary conditions in the Cambridge Model, that overlapped with the Guelph Tier 3 model, were updated using the non-pumping conditions in the Guelph model under the non-pumped scenario (note: pumping in the Cambridge area was also shut off and existing land use in both models was applied). The Allocated Rates in the Guelph and Cambridge Models were then applied and the northern and northeastern boundary conditions in the Cambridge Model were again updated to simulate the impact of increased pumping in both cities. The difference in groundwater level elevations within each of the modelled aquifers was estimated and contoured.

The average observed seasonal groundwater level elevation fluctuations for monitoring wells completed in bedrock and deep overburden production aquifers within the Cambridge area is approximately 2 m. Therefore, the 2 m drawdown contour interval was selected for use in delineating the WHPA-Q1 for the Cambridge municipal wells, because a variation of at least 2 m in observed groundwater level elevations would be required before considering whether the change was due to increased pumping or seasonal variability.

Four WHPA-Q1 areas lie within the Region as illustrated on **Map 10-9**. The westernmost is WHPA-Q1A, which underlies the western portions of Kitchener and Waterloo. The WHPA-Q1A area extends north to the town of Heidelberg, south to New Dundee, west to St. Agatha and east toward the Grand River.

The WHPA-Q1B underlies the majority of the urban portion of Cambridge, and extends in a northwestward direction toward Guelph. The WHPA-Q1B extends into Guelph, as the northern model boundary condition for the Cambridge Model coincides with the pumped groundwater level elevations for the aquifers in Guelph. As a result, the drawdown associated with groundwater pumping in Guelph was simulated in the Cambridge Model. The Guelph Tier 3 Assessment model delineated the WHPA-Q1 for Guelph and it overlaps with the Region's WHPA-Q1B; consequently, a combined WHPA-Q1 area for the two cities was proposed (**Map 10-9**).

The WHPA-Q1 for Guelph is considered more representative of the drawdown in the vicinity of Guelph than the drawdown simulated by the Cambridge Model in the Guelph area. Similarly, the drawdown simulated in the Cambridge area by the Cambridge Model is more representative than the drawdown simulated in the Guelph Model. The Grand River marked the southwestern limit of the Guelph Model and as such, the drawdowns associated with the Middleton, Blair Road and Willard Well Fields were not simulated in the Guelph Model. Consequently, the WHPA-Q1B delineated in the Cambridge Model extends further to the south and west as compared to the WHPA-Q1 delineated using the Guelph Model.

Review of the simulated groundwater level elevation contours in both the Cambridge and Guelph Models identified a groundwater divide within the Gasport Formation between the two cities. The gradient in this area is shallow and changes in groundwater demand in this area, or within the two cities, has the potential to shift the location of this inferred groundwater flow divide. Additional studies may need to be undertaken to delineate a zone surrounding the groundwater flow divide to ensure future source water protection policies are protective of the Region's and Guelph's water supply sources, as well as other water uses, including coldwater streams and wetlands.

The WHPA-Q1C area is a small drawdown cone located around the Blair Road Wells (Wells G4 and G4A). The drawdown extends approximately 140 m from the Blair Road Well Field Wells on the west side of the Grand River and is masked beneath the well symbols on **Map 10-9**.

The WHPA-Q1D area is represented by a 100 m buffer surrounding the Conestogo Plains Well Field (Wells C3 and C4). As the Allocated Rates for the wells are low relative to the estimated aquifer transmissivity, the 2 m drawdown cone has a limited spatial extent. As such, a 100 m buffer area was drawn around the municipal wells to delineate the WHPA-Q1D (Conestogo) area.

WHPA-Q2

The WHPA-Q2 is defined as the WHPA-Q1 area, plus any area where a future reduction in recharge may have a measurable impact on wells located in that area. Proposed land development areas that are predicted to reduce the available drawdown in municipal wells, such that the wells may have difficulty pumping at their Allocated Rates, would be included within the WHPA-Q2. Further details on the processes for updating the land use mapping are provided in **Section 10.2.5.**

Map 10-10 illustrates the WHPA-Q2 areas within the Study Area, as well as the proposed land use development areas. The majority of the land use development that is expected to occur is located within the WHPA-Q1 areas, with the exception of a few proposed areas that straddle and extend beyond the WHPA-Q1 boundaries as follows:

- **WHPA-Q1A:** Proposed residential development area southeast of the Parkway-Strasburg Well Field in Kitchener
- **WHPA-Q1A:** Proposed residential and industrial development north and south of the Pompeii / Forwell Well Fields (on the east and west sides of the Grand River, respectively)
- **WHPA-Q1B:** Proposed residential development area southeast of the Elgin Well in Cambridge
- **WHPA-Q1A** and **WHPA-Q1B**: Proposed industrial developments in the area surrounding the Fountain Street Well Field between Kitchener and Cambridge
- **WHPA-Q1C:** Proposed residential development area west of the Blair Road Well Field in Cambridge

To assess the impact of land use changes on water quantity for the municipal wells, and to determine if the impact of development is “measureable,” the Cambridge and Regional Models were updated to simulate the land use developments (assuming no best management measures). The simulated average annual groundwater recharge distribution from the Regional and Cambridge Models were updated to reflect the future reductions in recharge and the models were re-run. The reductions in groundwater level elevations due to all of the proposed land development areas within the Region (as illustrated on **Map 10-10**) were examined.

In summary, the seasonal variations in groundwater level elevations of approximately 2 m would mask any changes in proposed land use changes for the developments lying outside the WHPA-Q1 areas, and the simulated incremental additional drawdown at the municipal wells was much smaller than the available drawdown. Therefore, the reductions in recharge due to land use development taking place outside the WHPA-Q1 areas were not considered to cause a

measurable impact on the wells, and were not included in the WHPA-Q2 areas. The WHPA-Q2 areas are coincident with their respective WHPA-Q1 areas.

Local Areas

The Local Areas for this study are also illustrated on **Map 10-10**. The Local Areas by definition were delineated by combining the WHPA-Q1 and WHPA-Q2. As noted above, the WHPA-Q1 and WHPA-Q2 areas are coincident, reflecting low potential for measureable impact on groundwater level elevations at the municipal wells under proposed changes in land use outside the WHPA-Q1 areas. Local Area A includes many of the municipal wells in the Kitchener and Waterloo areas, Local Area B includes many of the wells in the Cambridge area, Local Area C includes the Blair Road wells and Local Area D includes the Conestogo Plains wells.

Following delineation of the vulnerable areas, a series of Risk Assessment scenarios were undertaken to assess changes in groundwater level elevations at the municipal wells, and changes in groundwater discharges to specified surface water features. The predicted changes in groundwater level and groundwater discharge values were compared to an established set of drawdown and ecological thresholds to determine if the predicted changes were acceptable or not. The following sections summarize the results of the Region's Tier 3 Risk Assessment.

Drawdown Thresholds

Safe additional drawdown is defined as the additional depth that the water level within a pumping well could fall and still maintain the well's Allocated Rate. It is calculated as the additional drawdown that is available over and above the drawdown created by the existing conditions (2008) average annual pumping rate. Where the safe additional drawdown is low, this indicates that the well may have a higher risk of not being able to meet pumping requirements in the future, if the same or additional pumping volumes are required to be produced by that well.

The additional drawdown predicted in each of the Risk Assessment model scenarios was estimated and compared to the estimated safe additional drawdown at each municipal well. The drawdown values for each scenario are additional, or incremental drawdown values relative to the drawdown already experienced within the well in 2008.

In the steady-state scenarios (Scenarios G1, G2 and G3), the difference between the groundwater level elevations in the wells in the existing conditions scenario (Scenario C) and the groundwater level elevations at the end of each model scenario were recorded as the additional predicted drawdown. For the transient scenarios, the lowest simulated groundwater level elevation in the aquifer at each municipal pumping well was compared to the water level in Scenario C. The model-simulated drawdowns in each scenario were then compared to the field-based safe additional drawdown values to identify municipal wells that may be unable to pump at their Allocated Rates.

In all Risk Assessment scenarios using the Regional Model, the predicted drawdown was less than the safe additional drawdown at each of the wells, which indicated the wells are able to pump at their current and Allocated Rates over the long-term (including drought conditions) under existing and future land use development conditions.

In all Risk Assessment scenarios using the Cambridge Model, the predicted drawdown was less than the safe additional drawdown at each of the wells, which indicated the wells are able to

pump at their current and Allocated Rates over the long-term (including drought conditions) under existing and future land use development conditions.

Ecological Thresholds – Stream Baseflow

The Province has prescribed specific baseflow reduction thresholds that should be used when assigning a Risk Level associated with predicted impacts to cold water fish community streams due to increased municipal pumping. For cold water streams, a Moderate Risk Level is assigned when groundwater discharge is predicted to be reduced by at least 10% of existing monthly stream baseflow. Potential baseflow reductions on cold water streams due to changes in land use conditions are not taken into account when assigning the Risk Level through the Tier 3 Risk Assessment; such impacts are reviewed for information purposes only.

Map 10-6 illustrates the cold water streams located within the Region that are subject to the Province's groundwater discharge reduction threshold, and the areas of assessment for those reaches.

Groundwater flow models are better able to predict relative changes as opposed to absolute changes under a variety of scenarios. As models are simplifications of very complex subsurface conditions, and as there are uncertainties in the model input parameter values, the model may not accurately simulate a single measured value such as baseflow. However, the model's parameters are physically based and so groundwater flow models are well suited to evaluate how the model predictions may change under various stressors.

The predicted impacts on groundwater discharge to rivers and streams was assessed for Scenario G2 (existing land use, and Allocated Rates) by comparing the predicted groundwater discharges under Scenario G2 to the groundwater discharges predicted under Scenario C (Existing Conditions). The differences in these groundwater discharge values were then normalized by the observed baseflow value to estimate the percent groundwater reduction (or increase).

Table 10-9 summarizes the steady-state model scenario results with respect to predicted reductions in groundwater discharges, for the Regional Model. The reaches hosting cold water fish communities are listed at the top of the table, and the warm water streams are italicized and listed in the lower half of the table.

Under Scenario G2, the predicted reductions in groundwater discharges, relative to current conditions, to reaches hosting cold water fish communities, were less than 10%.

The percent reduction in groundwater discharge was greater than 10% for Shoemaker Creek and Clair Creek under Scenario G2. However, both of these creeks are located in heavily urbanized portions of the cities and sections of these creeks are channelized with a number of culverts. As such, the predicted groundwater discharge reduction on Clair Creek and Shoemaker Creek were not interpreted to be significant from a fisheries or ecological standpoint. They are presented as water is simulated to flow out of these surface water features into the underlying groundwater flow system in the groundwater flow model, so the results are important from an overall water budget perspective.

Greater impacts were observed on cold water streams where reductions in recharge due to land use development were assessed. Specifically under Scenario G3 (change in land use only), reductions in groundwater discharge of 19% and 13% were predicted for Strasburg Creek and

the middle portion of Alder Creek just west of the Mannheim West Well Field, respectively. As noted previously, these results suggested the greatest impact that may be realized if land use development were to take place without any mitigating factors.

Table 10-9 Impacts to Groundwater Discharge - Regional Model

Reach	Thermal Regime	Simulated Discharge (% Reduction)		
		Scenario G1	Scenario G2	Scenario G3
Airport Creek	Cold water	7%	0%	7%
Alder Creek Headwaters	Cold water	11%	4%	7%
Alder Creek Middle	Cold water	15%	1%	13%
Alder Creek Lower	Cold water	1%	0%	1%
Hopewell Creek	Cold water	2%	0%	2%
Idlewood Creek	Cold water	4%	-2%	6%
Strasburg Creek	Cold water	20%	1%	19%
Laurel/ Beaver Headwaters	Cold water	11%	6%	6%
Clair Creek	*Warm water*	*32%*	*26%*	*6%*
Freeport Creek	*Warm water*	*10%*	*0%*	*10%*
Laurel Creek	*Warm water*	*8%*	*8%*	*1%*
Schneider Creek	*Warm water*	*3%*	*1%*	*2%*
Shoemaker Creek	*Warm water*	*19%*	*17%*	*4%*

Table 10-10 summarizes the reductions in groundwater discharges to all stream reaches in the Cambridge area. The reaches hosting cold water fish communities are listed at the top of the table, and the warm water streams are italicized and listed in the lower portions of the table.

Under Scenario G2, the predicted reductions in groundwater discharges, relative to current conditions, to reaches hosting cold water fish communities, were less than 10%.

Greater impacts were observed on reaches where the reductions in recharge due to land use development were assessed. Specifically under Scenario G3 (change in land use only), Moffatt Creek was predicted to have a 13% reduction in groundwater discharge due to recharge reduction.

Table 10-10 Impacts to Groundwater Discharge - Cambridge Model

Reach	Thermal Regime	Simulated Discharge (% Reduction)		
		G1 Base	G2 Base	G3 Base
Blair Creek		0%	0%	1%
Mill Creek Headwaters (Aberfoyle Creek)	Cold water	0%	0%	0%
Mill Creek upstream (downstream of Aberfoyle gauge)	Cold water	0%	0%	0%
Mill Creek (Gauge to Shades Mill Reservoir)	Cold water	6%	5%	2%
Mill Creek Reservoir to the Grand River	Cold water	4%	3%	0%
Ellis Creek	*Warm water*	*5%*	*-1%*	*5%*
Irish Creek	*Warm water*	*12%*	*7%*	*5%*

Reach	Thermal Regime	Simulated Discharge (% Reduction)		
		G1 Base	G2 Base	G3 Base
Moffat Creek	*Warm water/Cold water*	*18%*	*5%*	*13%*

Ecological Thresholds – Provincially Significant Wetlands

The Technical Rules (MOE 2009) specify that municipal water takings (Allocated Rates) cannot cause a detrimental impact to other water users, which include PSWs. As such, the results for Scenario G2 are of primary importance when assigning the Risk Level to the Local Areas. The results of Scenario G1 and G3 are provided for context, to highlight those wetlands that are influenced to a greater degree by changes in municipal pumping or by reductions in recharge due to proposed land use development.

In this assessment, the predicted changes in groundwater level elevations beneath wetland complexes (see **Table 10-11**), in each of the Risk Assessment scenarios, were noted and tabulated. The companion Model Calibration and Water Budget Report (Matrix and SSPA 2014) provides additional information on the wetland features of interest listed in **Table 10-11**.

In general, it is difficult to calibrate a groundwater flow model at large wetland features because often there are few data points such as observed water level elevations at surface or beneath the surface with which to calibrate the model. However, examining the relative changes in groundwater level elevations provides a quantitative measure of how the function of wetlands may potentially change.

The changes in groundwater level elevations between the model simulated groundwater level elevations under Scenario C (existing land use and municipal pumping) and Scenario G2 (existing land use and Allocated Rates) were evaluated and are summarized in **Table 10-11**. The average change in groundwater elevation within each wetland complex was tabulated (with negative values indicating a rise in elevation relative to Scenario C). The predicted directions of vertical hydraulic gradients (recharge or discharge) are also summarized in **Table 10-11**. In all steady-state scenarios, no changes in gradients were predicted at any of the wetland complexes.

In general under Scenario G2, municipal pumping was simulated to reduce the water level elevation on average less than 10 cm at 14 of the 18 wetlands assessed. The four wetlands that were predicted to decline by more than 10 cm due to increased municipal pumping include the Laurentian West Wetland, Mill Creek Wetland, Spongy Lake, and Portuguese Swamp. The Mill Creek Wetland in Cambridge was simulated as a discharge feature. However, under Scenario G2, the overall gradient in the wetland was still predicted to be discharging, despite the average decline in groundwater level elevation beneath the wetland of approximately 0.9 m.

The Laurentian Wetland in Kitchener was simulated in the model as a perched wetland that lies above the regional water table. The temporal variation in the perched water table is independent of the groundwater level variations of the underlying regional water table. As such, lowering of the regional water table beneath the wetland is not expected to cause a detrimental impact on the overlying perched wetland. A 0.2 m reduction in water level was simulated beneath Spongy Lake and Portuguese Swamp, and both of these features were simulated in the model as

recharging features, so the change in groundwater level beneath these features was also not expected to impact the form or function of those wetlands.

Wetlands that are predicted to be more influenced by changes to recharge (via land use change; Scenario G3;) include the Laurentian West Wetland near Mannheim, and the Mill Creek Wetland in Cambridge. If development were to occur without mitigative measures, such as the requirement for pre-development flows to equal post-development flows, low impact development techniques, or stormwater management controls, reductions in groundwater elevations of approximately 2 m were predicted beneath the Mill Creek and Laurentian West Wetlands. The same impacts due to land use development were noted in several other areas of the Region, stressing the importance of mitigative measures.

Table 10-11 Summary of Wetland Impacts for Steady-State Risk Assessment Scenarios

GRCA Complex	GRCA Sub-Complex	Reduction in Water Level Elevation (m)			Gradient
		Scenario G1	Scenario G2	Scenario G3	Wetland Recharge or Discharge to Groundwater
Laurel Creek Complex	Sunfish Lake	0.1	0.0	0.0	Recharge
	Sunfish Lake, Optimist Bog	0.2	0.1	0.1	Discharge
Mannheim Area	Laurentian West	3.0	0.9	2.0	Recharge
	Middle Alder Creek Complex	0.5	0.1	0.4	Recharge
	Upper Alder Creek Complex	0.5	-0.1	0.6	Recharge
Roseville Swamp	Cedar Creek Wetland	0.1	0.0	0.1	Discharge
	Roseville Swamp	0.1	0.0	0.1	Discharge
Spongy Lake		0.4	0.2	0.1	Recharge
Strasburg Creek		0.4	0.0	0.5	Discharge
Beverly Swamp		0.1	0.0	0.0	Recharge
Cheese Factory Rd/ Sudden Bog		0.2	0.1	0.1	Recharge
East of Cambridge	Mill Creek Wetland	3.0	0.9	2.0	Discharge
	Moffat Creek	0.5	0.1	0.4	Recharge
	Sheffield Rockton Complex	0.5	-0.1	0.6	Discharge
Ellis Creek Wetlands		0.1	0.0	0.1	Discharge
Puslinch Lake/ Portuguese Bog	Irish Creek Complex	0.1	0.0	0.1	Recharge
	Portuguese Swamp	0.4	0.2	0.1	Recharge
Upper Speed		0.4	0.0	0.5	Discharge

Local Area Risk Level

The Local Areas for the Region of Waterloo are illustrated on **Map 10-10**. The Risk Level classification applied to the Local Area is based on the ability of the wells to meet their peak demand ("Tolerance") as well as the results of the Risk Assessment scenarios outlined previously.

Tolerance

Municipalities typically implement physical solutions (e.g., storage reservoirs, peaking / back-up wells) and water conservation measures to reduce the amount of instantaneous water demand required from a primary drinking water source. These types of measures are implemented to increase a municipality's "tolerance" to short-term water shortages. Tolerance effectively reduces the potential that a municipality will face short- or long-term water shortages. A municipality's existing water supply system may be designed such that the wells or intakes alone cannot meet peak water demands; however, storage systems such as reservoirs and water towers may be in place for this purpose.

The Technical Rules (Part IX.1) specify that if the municipality's system is able to meet existing peak demands, the tolerance level for the existing system is assigned as high; otherwise, the tolerance is low. The Region of Waterloo does not have water shortage issues as the water supply system for the Tri-Cities is fully integrated, with significant inherent redundancy, a capacity that exceeds current and projected future demands, and storage systems (reservoirs, elevated tanks and ASR) in place to meet peak demands. Therefore, the tolerance of the Region of Waterloo water supply system is high. The surface water intake from the Grand River also adds significant supply tolerance to the water supply system.

Risk Level Circumstances

The Local Area for a groundwater system is assigned a Significant Risk Level if either of the following circumstance are present: 1) the wells are not able to meet their existing, or existing plus committed demands, determined when the drawdown at a municipal well exceeds the safe additional available drawdown; or 2) the tolerance is "low" and the drinking water system is not able to meet peak water demands in the drought scenario. This may be identified where an existing municipal system has had historical issues meeting peak demands.

The Local Area for a groundwater system is assigned a Moderate Risk Level if municipal pumping in Scenario G results in measurable and potentially unacceptable impacts to other uses. For cold water streams, this circumstance occurs when groundwater discharge is reduced by 10% or more of existing monthly baseflow (MOE 2013).

The results of the Risk Assessment scenarios for the Region showed that the drawdown predicted under all scenarios was less than the safe additional available drawdown for the wells. This suggested the wells are able to pump sustainably at their Allocated Rates into the future.

With respect to other water uses, the reductions in groundwater discharge to sensitive cold water streams were less than 10% of the stream baseflow value, and the reductions in groundwater level elevations beneath the PSWs was considered low enough that a Moderate Risk Level was not warranted.

Consequently, the four Local Areas delineated in the Region of Waterloo were assigned a Low Risk Level, based on circumstances that all of the wells were predicted to be able to meet their Allocated Quantity of Water, without affecting other uses. The assignment of a Low Risk Level is further supported by the tolerance provided by the integrated urban system of groundwater wells, the ASR system, and the surface water intake on the Grand River.

Uncertainty Assessment

The uncertainty analysis evaluated alternative conceptual models that contain different hydraulic conductivity values and recharge distributions than those present in the base case. Three alternative calibrated model realizations were developed for the Regional Model and for the Cambridge Model. These alternative models were considered to be as well calibrated as the base case model presented in the Model Calibration and Water Budget Report (Matrix and SSPA 2014a) and are referred to as alternative "realizations".

While the different realizations have varying parameter values with an equivalent degree of calibration, the predictive results may be different. As such, these realizations were used to assess the range of uncertainty values that stem from the uncertainty in the parameter values.

The eight Risk Assessment scenarios were evaluated, for each of the three alternative realizations for the Regional and Cambridge Models, to assess the sensitivity of the models to changes in the model input parameters. As each realization was as equally well calibrated as the base case, the Risk Assessment scenario results were equally plausible. In general, the predictions made by these realizations were consistent with those made by the base case and did not result in elevating the Risk Level of the Local Areas. Further details on these assessments are available in the Tier Three Water Budget and Local Area Risk Assessment Report (Matrix and SSPA, 2014b)

Although the safe additional available drawdown thresholds for a few wells within the Region were exceeded under these alternative realizations, the tolerance afforded by the integrated system, and the availability of other nearby groundwater wells with additional available drawdown, suggested that the Region will operationally be able to overcome any potential difficulties that may occur during short or long-term droughts, or under average climatic conditions.

The Low Risk Level applied to the four Local Areas within the Region was considered appropriate, and consequently, the uncertainty associated with the Risk Level applied to each of the Local Areas was Low.

20.3.3 Significant Groundwater Recharge Areas

A Significant Groundwater Recharge Area (SGRA) is defined as a specific type of vulnerable area on the landscape which has a hydrologic connection to an aquifer that is a source for a municipal drinking water system. The role of significant groundwater recharge areas is to support the protection of drinking water across the broader landscape.

A threshold of 115% of the average groundwater recharge rate was used to define SGRAs. The groundwater recharge rate was estimated using the regional GAWSER streamflow generation model. This methodology was used to delineate SGRAs in the Tier Two Water Budget and Water Quantity Stress Assessment (AquaResource 2009a), and so the same threshold was used in the Tier 3 Assessment, to maintain consistency between the two studies.

Delineation of SGRAs is limited by the processes used by the GAWSER model to estimate recharge, the mapping used to create hydrologic response units, and the climate data available. The hydrologic model is a simplification of natural processes. Advancements in the Tier 3 models allowed for better representation of evapotraspiration rates both in sandy soils and clay/silt soils. The updated model also incorporated a better representation of overland runoff estimates to include factors such as land slope, surface roughness, soil water content, and infiltration potential.

Professional judgment was used to remove potential groundwater discharge areas from the SGRA mapping. Discharge areas were defined as areas where the model simulated groundwater elevations were less than 2 m below ground surface. In the remaining distribution small, spurious polygons were removed; an area of less than 0.4 ha (40,000 m^2) was applied as a guide. The SGRA mapping was not clipped to the Local Areas, as the delineated SGRA area accounts for municipal as well as domestic water users.

The SGRAs cover a large portion of the Region, but are largely absent in the urban areas and along groundwater discharge areas including lakes, ponds and wetlands. Their delineation for the Central Grand and Canagagigue Creek Subwatersheds is described in the following sections.

Central Grand Assessment Area

SGRAs are delineated on a subwatershed-scale to protect the broader landscape. **Map 10-11** shows the SGRAs mapped as a part of the Tier Three Assessment for the Central Grand Subwatershed.

The average annual recharge rate (as determined by the GAWSER model), and SGRA threshold were 188 and 216 mm/year, respectively. For comparison, the threshold value for the Tier Two Study (AquaResource 2009a) was 202 mm/year.

There are two main contributing factors that account for the difference in threshold SGRA values. First, the Tier Three SGRA threshold value reflects updated characterization and increased refinement. Second, the Tier Three threshold was estimated specific to the simulated recharge of the Central Grand Subwatershed, whereas the Tier Two value was calculated considering the Grand River Watershed as a whole.

In general, the SGRAs are located outside the urban centres, as the impervious cover increases runoff to storm sewers and reduces the rate of infiltration (recharge). In the western portion of the subwatershed, the SGRA is large, continuous, and coincides with the core of the Waterloo Moraine. It covers an area from St. Agatha in the north to the New Dundee Well Field in the south.

East of the Waterloo Moraine, several small SGRA areas were mapped in the urban area of Kitchener-Waterloo, including portions in Waterloo North near the Laurel Creek Conservation Area, an area from the Strange Street Well Field in the west, to the Lancaster Well Field in the east, and south to the Greenbrook Well Field.

In the southern limits of the subwatershed, a SGRA is mapped from the Mannheim West Well Field in the west to the Strasburg Well Field, and eastward to the Grand River near the Blair Road Well Field.

All the urban well fields in the City of Cambridge, with the exception of Hespeler and Pinebush, were within the SGRA mapped area. Northeast of Cambridge, toward the City of Guelph, large areas of SGRA were mapped, coinciding with the sands and gravels associated with the Paris Moraine. Thick sands and gravels were mapped along the Grand River and these translate into pockets of mapped SGRAs as well. Notable areas include the Pompeii, Forwell and Woolner Well Fields, as well as the Lancaster Well Field.

Canagagigue Creek Assessment Area

For the Canagagigue Creek Subwatershed, the average annual recharge rate and SGRA threshold were 127 and 146 mm/year, respectively. For comparison, the threshold value for the Tier Two Study (AquaResource 2009a) was 202 mm/year, which considered the entire Grand River Watershed.

The spatial distribution of SGRAs in the Canagagigue Creek Subwatershed is presented on **Map10-12**. The SGRAs were typically situated on the eastern half of the subwatershed, which corresponds to permeable ice-contact drift materials at ground surface. On the western half of the subwatershed, patches of SGRA were limited to areas surrounding Conestogo Lake.

20.4 Risk Management Measures Evaluation

The Risk Management Measures (RMM) Evaluation Process is completed following the Tier Three Assessment to inform the policy development process. The goal of the evaluation is to identify and assess alternative Risk Management Measures that would effectively manage the Significant water quantity threats within vulnerable areas that have Significant Risk Levels. The key deliverable from the RMM evaluation is a Threats Management Strategy that provides guidance to the Source Protection Committee to establish policies that will help ensure the long-term sustainability of the municipal drinking water supplies.

In the Region of Waterloo, the risk level was determined to be low and as a result, a RMM evaluation was not required.

20.5 Section Summary

Four Local Areas were delineated for the various municipal supply wells within the Study Area **Map 10-10**. The areas were delineated following the Province's Technical Rules (MOE 2009), based on a combination of the cone of influence of each municipal well, as well as land areas where reductions in recharge has the potential to have a measurable impact on the municipal wells.

A series of Risk Assessment scenarios were undertaken, consistent with the Technical Rules (MOE 2009). The Risk Assessment scenario results, and the results of the uncertainty analysis, classified the Local Areas within the Region of Waterloo as having a Low Risk Level. The Low Risk Level is considered appropriate for Local Area A (containing the Kitchener - Waterloo municipal wells) because the integrated system of groundwater wells and well fields are completed in productive overburden aquifers within and beneath the Waterloo Moraine. The municipal production aquifers can supply water at sufficient rates to meet the Region's 2031 water demands without causing a negative impact on other water uses. In addition, the surface water intake on the Grand River and the ASR system at Mannheim are also available to supplement the groundwater wells within the Region.

Similarly, the municipal wells located within Local Area B (i.e., Cambridge wells) are completed within productive overburden and bedrock units that are able to transmit volumes of water on a long-term basis that more than meet the 2031 demands, without causing negative impacts on other water uses. Local Areas C and D (Blair Road and Conestogo, respectively), were also assigned a Low Risk Level as the future water demands for these wells are only marginally higher than what they are currently pumping, and pumping from these wells will not cause detrimental impacts to other water uses in these areas.

In accordance with the Technical Rules (MOE 2009), the consumptive water users and potential reductions to groundwater recharge within the Local Areas were not classified as Significant or Moderate water quantity threats. The potential reductions to groundwater discharges to sensitive surface water features such as cold water streams due to land use development varied from minor to significant. The model scenarios did not consider the influence of best management practices, or Low Impact Development measures; rather groundwater recharge was reduced proportionally to the imperviousness for areas where land use development was expected to occur. While these scenarios are conservative, as the Region has bylaws in place to mandate stormwater management practices for new developments in sensitive recharge areas, the results identify areas where groundwater recharge and discharge are predicted to be most sensitive to land use changes, and where the Region or the GRCA may wish to more closely monitor baseflow or stream flow in the future.

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-12 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Draft Updated Grant River Assessment Report and Source Protection Plan: County of Grey**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-12 – Draft Updated Grand River Assessment Report and Source Protection Plan: County of Grey – for information.

REPORT:

Updates to the Assessment Report

Technical work to update Wellhead Protection Areas (WHPAs) for the expanded Dundalk groundwater supply system has been completed and was presented to the SPC on April 5, 2018 (Report 18-04-06). Results of the Dundalk water quality technical study have been incorporated into an updated County of Grey, Township of Southgate section (4) of the assessment report. Updated enumeration of Significant Drinking Water Threats is not yet complete; threat numbers will be updated in the coming months and included in the complete draft updated Grand River Assessment report package that will be presented to the SPC in early 2019. The section has also been updated for brevity and added clarity.

In addition to updated content, the structure of the assessment report has been revised – water quantity technical work has been moved closer to the end of the document and water quality risk assessments, and each municipal water quality section, have been renumbered.

Updates to the Source Protection Plan

As a result of the technical updates in the assessment report, the Grand River Source Protection Plan was updated to include a revised policy applicability map for the Dundalk drinking water supply system and reflecting the addition of Well D5. County of Grey staff did not identify any policies that required revision.

Please see **Appendix A** for section 4 of the assessment report and updated Dundalk well supply policy applicability map.

Prepared by:

Ilona Feldmann
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Approved by:

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Source Protection Program Manager

Appendix A

Excerpts from the Draft Updated Grand River Assessment Report and Source Protection Plan

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4.0 COUNTY OF GREY

4.1 Township of Southgate

4.1.1 Dundalk Well Supply

The Village of Dundalk, located within the Township of Southgate, is ~~located~~ situated in the southeast corner of the County of Grey in southern Ontario. The Township of Southgate has a population of ~~just over 7,000 people.~~7,354 people, ~~with~~and a population of 2,046 within Dundalk (Statistics Canada, 2016).

Dundalk is located within the northwest part of the Grand River watershed (Upper Grand River subbasin) with the headwaters of the Grand River originating southeast of Dundalk. The headwaters of the Saugeen River are also located within the Township of Southgate and part of the Saugeen Valley Source Protection Area. ~~Surface water drainage is controlled mainly by a series of small streams and drainages that flow in a south-southeast direction and ultimately drain into headwaters of the Grand River.~~

The Dundalk municipal wells obtain their water from bedrock groundwater sources. The bedrock surface is generally highest in the east and slopes towards the west. The uppermost bedrock formations (Guelph and Gasport) are estimated to be 88 m thick and form the active aquifer system which supply the Dundalk municipal wells.

The bedrock aquifer is mainly overlain by drumlinized till plains, locally characterized as Elma Till and Catfish Creek Till. Overburden thicknesses range from approximately 5 m in the east and thicken to over 40 m in the southwest.~~Dundalk obtains its water supply from municipal groundwater supply systems located within the village.~~

The Dundalk drinking water system is classified as a large municipal residential system. ~~with 763 connections~~ The municipally~~ water~~ serviced area for Dundalk is shown in **Map 4-1**. A summary of all the municipal production wells in Dundalk are included in **Table 4-1**.

Table 4-1: Drinking Water System Information for the Dundalk Well Supply

Well	Well Field	Depth of Well (m)	Depth of Casing (m)	Purpose	Status
D1	Dundalk	61.3	32.7	Production	Decommissioned
D2	Dundalk	83.2	30.4	Production	Decommissioned
D3	Dundalk	86.9	28.0	Production	In Regular Use
D4	Dundalk	100.6	32.0	Production	In Regular Use
D5	Dundalk	96.0	35.35	Production	Future Use

Note: Depth of well and casing based on as constructed drawings and water well records.

The well supply system for Dundalk consists of two bedrock wells referred to as D3 and D4. Well D3 was drilled in 1975 and is located in the south end of Dundalk. The village originally obtained its water supply from two wells referred to as D1 and D2 that were drilled in 1960 and located in the village core. Due to the lower capacity of wells D1 and D2, a fourth well (D4) was drilled in 2002 and brought on-line. Well D4 is located northeast of the village. Wells D1 and D2 were decommissioned in 2005 in accordance with Ontario Regulation 903. In 2016, a new well referred to as D5 was constructed on the east side of Dundalk between the two existing

municipal wells. In 2017, a long term pumping test was conducted at ~~municipal~~ well D5. The new well will provide an additional groundwater source and redundancy to the system.

~~and will become part of the Dundalk municipal water supply. In 2017, the average pumping rates for well D3 and well D4 were 272 m^3/day and 188 m^3/day, respectively.~~

A summary of the drinking water system information and annual and monthly average pumping rates is presented on **Table 4-2** and **Table 4-3.**

Table 4-2: Drinking Water System Information for the Dundalk Well Supply

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served[2]
220001753	Dundalk Well Supply	Corporation of the Township of Southgate	GW	Large Municipal Residential System	1,700

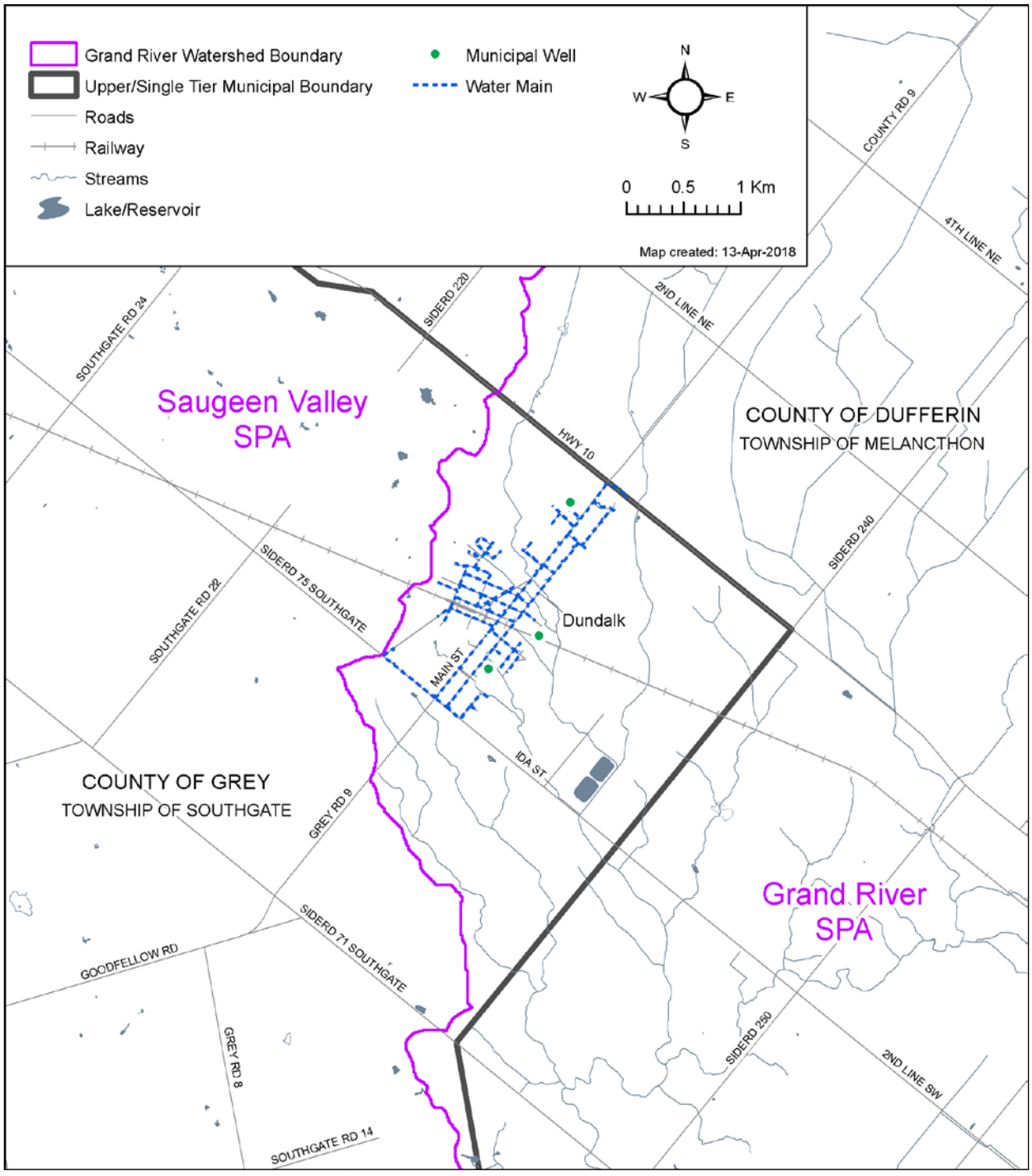
[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*
[2] Based on Township of Southgate Dundalk Waterworks 2009 Annual Report (Ellis, 2010)

Table 4-3: Annual and Monthly Average Pumping Rates for the Dundalk Well Supply

Well or Intake	Annual Avg. Taking[1] (m^3/d)	Monthly Average Taking[1] (m^3/d)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
D3	~~318~~272	~~398~~ 243	~~288~~2 48	~~360~~2 38	227	~~0~~278	~~0~~28 6	~~0~~46 6	~~0~~34 3	~~0~~25 8	~~0~~20 9	~~0~~23 6	~~0~~236
D4	~~540~~188	~~270~~ 206	~~269~~2 01	~~269~~1 97	~~394~~ 207	~~668~~1 81	~~743~~ 200	~~675~~ 0	~~649~~ 135	~~653~~ 245	~~654~~ 256	~~625~~ 225	~~605~~2 02

[1] source: Southgate Township annual summary report, based on ~~2009~~ 2017 monitoring data

Map 4-1: Dundalk Well Supply Serviced Areas



~~4.1.2 The 2009 Dundalk Waterworks Annual Report (Ellis, 2010) noted that Well D3 began to have sporadic total coliform counts in the raw water samples. This well was taken out of service so a comprehensive investigation could be completed.~~

~~4.1.3 Vulnerability Analysis~~

~~4.1.4 Delineation of Wellhead Protection Areas~~

~~Delineation of Wellhead Protection Areas (WHPAs) represents the foundation of a municipal groundwater protection strategy. The delineation of a WHPA for a municipal well field is based on the delineation of the time of travel capture areas for the municipal well field. The WHPA represents the area projected to land surface where groundwater can be captured by pumping at the municipal wells. It should be noted that the capture zones represent time of travel within the saturated zone of the aquifer to the well and do not account for travel time from ground surface down to the water table.~~

~~Wellhead Protection Areas associated with the municipal water supply represents the areas within the aquifer that contribute groundwater to the well over a specific time period. Four WHPAs are specified: one is a proximity zone and the others are time-related capture zones:~~

~~Zone A100m radius from wellhead~~

~~Zone B2-year Time of Travel (TOT) capture zone~~

~~Zone C 5-year time of travel capture zone~~

~~Zone D 25-year time of travel capture zone~~

~~The pumping rates used to determine the WHPAs are based on the allocated quantity of water. The allocated quantity of water is the lesser of:~~

~~The maximum annual quantity of water that can lawfully be taken under the Permit to Take Water; or~~

~~The quantity of water that would have to be taken annually to meet committed demand of the system.~~

~~4.1.5~~4.1.2 ~~T~~

~~he committed demand means the quantity of water provided by a drinking water system that would be required if the area served by the system were developed in accordance with the official plans for the area to an extent that would result in the greatest use of drinking water.~~ **Dundalk Wellhead Protection Areas**

~~***Modelling Approach for the Dundalk Well Supply***~~

~~A groundwater flow model was developed to identify time of travel capture zones for the municipal well fields. The model was constructed and applied using the three-dimensional model, MODFLOW.~~ In 2003, a~~A~~ local numerical groundwater flow model for the Dundalk area was ~~originally~~ constructed ~~during~~ as a part of the Grey and Bruce Counties' Groundwater Study ~~by~~ (Waterloo Hydrogeologic Inc, 2003). At that time, ~~capture zones~~WHPAs for the three ~~bedrock~~municipal wells (D1, D2, D3) were simulated using the model. ~~The model was constructed and applied using the three-dimensional model, MODFLOW.~~

~~During~~Later, as a part of the first phase ~~the first phase~~ of the source ~~water~~ protection technical stud~~y~~ies in 2008, the model was revised to add well D4 and remove the now-decommissioned D1 and D2 (Triton Engineering et al., 2007)

~~by Triton Engineering Services Limited, Blackport Hydrogeology Inc., and Waterloo Hydrogeologic Inc., the model was re-visited. Well D4 was added and D1 and D2 were set as inactive (since they had been decommissioned).~~ In ~~2009/~~2010, ~~Golder refined the~~ hydrogeological conceptualization was further refined and WHPAs for wells D3 and D4 were updated to reflect the revised hydrogeology (Golder, 2010) ~~and used the groundwater model to update the capture zones (D3 and D4) for the Dundalk municipal supply wells.~~

Later, in 2018, Well D5 was incorporated into the groundwater flow model, and the model was updated to reflect revised hydrostratigraphy and pumping test information based on the drilling results from well D5. ~~As part of the current study, the model was updated to refine the overburden conceptualization and incorporate greater detail in the spatial discretization of the overburden geology and refine the boundary conditions. New WHPAs were mapped by Golder Associates Ltd. (2009) for D3 and D4.~~

WHPAs were regenerated for wells D3, D4, and D5 with updated pumping rates for the system ~~have been re-delineated for the existing wells D3 and D4 as well as the new well D5 based on updated pumping rates and the most recent hydrogeological data~~ (Golder, 2018).

~~Within the area of the groundwater supply wells the bedrock surface is generally highest in the east and slopes towards the west. This corresponded to interpreted overburden thicknesses ranging from approximately 5 m in the east to over 40 m in the southwest. The uppermost bedrock formation (Guelph through Gasport) is estimated to be 88 m thick. Dundalk supply wells are completed within this portion of the bedrock sequence and the Guelph to Gasport Formations form the active municipal groundwater system. The municipal aquifer is mainly overlain by drumlinized till plains, locally characterized as Elma Till and Catfish Creek Till.~~

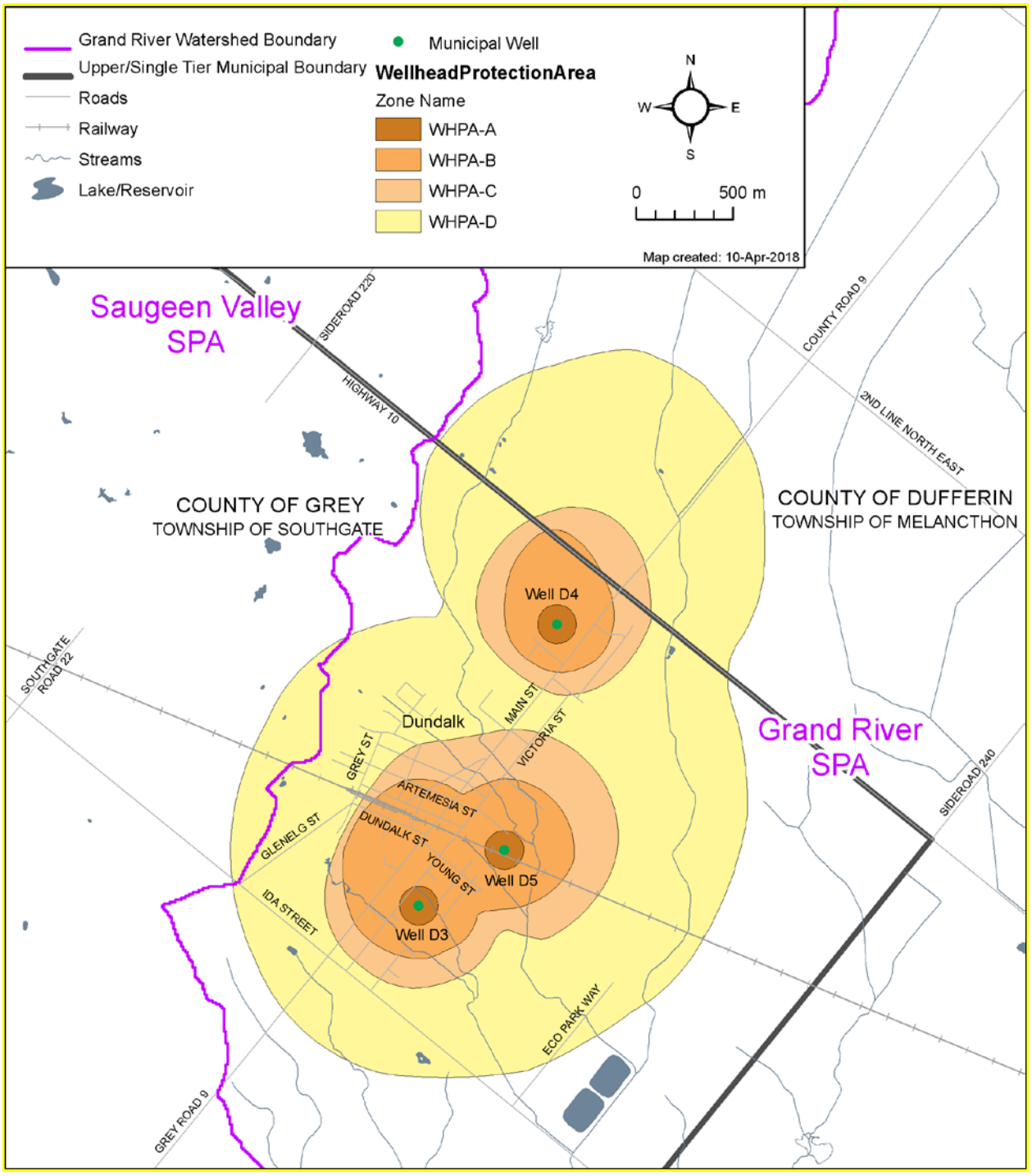
The pumping rates used to determine the Golder (2018) WHPAs ~~are~~were based on the allocated quantity of water. In each scenario, the allocated quantity of water or the total pumping rate for the wellfield was 1,344 m^3/day. This ~~is~~rate was based on an estimate of the 20- year forecast planned demand provided by Triton Engineering on behalf of the Township. The rate~~, which~~ represents the existing average day demand over the past three years for 1,799 people (490 m^3/day), plus a committed demand over the next 10 years for 2,111 people (574 m^3/day) and a planned demand for the next 20 years for 1,028 people (280 m^3/day).

Using the groundwater flow model, four pumping scenarios were developed for the municipal wells to represent possible future pumping conditions at the allocated rate. The resulting WHPAs (Golder, 2018) represent a composite of these four scenarios.

~~The WHPAs for Dundalk wells D3, D4, and D5 were determined by running the model with four different scenarios to represent possible combinations of future pumping from the wells (Golder, 2018).~~

The resulting WHPAs, ~~are~~ shown on **Map 4-2~~.~~,** ~~The WHPAs~~ extend north-northeast from the village in the direction (upgradient) of local groundwater flow through the bedrock. The majority of the WHPAs are within the Grand River SPA, however a small portion of the WHPA-D extends into Saugeen Valley SPA.

Map 4-2:~~Map 4-2:~~ Dundalk Well Supply Wellhead Protection Areas



A conceptual model was developed and formed the basis for the construction of a three-dimensional numerical representation of the aquifer system. The conceptual model includes: an interpretation of the hydrostratigraphic units within the overburden sequence; delineation of the distribution of the hydraulic properties within the study area (i.e., hydraulic conductivity and porosity) for the various units; specification of model (aquifer) boundary conditions; and an estimate of recharge rates over the surface area of the model domain. The numerical model was constructed and calibrated using the available hydrogeological data and hydrogeological mapping products and then used to delineate the capture zones which define the WHPAs. Water takings from individual domestic wells are relatively small and their effects on the model results are assumed to be negligible and are therefore not included in the model. As previously mentioned, a simplified approach was taken to represent the bedrock aquifer given lack of high quality data (Golder, 2009).

To account for some of the uncertainty in the capture zones developed for Dundalk, a factor of safety is applied that effectively increases the spatial coverage of each time of travel related capture zone. The factor of safety is comprised of two components: in the first instance, using the pumping well as the reference point, the width and length of the capture zone is increased by 20% to account for some uncertainty in the hydraulic characteristics of the aquifer system supplying water to the well; secondly, and again using the pumping well as the reference point, the orientation of the capture zone is adjusted by 5 degrees (plus and minus) along its centreline which accounts for some uncertainty in the regional flow direction by increasing the width of the capture zone at increasing distances from the pumping well.

Dundalk Wellhead Protection Areas

The pumping rates used in developing the Dundalk WHPAs are based on a forecast of anticipated future groundwater use. The previous numerical modelling indicates that Township of Southgate personnel anticipate that Dundalk will experience a water demand growth of approximately 20% in the next five years. It was also indicated in the report by Township personnel that the increase in pumping volume would come from well D3, the primary well.

This resulted in a future rate for well D3 of 598,000 L/day, while the rate for well D4 was maintained at 256,000 L/day (Triton Engineering Services Limited et al., 2008). The Township's engineer, Triton Engineering Services Limited (Triton), was contacted to determine water demand prediction for a longer period (i.e., 25 years) to coincide with the time of travel capture zone delineations. Triton indicated that the previously predicted water demand will not differ significantly over 25 years, if at all, given the economic climate and the fact that a number of businesses in the community have closed. Triton also indicated that it is anticipated that the demand will be shared by wells D3 and D4 (Triton Engineering Services Limited, 2009a). Therefore, the forecast rates used in the model were 427,000 L/day at each of D3 and D4. The pumping data for 2006 to 2008 indicate that D3 can operate at this rate and testing indicates that it is also possible to pump D4 at this rate (Anderson GeoLogic, 2002).

Map 5-2 illustrates the WHPAs established for the Dundalk municipal water wells. The capture zones for the Dundalk wells each extend approximately 1.5 km to the northwest in the direction (upgradient) of regional groundwater flow in the bedrock. The land use overlying much of the WHPA for D3 and 2 year capture zones for D4 is within the urban area of Dundalk. The area outside the 2 year capture zone for D4 is mainly rural agricultural.

Peer Review

A peer review of the report *Township of Southgate Village of Dundalk: Source Protection Vulnerability Assessment and Issues Evaluation* (Golder, 2010d) was completed by Christopher

~~Neville of S. S. Papadopulos & Associates, Inc. The overall impressions of the report by the peer review are as follows:~~

~~*"In [the Peer Reviewer's] opinion, the approaches adopted for the assessment are consistent with the Ontario Ministry of the Environment Technical Rules for the Clean Water Act (version of November 16, 2009). In our opinion it is unlikely that we would obtain significantly different results from an independent analysis. The text of the report is clear and concise, and the figures are appropriate."*~~

~~The responses to the peer review comments enhanced the overall defensibility of the report but did not impact the outcome of the WHPAs or vulnerability scoring.~~

~~4.1.6~~

~~4.1.7 **Vulnerability Scoring in Wellhead Protection Areas**~~

~~Surface and sub-surface contaminants pose a risk to groundwater resources and can have long-lasting impacts that can impair water quality conditions. The intrinsic vulnerability of the aquifer refers to the level of protection provided by the geological materials overlying the aquifer and is independent of the potential contaminant.~~

~~The surface to aquifer advection time (SAAT) approach is described as "a direct estimate of the vertical travel time from the ground surface (or near ground surface) to the top of the aquifer (or top of the water table in an unconfined aquifer)". The intrinsic vulnerability derived from the SAAT method is expressed in units of time and was completed by Earthfx (2008).~~

~~The (SAAT) time of travel has two components, 1) the unsaturated zone arrival time (UZAT), and 2) the water table to aquifer arrival time (WAAT). The UZAT is the time of travel from the surface to the water table and the WAAT is the time of travel from the water table to the aquifer of interest. The SAAT and UZAT are the same for unconfined aquifers. SAAT aquifer vulnerability mapping was completed for most of the Grand River watershed as a separate project (Earthfx, 2008). This SAAT aquifer vulnerability mapping was used as the basis for the vulnerability scoring, although some WHPA scale adjustments to this mapping were made to account for local conditions in the Dundalk WHPA, as described later in this section. The unadjusted intrinsic vulnerability for the Dundalk Well Supply is shown on **Map 5-3.**~~

Dundalk Vulnerability Scoring in Wellhead Protection Areas

~~Vulnerability Scoring for the Dundalk Wellhead Protection Areas~~ Most of the regional intrinsic vulnerability within the Grand River SPA was completed ~~by EarthFX Inc. (2010)~~ using the Surface to Aquifer Advective Time (SAAT) method (EarthFX, 2010) and modified at the municipal well scale to account for local conditions (Golder, 2010a). ~~This SAAT aquifer vulnerability mapping was used as the basis for the vulnerability scoring, although some WHPA scale adjustments to this mapping were made to account for local conditions in the Dundalk WHPA, which is mainly considered low., as described later in this section .~~ The ~~unadjusted~~ intrinsic vulnerability for the Dundalk ~~Well Supply~~WHPAs, as ~~is~~ shown on **Map 4-3,** is predominantly low with some small sections of medium vulnerability in the eastern portion of the WHPA-D.

The ~~wellhead protection zones~~WHPAs were overlain ~~/ integrated~~ with the SAAT map for the Dundalk area to produce vulnerability scoring maps. ~~The v~~Vulnerability scores~~ing and mapping, ~~, which incorporated~~including the~~ identified transport pathways (refer to Section 4.1.3), were ~~performed~~ calculated using the method outlined in ~~the~~ Part V11.2 in the Technical Rules~~. The MOE Technical Rules procedure for vulnerability scoring is~~ as ~~summarized in **Table 4-4**.

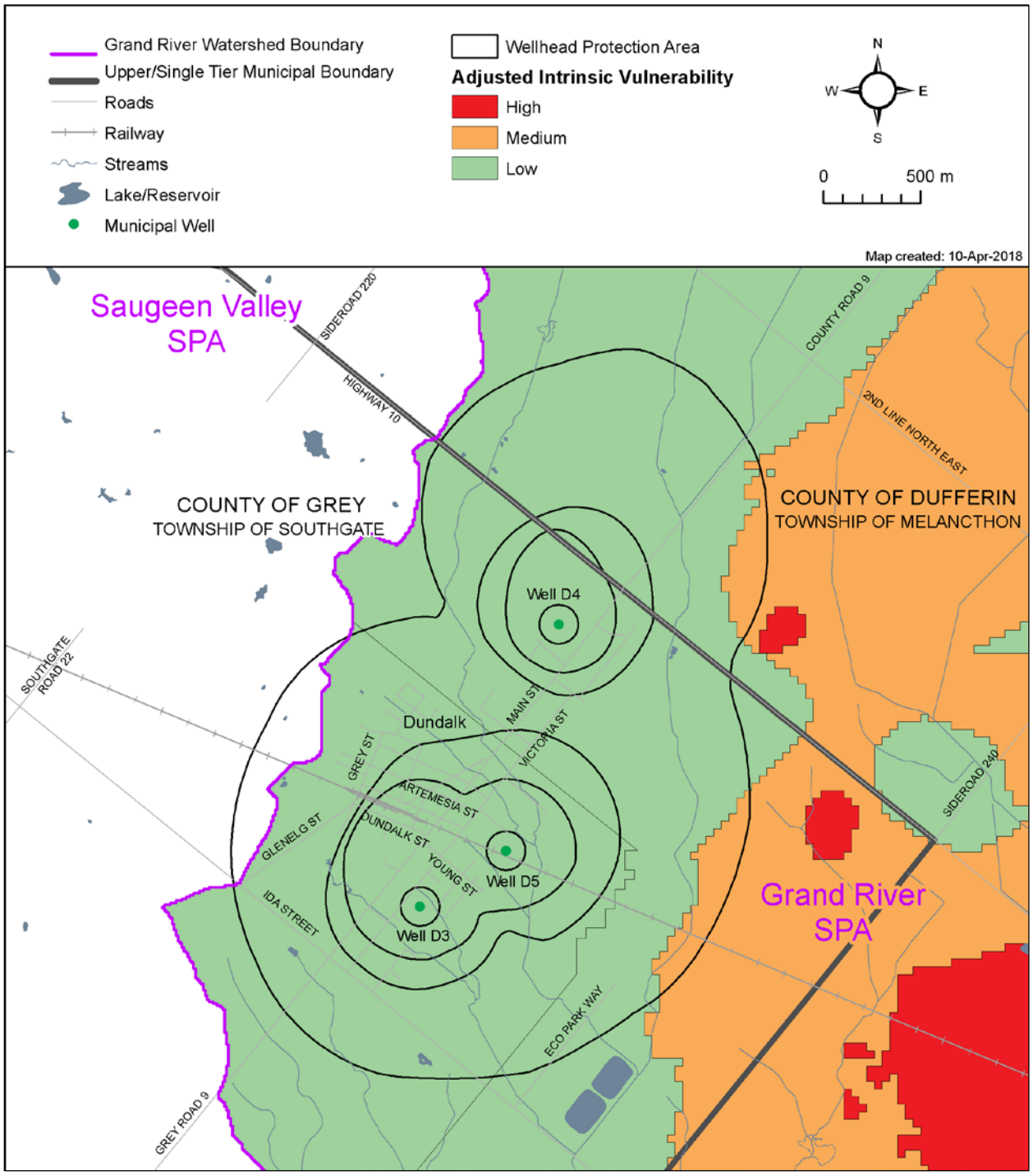
Table 4-4: Wellhead Protection Area Vulnerability Scores - SAAT

Intrinsic Vulnerability	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	2	2

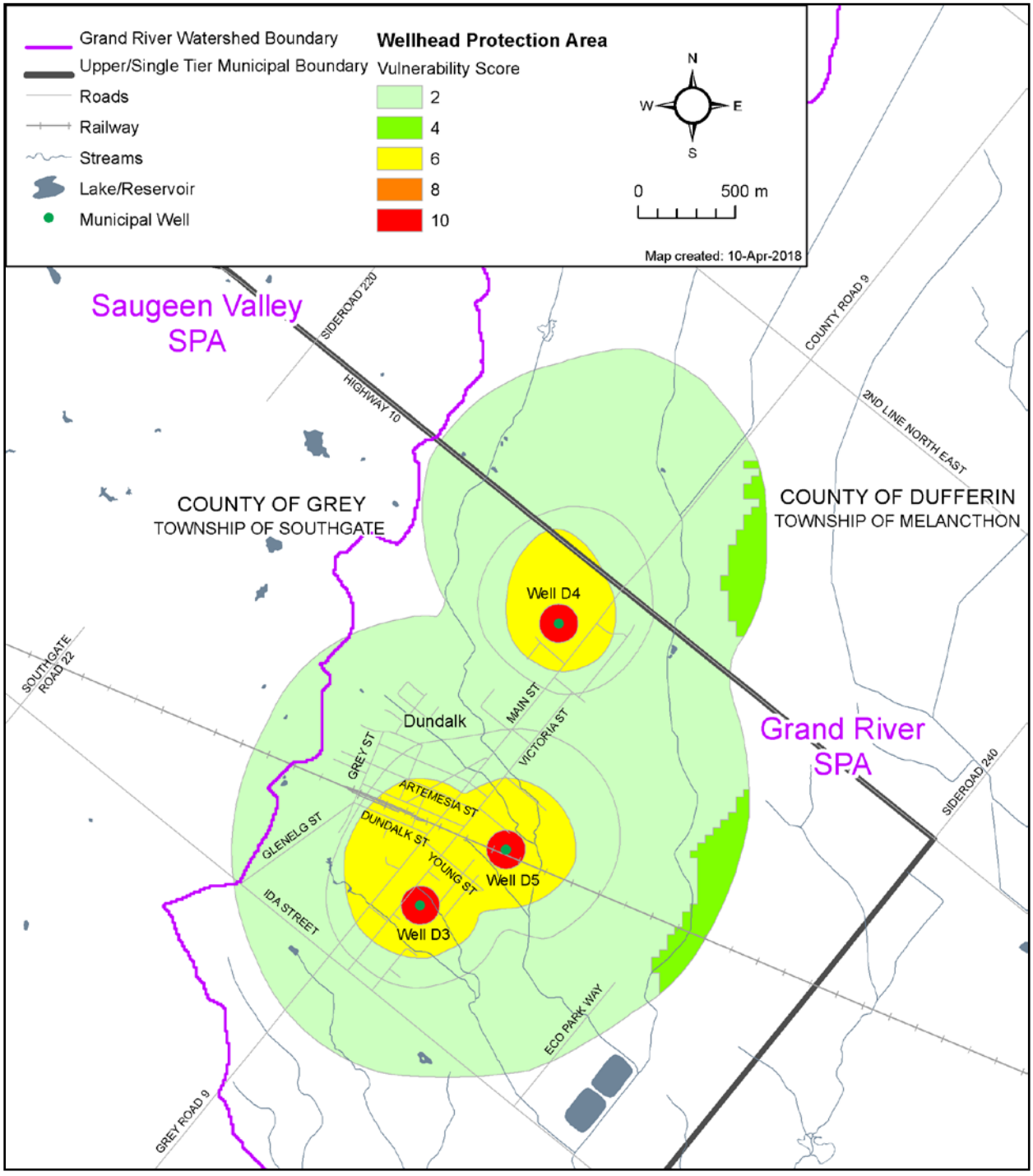
The vulnerability scoring map for Dundalk is included in **Map 4-4.** The 100 m radius zone is categorized as a vulnerability of 10, the 2-year time-of-travel zone is categorized as a

vulnerability of 6 and the remaining area within the WHPAs are categorized as a vulnerability of 2, with some vulnerability 4 on the eastern edge. ~~This~~ These scores are~~is~~ reflective of the low permeable sediments overlying the bedrock aquifer.

Map 4-3 Dundalk Well Supply ~~Unadjusted~~ Intrinsic Vulnerability



Map 4-4: Dundalk Well Supply Wellhead Protection Area Final Vulnerability



4.1.84.1.3

dentification ofDundalk Transport Pathways and Vulnerability Adjustment

A constructed transport pathway is "a pathway, or shortcut, that can make it easier for a contaminant to be transported to a drinking water source." The vulnerability of the municipal aquifers is being assessed to account for the natural protection provided by the materials overlying the aquifers of interest; however, anthropogenic activities can bypass this natural physical protection thereby increasing the vulnerability. The presence of the transport pathways should be accounted for in the vulnerability assessment and these pathways may include private water wells, unused water wells, abandoned water wells, construction of underground services, subsurface excavations, pits and quarries.

A review of water well records and previous transport pathway assessment (Triton Engineering Services et al., 2008) was conducted to identify transport pathways but no on-site inspection of wells took place.

Transport Pathways in the Dundalk Wellhead Protection Areas

Rural homes and farms in the area obtain water supplies from private wells. Abandoned wells may exist at some of the rural residences, but none have been identified based on the work to date. However because there are no confirmed well pathways, no increases to vulnerability due to the presence of private wells was included.

. A review of the potential for private wells to act as conduits to the bedrock aquifer within the 2-year time of travel capture zone for production well D3 was completed. Water level monitoring occurred in identified shallow dug wells and both the water level and water quality was monitored in the single private drilled well. Neither set of monitoring identified a connection between the private wells and production well D3. In total, ten private wells have been decommissioned in accordance with Ontario Regulation 903. Further results of the study are not available at this time to include in the analysis.

Wells D1 and D2 have been decommissioned in accordance with Ontario Regulation 903, and are not considered transport pathways. Shallow potential transport pathways are possible; rural homes and farms use septic systems for wastewater treatment and disposal and there are buried utilities within the urban area.

Similarly, Nno adjustments to the vulnerability were made due to septic systems and buried utilities as they most likely do not act as significant transport pathways due to their shallow nature within a fairly thick aquitard overlying the bedrock aquifer (i.e., they do not breach the aquitard).

Adjustments to Vulnerability to Account for Transport Pathways

Transport pathways may provide a faster pathway for the potential threats and contaminants to travel to the aquifer and ultimately to the municipal wells. As part of this study, transport pathways were reviewed and analyzed to determine their effect on the aquifer vulnerability.

The vulnerability of the aquifer may be increased by any land use activity or feature that disturbs the surface above the aquifer, or which artificially enhances flow to that aquifer. In areas where transport pathways exist, the intrinsic vulnerability can be increased to reflect the higher vulnerability caused by the constructed pathway (i.e., from low to moderate or high, and

~~moderate to high). In some cases the intrinsic vulnerability index is already high and cannot be further increased. Based on the assessed presence of transport pathways and modified vulnerability index, the resultant vulnerability score increases to reflect the identified enhanced vulnerability.~~

~~The vulnerability of the aquifer should only be increased to account for a transport pathway where there is sufficient confidence in the available data to justify increasing the vulnerability. The vulnerability should be adjusted to account for deep excavations, pits and quarries, etc., where it is documented that the features penetrate a confining unit or remove sufficient material and thus decrease the natural protection of the materials overlying the municipal aquifer. These areas are delineated based on supporting documentation including air photo interpretation and local knowledge of the study areas.~~

~~Adjusted Vulnerability Scoring for the Dundalk Wellhead Protection Area~~

~~No adjustments to the vulnerability were made due to septic systems and buried utilities as they most likely do not act as significant transport pathways due to their shallow nature within a fairly thick aquitard overlying the bedrock aquifer (i.e., they do not breach the aquitard).~~

Uncertainty in the Wellhead Protection Area Delineation and Vulnerability Scoring for the Dundalk Well Supply

An uncertainty assessment associated with the development of WHPAs and vulnerability mapping is required to assess the level of confidence in the results and determine the need for additional data collection and/or analysis as part of future assessments. Uncertainty ratings within each WHPA must be designated as either high or low and can vary within the zones of the WHPA.

~~The Technical Rules (MOE, 2009b) list the following factors that must be considered in the analysis:~~

- ~~The distribution, variability, quality and relevance of data used in the assessment;~~
- ~~The ability of the methods and models used to accurately reflect the flow processes in the hydrogeological 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; and~~
- ~~The accuracy of which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features.~~

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrogeological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that groundwater systems are influenced by a myriad of interacting man-made and natural influences that vary spatially and temporarily.

Since the municipal supply wells are completed in the bedrock aquifer, there is a fair amount of uncertainty over the times of travel and the affective area of capture. In general, there would be greater uncertainty for bedrock systems than overburden systems due to the assumptions with effective porosity.

For the Dundalk area, in addition to the regional studies that have been conducted, local hydrogeological studies have been completed, including aquifer testing at Well D4 and D5. Also, numerous water well records exist for private wells located within and around the WHPA. After filtering out lower quality well records (due to location accuracy, missing geology and anomalous geology), the remaining water well records were used to fill in the gaps of the detailed studies. The WHPAs were delineated using a numerical model that had been calibrated reasonably well with the field data as described previously.

For Dundalk, intrinsic vulnerability mapping results were reviewed at a WHPA scale and changes were applied to improve the results and reduce uncertainty in the vulnerability mapping. Further assessment was conducted using a different method that produced similar results in the area of the WHPA.

Missing information associated with the WHPA delineation and vulnerability scoring are as follows; there is no site specific information on the effective porosity of the bedrock; there are relatively few high quality monitoring wells within and surrounding the capture zone to confirm the local groundwater flow direction; and the influence on the nature of the fracturing and distribution of water bearing zones within the bedrock are not explicitly mapped.

~~It should also be recognized that because these are bedrock wells, there is a fair amount of uncertainty over the time of travel and the effective area of capture. In a general sense, there is greater uncertainty for bedrock systems than overburden systems due to the complexity of fractured rock and assumptions with effective porosity.~~

~~In addition to the regional studies that have been conducted, local hydrogeological studies have been completed for the Dundalk area including aquifer testing at Well D4. Also, numerous water well records exist for private wells located within and around the WHPA. These records can provide information to fill in the gaps of the detailed studies; lower quality well records are filtered to improve reliability. The WHPAs were delineated using a numerical model that had been calibrated reasonably well with the field data as described previously. In addition, a factor of safety was applied in delineating the WHPAs to help address, in part, the uncertainty in the hydraulic parameters assigned and potential regional variation in the flow direction. The possible presence of karst needs to be determined for further assessment. If karst is identified in the vicinity of the WHPAs, then the uncertainty rating should be revised from low to high.~~

~~The SAAT mapping was initially conducted at a watershed scale to provide a consistent mathematical approach to the vulnerability aspect of the scoring. For Dundalk, these results were further reviewed at a WHPA scale and changes applied to improve the results and reduce uncertainty in the SAAT mapping. The vulnerability scoring used in the threats assessment is based on both the WHPA delineation and the SAAT vulnerability mapping and therefore the overall uncertainty is related to the combined uncertainty of these two tasks.~~

~~Efforts have been made to reduce the uncertainty in the hydrogeological mapping products, following the guidance outlined in the Technical Rules (as stated above). However, some missing information is as follows: there is no site specific information on the effective porosity of the bedrock; there are relatively few high quality monitoring wells within and surrounding the capture zone to confirm the local groundwater flow direction; and the influence on the nature of the fracturing and distribution of water bearing zones within the bedrock are not explicitly mapped.~~

Notwithstanding the above, the vulnerability scoring reflects the best estimate of the actual conditions at the Dundalk wells. The WHPAs, SAAT vulnerability and resulting vulnerability scoring for Dundalk are therefore estimated to have a low uncertainty rating.

~~4.1.9~~4.1.4 M anaged Lands within the Dundalk Wellhead Protection Area

Managed lands are lands that may receive Agricultural Source Material (ASM), Non-Agricultural Source Material (NASM) or commercial fertilizer and can be divided into 2 categories: agricultural managed lands (AML) and non-agricultural managed lands. Agricultural managed lands include cropland, fallow and improved pasture that may receive ASM. Non-agricultural managed lands may include golf courses, sports fields, residential lawns and other built-up grassed areas or turf that may have commercial fertilizers applied.

~~Managed Lands are lands to which nutrients are applied. Managed lands can be categorized into two groups: 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 land includes golf courses, sports fields, lawns and other grassed areas that may receive nutrients (primarily commercial fertilizer).~~

~~The Technical Rules (Part II, Rule 16) require that the percentage of managed lands within WHPA-A, B, C and D be assessed in areas where the vulnerability scores allow for significant, moderate or low threats. The calculated percent managed land is used in the threat assessment to determine the circumstances for nutrient application related threats including the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land.~~

~~Part I.1 of the Technical Rules describes "managed land" as land to which agricultural source material, commercial fertilizer or non-agricultural source material is applied. Managed land can be broken down into agricultural managed land and non-agricultural managed land. The Technical Rules define "agricultural managed land" as managed land that is used for agricultural production purposes including areas of cropland, fallow land and improved pasture where agricultural source material, commercial fertilizer or non-agricultural source material is applied or may be applied. Non-agricultural land is interpreted to include golf courses, sports fields, lawns and other grassed areas that may receive nutrient applications.~~

~~The percentage of managed land is considered to be the sum of agricultural managed land and non-agricultural managed land divided by the total land area of the vulnerable zone. It should be noted that the area only includes those parts of a property that are within the vulnerable zone regardless of whether the property extends beyond the zone.~~

~~A GIS based approach was used to delineate the agricultural managed land areas, which included the area of properties within a protection zone identified as an agricultural property (identified through property code assessment) minus the area of woodlands, wetlands, rivers and lakes within the agricultural properties. These areas were further refined manually to a limited degree through air photo interpretation.~~

~~Similarly, a GIS based approach was used to delineate the non-agricultural managed lands. Golf courses, sports fields and other grassy areas were identified through property code assessment or identification based on air photos. Again, the areas of woodlands, wetlands, rivers and lakes were removed from the managed land areas for the golf courses and sports fields. Residential properties were treated differently since the area of structures and driveways~~

~~on a specific property can vary. In this case, all residential properties were identified based on MPAC property codes and it was assumed that the managed land covers 50% of these properties based on typical zoning by-law constraints. Note that this MOE approach conservatively treats residential managed land areas equally to agricultural managed land areas in the calculation of total managed land.~~ The managed land mapping was completed for the WHPA-A and~~,~~ WHPA-B ~~and WHPA-C~~ zones ~~only~~as the vulnerability is only high enough in these zones for related activities~~threats~~ to be considered low, moderate or significant threats. Managed lands were completed ~~,~~using the methodology outlined in Chapter 3, with the results for Dundalk summarized~~.~~ o~~The delineated managed lands are included i~~n **Map 4-5** ~~for Dundalk~~ and in ~~**Table 5-3**~~ **Table 4-5** ~~summarizes the percent managed land~~.

Table 4-5: Percent Managed Lands

	WHPA-A	WHPA-B
D3	56~~27~~% (~~<~~40% - 80%)	~~3~~28~~2~~% (<40%)
D4	4~~2~~7% (40% - 80%)	48~~57~~% (40% - 80%)
D5	15 (<40%)	28% (<40%)

Note: Percent in brackets represents the MOE threshold for percent managed land as related to the threats table.

Livestock Density within the Dundalk Wellhead Protection Area

~~The Technical Rules (Part II, Rule 16) also require the mapping of livestock density. Livestock density is defined as the number of nutrient units over a given area, and is expressed by dividing the nutrient units by the number of acres in the agricultural managed land area or the livestock grazing area depending on the threat being assessed.~~ Livestock density is used as a measure to determine the intensity of livestock animals and as such can be used as a measure of the potential for generating, storing and land applying agricultural source material. Similar to the managed land mapping,

~~The calculation of livestock density involves the following steps; estimate the number of each category of animal present, convert the numbers of each animal present into nutrient units (to allow for all animals to be compared on an equivalent unit of measure) and sum the total nutrient units of all animals present and divide by the agricultural managed land within the same area.~~ the livestock ~~density for the Dundalk Wellhead Protection Areas~~ density for the Dundalk ~~Wellhead Protection Areas~~WHPAs was completed for WHPA-A and WHPA-B zones only, using the methodology outlined in Chapter 3. ~~They~~Results ~~can be seen~~are summarized in **Table 4-6** ~~**Table 4-4**~~ and on **Map 4-6.**

Table 4-6: Livestock Density

	WHPA-A	WHPA-B
D3	N/A	N/A
D4	N/A	0
D5	N/A	N/A

Note: N/A means that livestock density was not calculated as there were no agricultural managed lands in those areas.

Percent Impervious Surface Area within the Dundalk Wellhead Protection Area

Percent impervious surface is used as a surrogate measure of the potential for the application of salt for the purposes of melting snow and ice. It measures the percentage of the study area

covered by impervious surfaces where road salt would likely be applied (roads, sidewalks, and parking lots), but not those where it would not (buildings, landscaped areas, etc). The calculation of impervious surface area for the Dundalk Wellhead Protection Area used the moving window average approach, which is described further in Chapter 3. ~~The Technical Rules (Rule 16(11) and 17) require calculation and mapping of the percentage of total impervious surface area where road salt can be applied per square kilometre in each of the vulnerable areas. This impervious surface area mapping is to be used in the MOE water quality risk scoring and assessment of threat circumstances relating to road salt application. Total impervious surface area is defined in the Technical Rules as the surface area of all highways and other impervious land surfaces used for vehicular traffic and parking, and all pedestrian paths.~~

~~The procedure for impervious area mapping was modified to provide a more applicable analysis for this study. Rather than using a 1 km^2 grid, the percent impervious surface was calculated for each protection zone in a similar manner as for livestock density and percent managed land, except the WHPA-A and WHPA-B zones were combined into a single zone for impervious calculation given the relatively small size of these zones. A that calculation was completed for the entire WHPA-D zone regardless of whether the vulnerability score was equal to 6. The percent impervious surface areas were therefore calculated for each of WHPA-A/B, WHPA-C and WHPA-D. The calculations were completed for areas within the WHPA and did not include portions of parcels that lie outside a protection area boundary as specified by the Technical Rules (i.e., only the portion of the parcel within the WHPA was included in the calculation). As per Technical Rule 15.1, the Director has provided confirmation that he agrees to the departure. The Director's letter of confirmation can be found in **Appendix B.**~~

~~Roads, sidewalks, parking lots and driveways are identified as the impervious surface types for this area and all other land uses including agricultural, urban/rural vegetation, bare soils, woodlots, roofs of buildings and houses and water features are classified as pervious surfaces. Aerial photography was used in conjunction with the Natural Resources and Values Information (NRVIS) vector data from the Ministry of Natural Resources, and spectral and textural algorithms to identify these impervious surface types.~~

~~The following provides the key steps in the methodology used to complete the impervious surface area mapping:~~

~~1. The 30 cm aerial photography was re-sampled to 2 m for use in imagery land use classification;~~

~~2. Building and road vector data from NRVIS was incorporated in imagery classification software;~~

~~3. Roads and buildings were initially classified with the aid of the digital vector data, to try to eliminate confusion that often exists between bare soil and pavement;~~

~~4. Using spectral and textural algorithms standard to the classification software, the remaining land uses, parking lots, other paved surfaces, agricultural, urban/rural vegetation, bare soils, woodlots and water features were classified as either impervious or pervious as indicated above;~~

~~5. QA/QC initial classification;~~

~~6. Visual comparison of initial classification and the aerial photography was conducted and adjusted as necessary;~~

7. Two categories were grouped from the previously mentioned land use polygons and mapped as impervious versus pervious areas; and

8. The percentage of total impervious surface areas was calculated within each of WHPA-A/B, WHPA-C and WHPA-D using results of Step 7.

Map 4-7 shows the results of the impervious area mapping.

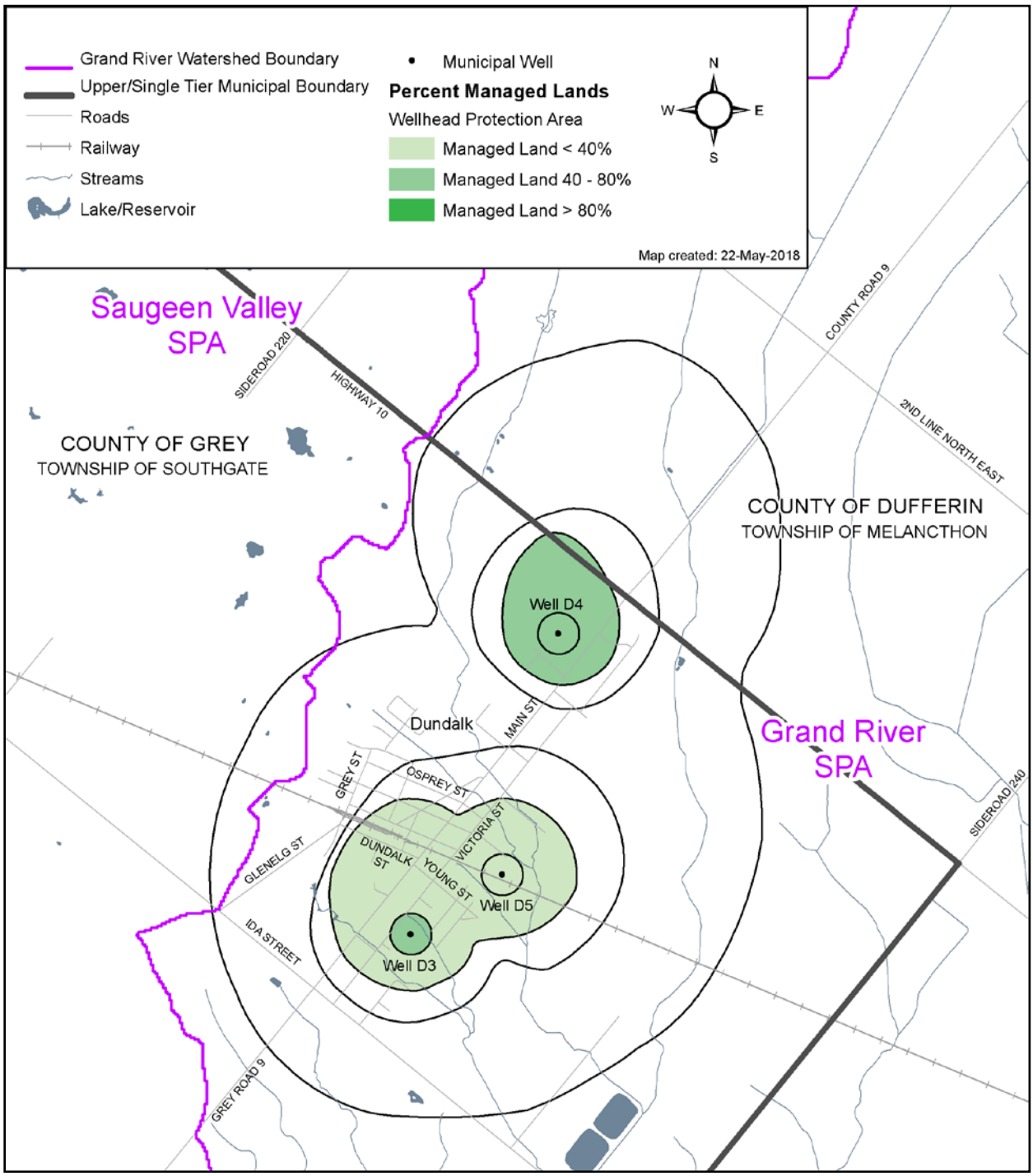
and **Table 5-5Table 4-5** summarizes the calculations for each protection area. Impervious surfaces mapping

Table 4-1: Percent Impervious Surface Area in the Dundalk Wellhead Protection Areas

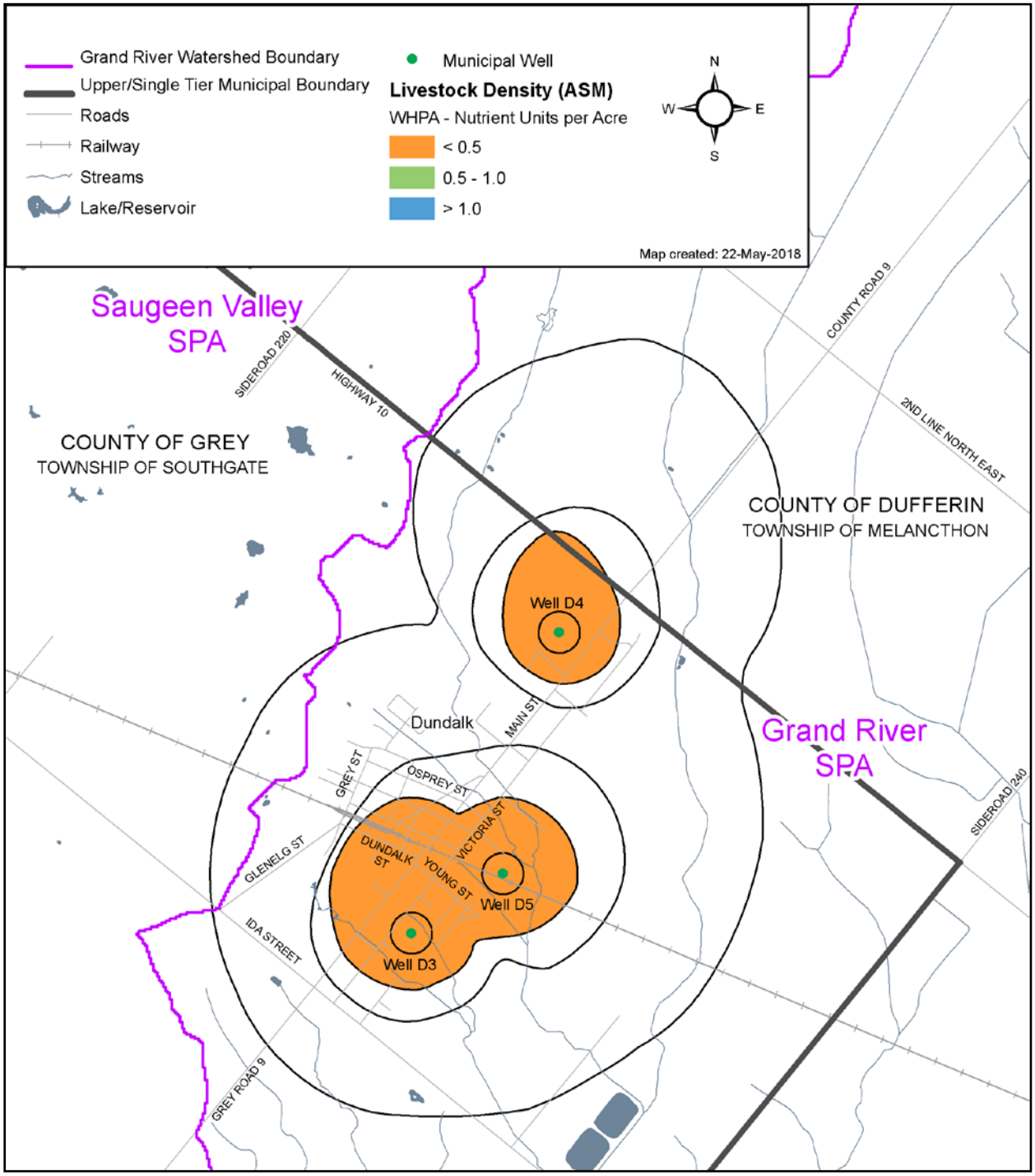
	WHPA-A/B	**WHPA-C**	**WHPA-D**
D3	18% (>8% - <80%)	20% (>8% - <80%)	11% (>8% - <80%)
D4	12% (>8% - <80%)	8% (>1% - 8%)	2% (>1% - 8%)

Note: Percent in brackets represents the MOE threshold for percent impervious surface area as related to the threats table.

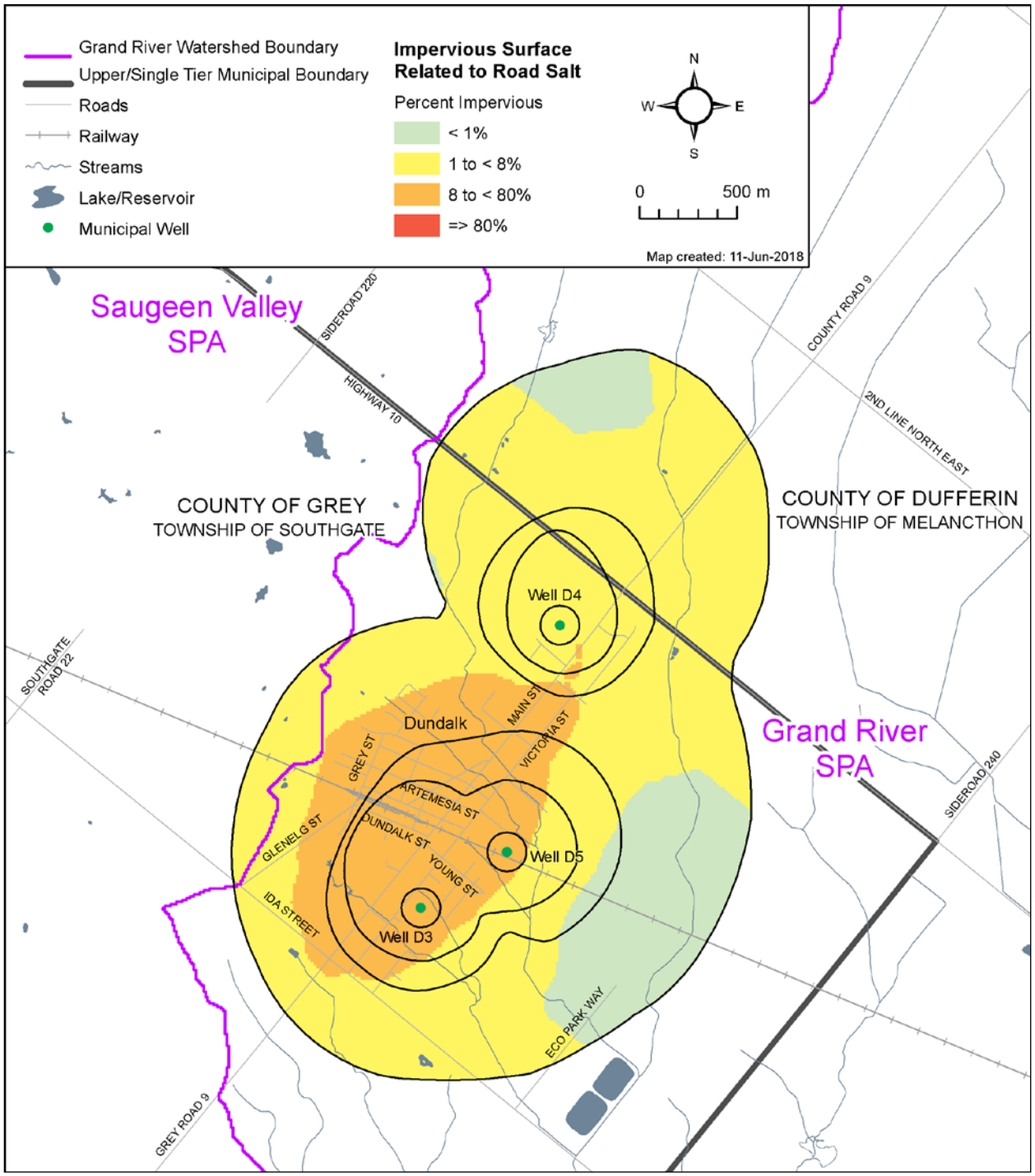
Map 4-5: Dundalk Well Supply Percent Managed Lands



Map 4-6: Dundalk Well Supply Livestock Density



Map 4-7: Dundalk Well Supply Percent Impervious Surfaces



~~***Uncertainty in the Vulnerability Analysis for the Dundalk Wellhead Protection Area***~~

~~The following key points are made regarding the limitations of the data used for the completion of the assessment:~~

~~The conceptual model of the aquifer system at the municipal well field is based in part on production well logs, monitoring well logs and water well records. As the distance away from the production wells increases, the interpretation relies more on the water well records and less on the monitoring well logs as they are typically not present. Water well record locations may be plotted in the wrong location and the accuracy of the geologic descriptions is dependent on the knowledge of the well driller. The geological descriptions provided on the borehole records for monitoring wells were usually provided by a person experienced in geological material descriptions and are considered more reliable for the development of conceptual hydrogeological models of the WHPA. Therefore, for analyses that involve use of the water well records (SAAT mapping, vulnerability mapping, capture zones), the accuracy is considered to decrease with distance away from the municipal wells.~~

~~While the numerical model is constructed on the best available information at present, the model can be updated in the future if more information becomes available. Incorporating such information into the model can help reduce the uncertainty associated with the WHPA delineation and vulnerability mapping.~~

~~***The transport pathway inventory is a desktop analysis and involved only minor field verification or site visits to validate the information.***~~

- ~~The MOE livestock density circumstance is averaged over the entire protection zone and does not represent the livestock density at an individual property. The degree of threat posed by nutrient application at the scale of an individual property would need to be established from field visits and additional information from land owners, such as that collected as part of the development of nutrient management plans. The data on actual and historic farming practices are currently based on assumptions.~~

~~Efforts have been made to reduce the uncertainty in the hydrogeological mapping products, following the guidance outlined in the CWA Technical Rules (as stated above). However, some missing information is as follows: there is no site specific information on the effective porosity of the bedrock; there are relatively few high quality monitoring wells within and surrounding the capture zone to confirm the local groundwater flow direction; and the influence on the nature of the fracturing and distribution of water bearing zones within the bedrock are not explicitly mapped.~~

~~Notwithstanding the above, the vulnerability scoring reflects the best estimate of the actual conditions at the Dundalk wells, and managing activities using this as the basis for Source Protection programs would serve to reduce the risk (threat) of future contamination to these wells. The WHPAs, SAAT vulnerability and resulting vulnerability scoring for Dundalk are therefore estimated to have a low uncertainty rating.~~

~~4.1.10~~4.1.5

~~D~~Dundalk Drinking Water Quality Threats Assessment

The Ontario Clean Water Act, 2006 defines a Drinking Water Threat as “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 a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat.”

~~The Technical Rules (MOE, 2009) list five ways in which to identify a drinking water threat:~~

~~a) Through an activity prescribed by the Act as a Prescribed Drinking Water Threat;~~

~~b) Through an activity identified by the Source Water Protection Committee as an activity that may be a threat and (in the opinion of the Director) a hazard assessment confirms that the activity is a threat;~~

~~c) Through a condition that has resulted from past activities that could affect the quality of drinking water;~~

~~d) Through an activity associated with a drinking water issue; and~~

~~e) Through an activity identified through the events based approach (this approach has not been used in this Assessment Report).~~

Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Dundalk Well Supply

Identification of Drinking Water Quality Threats in the Dundalk Well Supply Wellhead Protection Areas. **Table 4-7~~Table 4-6~~** provides a summary of the threat levels possible in the Dundalk Well Supply for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), Pathogen, and Local Threats (Oil Pipelines). A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map 4-4.**

Table 4-7: Identification of Drinking Water Quality Threats in the Dundalk Well Supply Wellhead Protection Areas

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A	10	✔	✔	✔
	WHPA-B	6		✔	✔
	WHPA-C/D	2			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✔		
	WHPA-D	2			
Pathogens	WHPA-A	10	✔	✔	
	WHPA-B	6			✔
	WHPA-C/D	2			
Local Threat (Oil Pipelines)	WHPA-A	10	✔		
	WHPA-B	6			✔
	WHPA-C/D	2			

~~Activities that Are or Would be Drinking Water Threats in the Wellhead Protection Areas~~

~~Ontario Regulation 287/07, pursuant to the *Clean Water Act*, provides a list of Prescribed Drinking Water Quality Threats that could constitute a threat to drinking water sources.~~ **~~Table~~**

~~4-8 lists the activities that are prescribed drinking water threats. Listed beside the prescribed drinking water threats are the typical land use activities that are associated with the threat.~~

~~In addition, there is one local threat that has been identified in the Lake Erie Source Protection Region: the transportation of oil and fuel products through a pipeline. To locate and learn about nearby pipelines, visit the Canadian Energy Pipelines Association's interactive pipeline map at http://aboutpipelinesmap.com.~~

~~A spill of oil and fuel products could result in the presence of petroleum hydrocarbons or BTEX in groundwater. The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act,* was approved as a local threat. The letter of approval from the Director of the Source Protection Programs Branch and table of hazard ratings is found in **Appendix D**.~~

Table 4-8: Drinking Water Threats

Prescribed Drinking Water Threat Ontario Regulation 287/07 s.1.1.(1)		**Land Use / Activity**
1	The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Landfills – Active, Closed Hazardous Waste Disposal Liquid Industrial Waste
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage Infrastructures Septic Systems, etc.
3	The application of agricultural source material to land.	e.g. manure, whey, etc.
4	The storage of agricultural source material.	e.g. manure, whey, etc.
5	The management of agricultural source material.	aquaculture
6	The application of non-agricultural source material to land.	Organic Soil Conditioning Biosolids
7	The handling and storage of non-agricultural source material.	Organic Soil Conditioning Biosolids
8	The application of commercial fertilizer to land.	Agriculture Fertilizer
9	The handling and storage of commercial fertilizer.	General Fertilizer Storage
10	The application of pesticide to land.	Pesticides
11	The handling and storage of pesticide.	General Pesticide Storage
12	The application of road salt.	Road Salt Application
13	The handling and storage of road salt.	Road Salt Storage
14	The storage of snow.	Snow Dumps
15	The handling and storage of fuel.	Petroleum Hydrocarbons
16	The handling and storage of a dense non-aqueous phase liquid.	DNAPLs
17	The handling and storage of an organic solvent	Organic Solvents
18	The management of runoff that contains chemicals used in the de-icing of aircraft.	De-icing
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.	Private water taking
20	An activity that reduces the recharge of an aquifer.	Impervious Surfaces
21	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	Agricultural Operations
Local Drinking Water Threat		**Land Use / Activity**
The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of the Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act.* [1]		Oil pipeline

1: As confirmed by the letter from the Director of the Source Protection Programs Branch in Appendix D.

Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Dundalk Well Supply

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**. The information above can be used with the vulnerability scores shown in **Map 5-4** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 4-8: Identification of Drinking Water Quality Threats in the Dundalk Well Supply Wellhead Protection Areas

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A	10	✓	✓	✓
	WHPA-B	6		✓	✓
	WHPA-C/D	2			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✓		
	WHPA-D	2			
Pathogens	WHPA-A	10	✓	✓	
	WHPA-B	6			✓
	WHPA-C/D	2			
Local Threat (Oil Pipelines)	WHPA-A	10	✓		
	WHPA-B	6			✓
	WHPA-C/D	2			

Significant Drinking Water Quality Threats for the Dundalk Well Supply

A summary of the threats enumeration results for each WHPA, grouped by threat type, are shown in **Table 5-9**. There is one significant threat identified in Dundalk, which occurs on one property.

Table 4-3: Dundalk Well Supply Significant Drinking Water Quality Threats

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
1	Waste Disposal Site - Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste	1	WHPA-A
Total Number of Properties		**1**	
Total Number of Activities		**1**	

1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 2987/07

s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

A review of the data for the Dundalk Well Supply System did not identify any Conditions or any Issues with the drinking water sources.

Conditions Evaluation

Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the CWA Technical Rules, lists the following two criteria for groundwater sources:

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.
- The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.

The above listed criteria were used to evaluate potentially contaminated sites within the WHPAs to determine if such a Condition was present at a given site.

Conditions Evaluation for the Dundalk Well Supply

The Technical Rules state that if there is evidence that a Condition is causing off-site contamination, a hazard rating of 10 is applied. If there is no evidence of off-site contamination, the hazard rating is 6, which would result in a moderate or low drinking water threat within the WHPA.

In consultation with Triton Engineering Services, two sites with groundwater or soil contamination that may be potential Conditions were identified within D3 WHPA-C.. One site was owned by the local hydro company and was a former location for transformer storage, located adjacent to D2. There is awas a potential for arsenic and selenium from the transformers to have leached into the ground, but there is no evidence to support this. Sampling for arsenic confirmed that there was no evidence to support leaching into the ground. On the second site, there was a heating oil spill that was immediately cleaned up by the Ministry of the Environment. No documentation was found to suggest a continued presence of BTEX (benzene, toluene, ethylbenzene and xylene) on this site.

At the current time, there is no evidence to suggest that either of the two sites have Conditions as defined by Rule 126 of the Technical Rules. If more information becomes available, these sites could be re-evaluated to determine if they meet the requirement of identified Conditions. Both of the sites are located within a vulnerability score area of 2, which would result in a risk

score of 20 (assuming a worst case hazard rating of 10). Should they exist, these conditions would not be drinking water threats under the Technical Rules.

~~4.1.11~~4.1.6 ~~D~~

Dundalk Drinking Water Quality Issues Evaluation

~~The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)).~~

~~Once a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the issue within an Issue Contributing Area and manage these threats appropriately. If at this time the Issue Contributing Area cannot be identified or the Issue cannot be linked to threats then a work plan must be provided to assess the possible link.~~

~~If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are significant drinking water threats, regardless of the vulnerability.~~

~~*Water Quality Issues Evaluation for the Dundalk Well Supply*~~

~~In addition to identifying the Issues, the water quality information was used as an independent measure of consistency to assess the aquifer vulnerability in the WHPAs or identify gaps in the vulnerability assessment. As previously indicated, nitrate and chloride are good indicators of potential anthropogenic impacts.~~

Potential Issues were evaluated through a review of raw and treated production well water quality data provided by the Township from 2004 to ~~2008~~ 20017 and discussions with Township staff. The raw water quality data available for the review were compared to the ODWQS and the Technical Support Document to identify parameters approaching or exceeding a standard.

A review of the data for the Dundalk Well Supply System did not identify any Issues with the drinking water sources under Technical Rule 114. None of the parameters analyzed exceeded a drinking water standard or showed signs of an increasing trend.

Nitrate and chloride are typically good indicators of surface impacts to the groundwater system. Samples analyzed for nitrate indicate concentrations below ~~1~~ 2.2 mg/L (2014) ~~as N~~ with no evidence of an increasing trend. For comparison, the ODWQS MAC ~~drinking water standard~~ for nitrate is 10 mg/L ~~as N~~. Chloride concentrations are not regularly monitored, however, the limited results provided by the Township indicate a concentration of 16 mg/L at D4 in 2002 and a concentration of 20 mg/L at D3 in 2001. These concentrations are low and do not indicate a local source of road salt impact. The Township ~~has since implemented the taking of~~currently samples for chloride ~~samples~~in raw water a couple times ~~a~~per year.

Sodium concentrations at both Wells D3 and D4 exceeded the aesthetic objective~~maximum acceptable concentration~~ for those on a sodium-restricted diet of 20 mg/L on most occasions from 2009 to 2017. Sodium concentrations ranged from 18.4 mg/L in 2011 to 31.5 mg/L in 2014. In 2013, water samples were taken in both March and July to evaluate possible road salt impacts. Results indicate that the sodium is likely naturally occurring as the sodium

concentration in March were similar to those in July. Water samples for sodium are ~~reportable~~reported every 57 months.

~~The microbiological data for the raw water from the municipal wells was reviewed in the annual reports for the period from 2004 to 2008.~~

Review of microbiological data (2004 to 2008) for Dundalk and the summary in the memorandum (Triton Engineering Services, 2009b) indicates that for Well D3 an E. coli value of 1 CFU/100 mL was detected in two samples out of 53 tests in 2008. Total coliforms concentrations at Well D3, ranging from 1 to 32 CFU/100 mL occurred in 11 of 53 total tests in 2008. From 2004 to 2007 there was ~~only~~ one detection of total coliforms in June 2005 out of a total of 202 tests at D3. E. coli was not detected in Well D3 during the 2004 to 2007 period of record. Well D4 did not have any E. coli detections according to the Water Operations Manager. The recent increase in total coliform detections in the raw water samples collected from Well D3 indicate that microbial water quality is a concern and as such has been investigated by the Township of Southgate.

~~At this time, the source of the detected microbial parameters remains unknown. Triton Engineering Services Limited, Blackport Hydrogeology and Ontario Water Well Services have been investigateding t~~The source of the microbiological Issues at Well D3 was investigated (Triton Engineering, 2009b) ~~. A memorandum (Triton Engineering Services Limited, 2009b) indicates that the investigation included~~which included monitoring private wells and testing of well D3 at length. Monitoring at D3 included precipitation quantities, continuous turbidity and particle counting, daily grab samples for bacteria testing, microscopic particle analysis (MPA), packer testing and downhole video inspection. ~~The memorandum~~Triton Engineering (2009b) concluded~~s~~ that the well is not groundwater under the direct influence of surface water (GUDI) and that the existing disinfection system has been working adequately. The MOECC ~~concurred~~ concurred ~~is in agreement that the well is not considered GUDI~~with this conclusion as well (Triton Engineering Services, 2010).

As the existing treatment is capable of eliminating any pathogens present and additional ultra-violet treatment ~~is being proposed~~has been added to further reduce the potential risk of microbial contamination, it can be concluded that pathogens at D3 do not represent a drinking water quality Issue~~. It is recommended that the water quality be monitored to determine if decommissioning the private wells has reduced the pathway to the aquifer.~~. Review of microbiological data from 2010 to 2017, indicates no issues with total coliforms and E.coli, as there are only limited detections a couple times a year. ~~The 2009 Dundalk Waterworks Annual Report (Ellis, 2010) noted that Well D3 began to have sporadic total coliform counts in the raw water samples. This well was taken out of service so a comprehensive investigation could be completed.~~

~~Summary of Water Quality Issues Evaluation~~

~~Microbial water quality is a concern at D3 and the source of this concern has been investigated by the Township of Southgate. It is not considered an Issue under Technical Rule 114 as treatment is currently in place and additional ultra-violet treatment is being proposed to further reduce the potential risk of microbial contamination. As well, a management measure was undertaken by decommissioning 10 nearby private wells. Continued water quality monitoring is recommended over the long term to assess the effectiveness of this measure in reducing microbial concentrations.~~

Limitations and Uncertainty for the Water Quality Issues Evaluation for the Dundalk Well Supply

The following limitation is presented for the analysis of Issues within Dundalk:

- Although chloride is not considered an Issue in Dundalk due to the limited amount of data, the Township should ~~conside~~continue~~r~~ routine sampling and analysis of the municipal raw water supply for chloride.

~~4.1.12~~4.1.7 **E**

~~E~~numeration of Significant Drinking Water Quality Threats

A summary of the threats enumeration results for each WHPA, grouped by threat type, are shown in **.** As of 2018, ~~There is~~ one significant threat has been identified on one property in Dundalk~~, which occurs on one property~~.

Table 4-8: Dundalk Well Supply Significant Drinking Water Quality Threats

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
1	Waste Disposal Site - Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste	1	WHPA-A
Total Number of Properties		**1**	
Total Number of Activities		**1**	

1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 2~~9~~87/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

A review of the data for the Dundalk Well Supply System did not identify any Conditions or any Issues with the drinking water sources.

~~The Technical Rules require an estimation of the number of locations at which an Activity is a significant drinking water threat and the number of locations at which a Condition resulting from past activity is a significant drinking water threat.~~

~~The enumeration of land use activities that may be associated with prescribed drinking water threats 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 drinking water threats are considered potential threats. As more site specific information becomes available during the source protection planning process, the presence of drinking water threats and their current level of management can be confirmed.~~

Data Sources for the Activity Threats Assessment for the Dundalk Well Supply

The key data sources used to identify threats on properties within the WHPAs include the following:

- Municipal Property Assessment Corporation (MPAC) assessment information.
- Hazardous Waste Information Network (HWIN) database.
- Technical Safety and Standards Authority (TSSA) database.
- Discussions with Triton Engineering Services to identify current and historical land use activities.
- Review of previous threats enumeration by Triton Engineering Services.
- Review of air photos.

Table 4-3: Dundalk Well Supply Significant Drinking Water Quality Threats

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
1	Waste Disposal Site - Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste	1	WHPA-A
Total Number of Properties		**1**	
Total Number of Activities		**1**	

1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 2987/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

Limitations and Uncertainty for the Enumeration of Significant Drinking Water Quality Threats for the Dundalk Well Supply

The following key points are made regarding the limitations of the data used and developed as part of the enumeration of significant drinking water threats:

- The threat assessment is a desktop scale analysis based on the assumptions used for the threat enumeration. The assessment has involved only minor field verification or site visits to validate the information. The current assessment identifies significant water quality threats based on a number of assumptions and not a survey of actual site conditions and circumstances. As such, the uncertainty associated with the identified threats is high.

- The terms “significant threat” and “risk” used in this report are used expressly in the context of the Clean Water Act. Use of these words does not provide an indication of the actual risk or threat, in the scientific definition of these terms that an activity poses to drinking water sources. In accordance with the Clean Water Act legislation and Technical Rules documentation, the threat rankings do not take into account any risk management/reduction/mitigation measures that may be in place for any Activity on a property; nor any local scale evaluation of the site conditions.

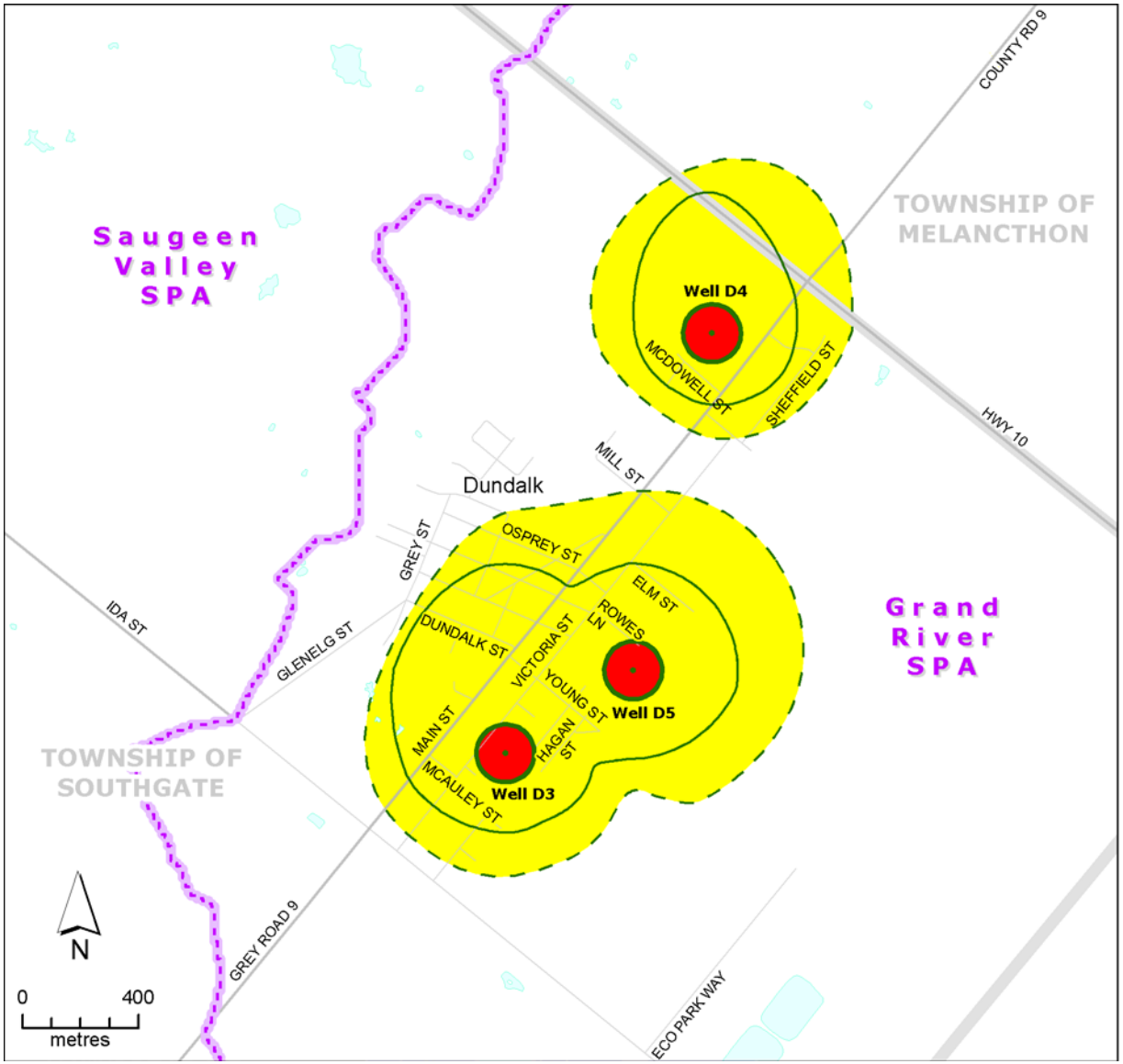
- The threat assessment has relied on a number of pre-existing data sources to complete the evaluation. In some cases the existing data sources are not current. Activities taking place on a given property may change from year to year or month to month.

- The MPAC property codes, used to identify the use of the property and the associated threats, do not always represent the current land use activity on the property. As such, threats may be applied to a property where they do not exist or vice versa, threats may have been missed on a property where they do exist.

- ~~A database of lands where biosolids are spread was not available for the preparation of this report. Such a data base would be useful to identify lands where this threat is present.~~

- ~~The location of a threat Activity on a property was assumed to be over the most vulnerable portion of a property where the underlying soils had areas of more than one vulnerability zone present.~~

3.6 Schedule A: County of Grey, Township of Southgate: Dundalk Well Supply



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

	Significant Drinking Water Threat Policy Categories	Vulnerability Scores on Map: 10	8	2,4,6
1.	Waste Disposal			
2.	Sewage Systems			
3, 4.	Agricultural Source Material			
6, 7.	Non-Agricultural Source Material*			
8, 9.	Commercial Fertilizer*			
10, 11.	Pesticide			
12, 13.	Road Salt*			
14.	Storage of Snow			
15.	Fuel			
16.	DNAPLs			
17.	Organic Solvents			
18.	Aircraft De-icing			
21.	Livestock Area			
Local Threat	Oil Pipelines			

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

Well
Road
Lake / Main River
Source Protection Area Boundary
Municipal Boundary
Wellhead Protection Zones:
WHPA-A
WHPA-B
WHPA-C

Ontario
Grand River Conservation Authority

1. Updated April 12, 2018.
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
3. This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-06-13 **DATE:** June 21, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Draft Updated Grant River Assessment Report and Source Protection Plan: Dufferin County**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-06-13 – Draft Updated Grand River Assessment Report and Source Protection Plan: Dufferin County – for information.

REPORT:

Updates to the Assessment Report

Technical changes to the assessment report are relatively minor: one backup well (PW8) was added to the Shelburne water supply system in 2014. The backup well was installed in close proximity to the existing well (PW7). Although Wellhead Protection Areas (WHPAs) were not modelled for Well PW8, it can be assumed that the footprint of the WHPA-B to D would be similar to that of Well PW7 as the two wells are 10 metres apart and only one of the wells is pumping at a time (i.e., no change in overall pumping rate). Backup supply well PW8 was incorporated into the Dufferin County, Town of Shelburne section (5) of the assessment report. The section has also been updated for brevity and added clarity.

In addition to updated content, the structure of the assessment report has been revised – water quantity technical work has been moved closer to the end of the document and water quality risk assessments, and each municipal water quality section, have been renumbered.

Updates to the Source Protection Plan

Policy applicability maps in the Grand River Source Protection Plan were updated in response to the addition of well PW8, a new Shelburne WHPA extending from the Nottawasaga Source Protection Area into the Grand River Source Protection Area, and updates to Dundalk WHPAs. Dufferin County did not identify any policies that required revision.

Please see **Appendix A** for an excerpt from section 5 of the assessment report and updated Source Protection Plan policy applicability maps. The Dufferin County section of the Draft Updated Grand River Source Protection Plan is available in its entirety on the June 21, 2018 eScribe meeting site.

Prepared by:

Ilona Feldmann
Source Protection Program Assistant

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

Excerpts from the Draft Updated Grand River Assessment Report and Source Protection Plan

5.4 Town of Shelburne

5.4.1 Shelburne Water Supply

The Town of Shelburne is situated at the headwaters of the Boyne River in the centre of Dufferin County and in the Nottawasaga Valley Source Protection Area. The Shelburne Water Supply System services a population of approximately ~~5~~8,~~000~~ 500 people and consists of ~~four~~ ~~five~~six ~~-~~groundwater supply wells (PW 1,3,4,5,7,8) and three pump houses. Wells PW 1, 3, 4, and 5 are located within the Nottawasaga Valley Source Protection Areas and Wells 7 and 8 are within the Lake Erie Region Source Protection Area. ~~Of the six~~five ~~wells, f~~Four of the wells are open hole in the shallow bedrock (Guelph Formation) and two are open hole in a deep confined bedrock aquifer (Gasport Formation). Portions of WHPA-D for ~~all four of the Shelburne wells~~Wells 1, 3, 4, and 5 cross into the Grand River Source Protection Area.

~~PW7 is located 3 km west of the Town of Shelburne, within the boundaries of the Grand River Source Protection Area. The new well was added to address the projected increase in system demand and to secure a new municipal water supply with minimal concentrations of naturally-occurring arsenic. Naturally occurring concentrations of arsenic are currently found in the existing Town supply wells.~~

PW7 was more recently added to the Shelburne Water Supply System to address the projected increase in system demand~~.~~. PW7 is a 305 mm diameter well drilled to a depth of 86.6 m bgs (meters below ground surface). As bedrock was encountered at 9.1 m bgs, the well was completed with a steel casing extending down to a depth of 47.2 m bgs, followed by 39.4 m of open hole. ~~The well draws water from the Gasport aquifer unit, which is considered to have more desirable formation water chemistry than the shallower Guelph aquifer (EarthFX, 2015)~~

In ~~2010~~2014, ~~a new well (PW7~~PW8~~)~~ was ~~drilled and is currently being incorporated into the Town's water supply system.~~ installed approximately 10 m adjacent to PW7. PW8 is a 305 mm diameter well drilled to a depth of 86.6 m bgs. As bedrock was encountered, the well was completed with a steel casing extending down to a depth of 47.6 m bgs, followed by 39.0 m of open hole.

PW8 was installed as a back-up well to PW7 and the current PTTW allows for one or the other well to be pumped at a maximum rate of 18.9 L/s (1135 L/min).

~~The well~~Both PW7 and PW8, draw~~s~~ water from the Gasport ~~aquifer unit~~Formation, which is considered to have more desirable formation water chemistry than the shallower Guelph ~~aquifer~~Formation, which contains ~~due to~~ naturally occurring arsenic (EarthFX, 2015). Both wells have been ~~put into~~in service early in 2016.

For further information on wells PW1, PW3, PW5 and PW6 of the Shelburne Water Supply System, please see the Assessment Report for the Nottawasaga Valley Source Protection Area. Details on the Permit To Take Water and Drinking Water System Information are found in Table 5-28 and Table 5-29.

Table 5-28: Summary of Permit-To-Take-Water Pumping Rates for the Shelburne Water Supply

Well	Depth (m)	Open Interval	Permitted Pumping Rate (PTTW No.1814-7QVK7S)

PW7	86.5	47.2 m to 86.5m	1135 L/min (one well may pump at a time at this rate)
PW8	86.6	47.6m to 86.6 m	

Table 5-29: Drinking Water System Information for the Shelburne Water Supply

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served
220004965	Shelburne Drinking Water System	Ontario Clean Water Agency	GW	2	6900

[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*

5.4.2 ~~Vulnerability Analysis~~Shelburne Wellhead Protection Areas

~~Delineation of Wellhead Protection Areas~~

~~Wellhead Protection Areas (WHPAs) associated with the municipal water supply represent the areas within the aquifer that contribute groundwater to the well over a specified time period. According to the Technical Rules (MOE, 2009b), four Wellhead Protection Areas must be identified.~~

~~The delineation of a Wellhead Protection Area for a municipal well field is based on the delineation of the time of travel capture areas for the municipal well field. The Wellhead Protection Area represents the area projected to land surface where groundwater can be captured by pumping at the municipal wells. It should be noted that the Wellhead Protection Areas represent time of travel within the saturated zone of the aquifer to the well and do not account for travel time from ground surface down to the water table. The pumping rates used to determine the Wellhead Protection Area are based on the allocated quantity of water.~~

~~The Wellhead Protection Areas were sub-divided into four zones as follows according to Technical Rule V.3 (47-50):~~

- ~~Zone A (WHPA-A) 100 m radius from wellhead~~
- ~~Zone B (WHPA-B) 2 year time of travel (TOT) capture zone~~
- ~~Zone C (WHPA-C) 5 year time of travel capture zone~~
- ~~Zone D (WHPA-D) 25 year time of travel capture zone~~

~~Modelling Approach for the Shelburne Water Supply~~

Wellhead Protection Areas (WHPAs) for the Shelburne well PW7 were delineated in 2015 using a newly developed numerical groundwater flow model for the area surrounding Shelburne ~~as part of a study completed by~~ (EarthFX ~~(~~2015~~)~~). A new hydrologic model was developed as well for the area to provide the recharge values to the groundwater model. Details of the modelling are found in EarthFX (2015). ~~MODFLOW was employed to create a new groundwater flow model for the area surrounding Shelburne. The model was constructed and calibrated with available hydrogeological data and hydrological mapping products (EarthFX, 2015). GSFLOW was used to create an updated surface water model for the Shelburne area. Output from the surface model supplied the recharge rates to the groundwater flow model.~~

Pumping rates were selected based on the maximum reported takings in 2013 for the existing Shelburne municipal wells. The simulated pumping rate for Shelburne well PW7 was based on initial well capacity tested completed by Golder and Banks (2013). The pumping rates used in developing the capture zones are presented in **Table** 5-30. ~~Withdrawals from five other municipal wells (three belonging to the Town of Mulmur and two in the Hamlet of Rosemount) were also simulated in the model along with nine non-municipal takings.~~

~~To develop Time of Travel (TOT) capture zones 100 virtual particles were released on each of the four sides of the model cell containing a production well. The particles were released in the layer of the model representing the Gasport Formation for well PW7. TOT zones were created by manually drawing a polygon around each well that encompasses all particle locations at the designated times (i.e., 2, 5 and 25 years). The large number of particles (400 per well) released meant that TOT zones were drawn as accurately as possible (EarthFX, 2015).~~

Table 5-30: Pumping Rates Used for the Shelburne Well Supply ~~Wellhead Protection Areas Delineation~~ WHPA Delineation

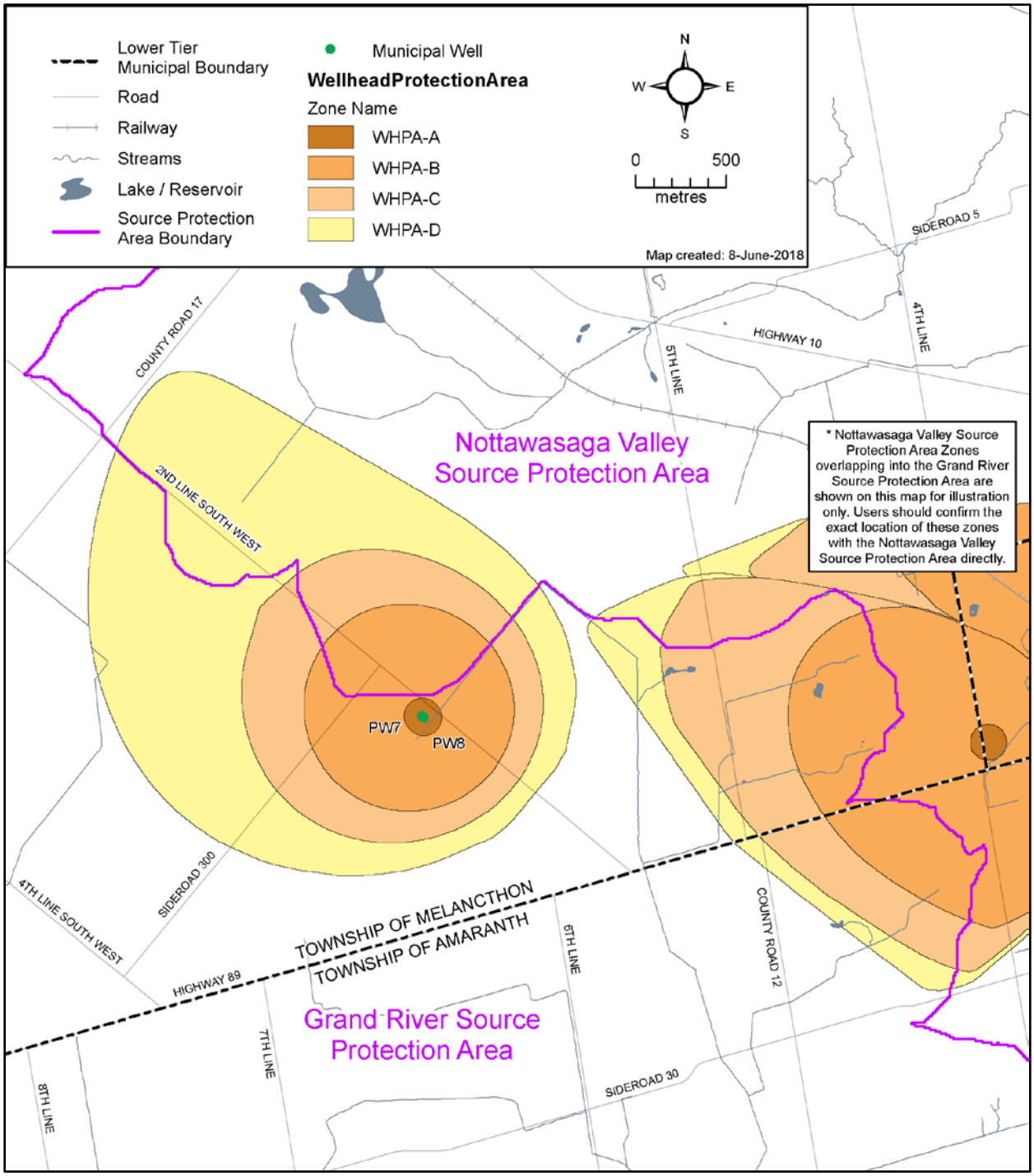
Supply Wells	Simulated Pumping Rate	Actual Pumping Rate*
PW 1	1,030 m3 / day	519 m3 / day
PW 3	1,067 m3 / day	528 m3 / day
PW 5	982 m3/day	-
PW 6	982 m3/day	344 m3 / day
PW 7	1,635 m3/day	-

*Average daily pumping rate in 2014 (WSP Canada Inc, 2014)

~~Shelburne Wellhead Protection Areas~~

~~The location and orientation of the Wellhead Protection Areas for the Shelburne Well PW7 and PW8 is shown in **Map** 5-28. Although~~ WHPAs were not ~~modelled~~delineated using the groundwater flow model for Well PW8. As the two wells are 10 m apart and only one of the wells is pumping at a time, ~~, it is assumed that~~ the footprint of the PW8 WHPAs ~~would~~will be similar to that of Well PW7 ~~as the two wells are 10 m apart and only one of the wells is pumping at a time~~. However, a 100 m WHPA-A zone was ~~drawn~~mapped for Well PW8. The Shelburne Wells PW7 and PW8 WHPAs~~ellhead Protection Areas~~ extend to the north east and cross the watershed divide between the Grand River and Boyne River systems. The location and orientation of the WHPAs for the Shelburne Well PW7 and PW8 are shown in **Map** 5-28.

Map 5-28: Shelburne Water Supply Wellhead Protection Area



Vulnerability Scoring in Wellhead Protection Areas

According to the Technical Rules, aquifer vulnerability must be assessed by one or more of the following groundwater vulnerability assessment methods (Rule 37):

1. Intrinsic Susceptibility Index (ISI);
2. Aquifer Vulnerability Index (AVI);
3. Surface To Aquifer Advection Time (SAAT); or
4. Surface To Well Advection Time (SWAT).

The Surface to Well Advective Time (SWAT) method was used to delineate areas of low, medium and high vulnerability within the WHPAs.

Part IV of the Technical Rules for Assessment Reports defines areas of high, medium, and low groundwater vulnerability for each of the assessment methods. For the surface to well advection time (SWAT) method, the classification is based on actual travel times from the surface to the well as follows:

1. areas of high vulnerability are those areas with travel times to a well less than 5 years;
2. areas of medium vulnerability are those areas with travel times greater than or equal to 5 years but less than or equal to 25 years; and
3. areas of low vulnerability are those areas with travel times greater than 25 years.

Surface to well advective travel times consists of two components: the vertical travel time through the unsaturated zone above the water table (UZAT); and the travel time from the water table to the well through the saturated zone (WWAT). Determining the time of travel through the unsaturated zone is highly complex and data on unsaturated soil properties in the study area are virtually nonexistent. Due to the uncertainties related to the estimation of unsaturated travel times, the unsaturated zone travel times (UZAT) were not factored into the calculation of SWAT values discussed below. This is considered to be a conservative assumption because assuming rapid flow through the unsaturated zone travel times will slightly increase the size of the high and medium aquifer vulnerability zones.

WWAT values were determined by releasing virtual particles from cells in the uppermost active groundwater model layer (i.e., the layer containing the water table) within a larger area surrounding the 25-year time-of-travel zones. The particles were forward-tracked from the water table, using MODPATH, to their point of discharge, either the municipal well or to another discharge point such as a nearby stream. The times-of-travel for particles ending up in the municipal wells were assigned back to the originating cell. WWAT values ranged from 0 to about 174 years.

The use of WWAT values allows the vulnerability to be expressed in terms of potential contaminant travel times as opposed to other methods which use relative index values. It should be recognized, however, that the advective travel times are calculated without consideration of the nature of the potential contaminants, release mechanisms, and attenuation processes (e.g., diffusion, dispersion, adsorption and chemical transformation).

The various vulnerability ratings based on the travel times are shown in **Table** 5-39**Table 6-39.**

Table 5-39: SWAT Vulnerability Ratings

~~Time of Travel (years) -~~	~~Vulnerability Rating~~
~~<5~~	~~High~~
~~5 to 25~~	~~Medium~~
~~>25~~	~~Low~~

~~As described in the Technical Rules (MOE, 2009b), within the WHPAs, vulnerability scores were calculated based on the intersection of the individual WHPAs (ie. A, B, C, D) and the vulnerability ranking that resulted from the SWAT analysis.~~

Vulnerability Scoring in the Shelburne Wellhead Protection Area

Aquifer vulnerability within the Shelburne WHPAs was mapped using the Surface to Well Advection Time (SWAT) method (EarthFX 2015). Vulnerability scores were then applied using the information shown in **Table** 5-31 ~~The~~ where ~~resulting~~ vulnerability scores range ~~for the Shelburne WHPAs were completed in accordance with Rule 82 of the Technical Rules. Vulnerability scores range~~ from a score of 10 for areas with the highest vulnerability to 2 for areas with low vulnerability. ~~Scores were assigned as per Table 2(a) in Part VII of the Technical Rules (MOE, 2009b).~~ Detailed methodology is discussed ~~further~~ in Chapter 3 of the Grand River Assessment Report. ~~A summary of the process used to define vulnerability scores is outlined in the **Table** 5-31**Table** 5-40**Table 6-40** below:~~

Table 5-31: Wellhead Protection Area Vulnerability Scores – SWAT

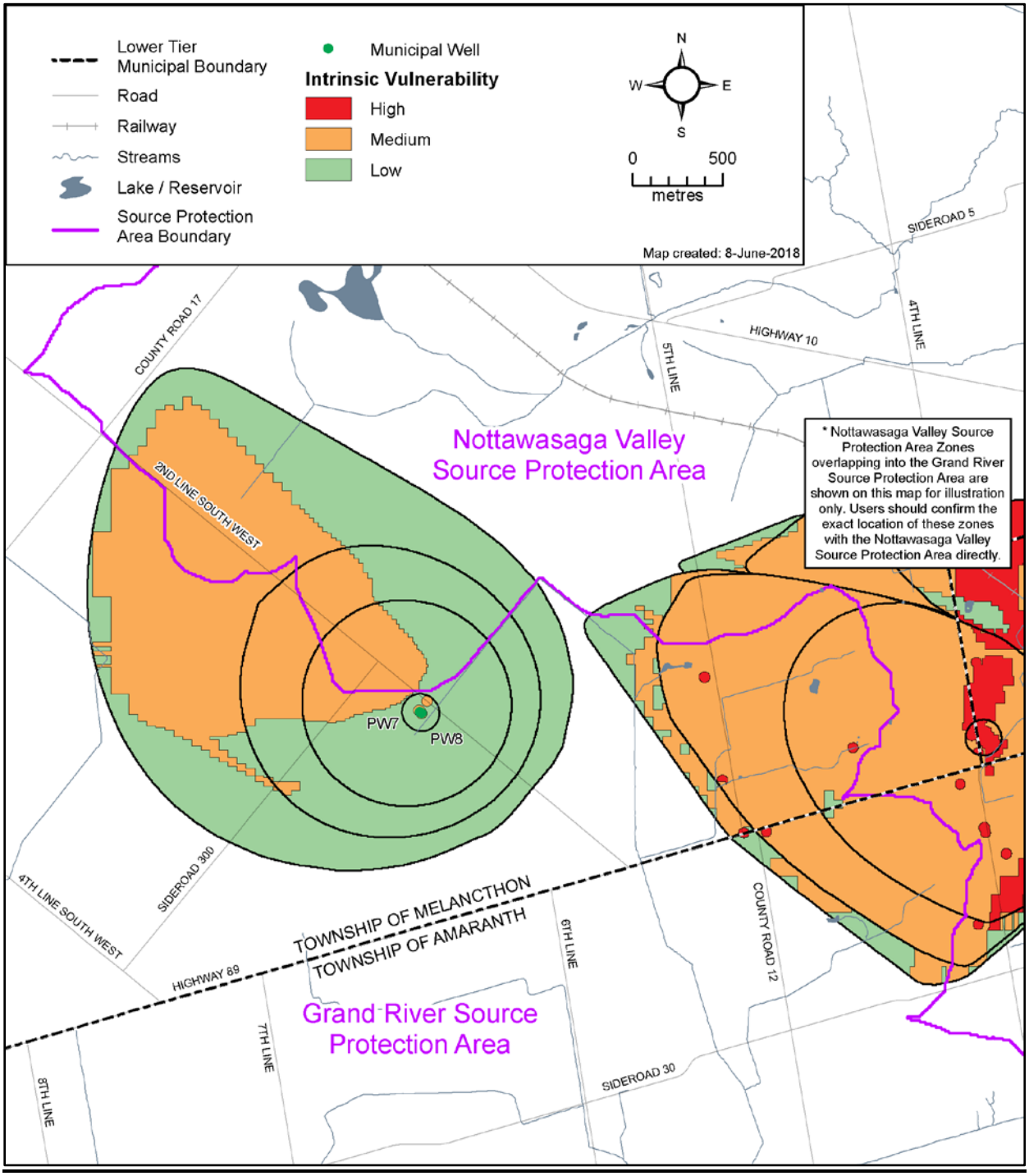
Time of Travel Zone (WHPA)	0 to 5 years (High)	5 to 25 years (Medium)	> 25 years (Low)
WHPA-A (100m)	10	10	10
WHPA-B (2yr time of travel~~TOT~~)	10	8	6
WHPA-C (5yr time of travel~~TOT~~)	8	6	2
WHPA-D (25yr time of travel ~~TOT~~)	6	4	2

~~***Vulnerability Scoring in the Shelburne Wellhead Protection Area***~~

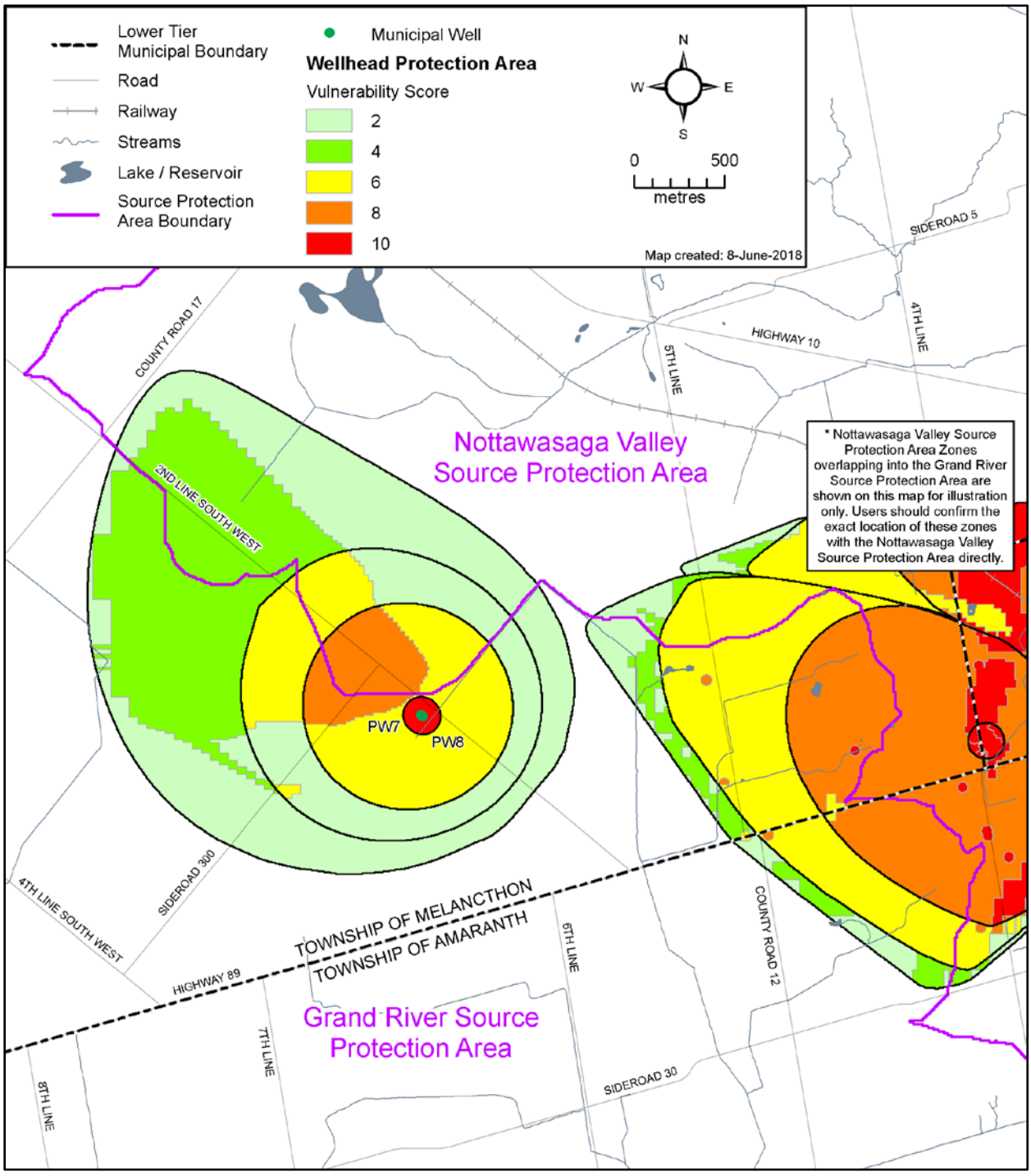
~~Due to uncertainties related to the estimation of unsaturated travel times, UZAT values were not factored into the calculation of the SWAT values, resulting in a more conservative vulnerability assessment. It should be noted that~~

~~n~~No areas of high vulnerability (ie. Where the time of travel~~TOT~~ to the well is less than 5 years) were identified for Shelburne ~~Wells~~ PW7 and PW8 WHPAs. This ~~, which~~ reflects the degree of confinement to the deeper Gasport Formation aquifer. Because the Guelph Formation is a confined aquifer in the Shelburne location, it's afforded a certain degree of protection from surficially derived materials (ie road salt, fertilizers etc). The ~~un~~adjusted intrinsic vulnerability (based on SWAT mapping) is ~~is~~ shown on **Map** 5-29**. Map** 5-30 shows the vulnerability scores assigned to the Shelburne Wells PW7 and PW8 ~~Wellhead Protection Area~~WHPAs using the SWAT vulnerability mapping.

Map 5-29: Shelburne Water Supply A~~Una~~djusted Intrinsic Vulnerability



Map 5-30: Shelburne Water Supply Wellhead Protection Areas Final Vulnerability



~~***Identification of Transport Pathways and Vulnerability Adjustment***~~

~~Rules 39 to 41 of the Technical Rules (MOE, 2009b) allow for an increase in vulnerability rating of an aquifer due to the presence of transport pathways that may increase the vulnerability of the aquifer by providing a conduit for contaminants to bypass the natural protection of the aquifer. The presence of transport pathways should be accounted for in the vulnerability assessment and these pathways may include private water wells, unused water wells, abandoned water wells, construction of underground services, subsurface excavations, pits and quarries.~~

Transport Pathways in the Shelburne Wellhead Protection Area

The risk posed by water wells in the area was assessed using the ~~Ministry of Environment well records database~~MOECC Water Well Information System. The potential for a water well to impact the Shelburne Wells PW7 and PW8 water supply was conducted based on two criteria, whether the well is connected to the production aquifer and the interpreted condition and quality of the well construction with respect to preventing contaminants from reaching the aquifer. The survey resulted in the identification of ~~11~~ 13 wells within the Shelburne PW7 and PW8 WHPA (**Map** 5-31), of which four affect the vulnerability scoring.~~.~~ ~~None were classified as high risk wells, 2 as medium risk and 9 as low risk.~~

~~***Adjusted Vulnerability to Account for Transport Pathways***~~

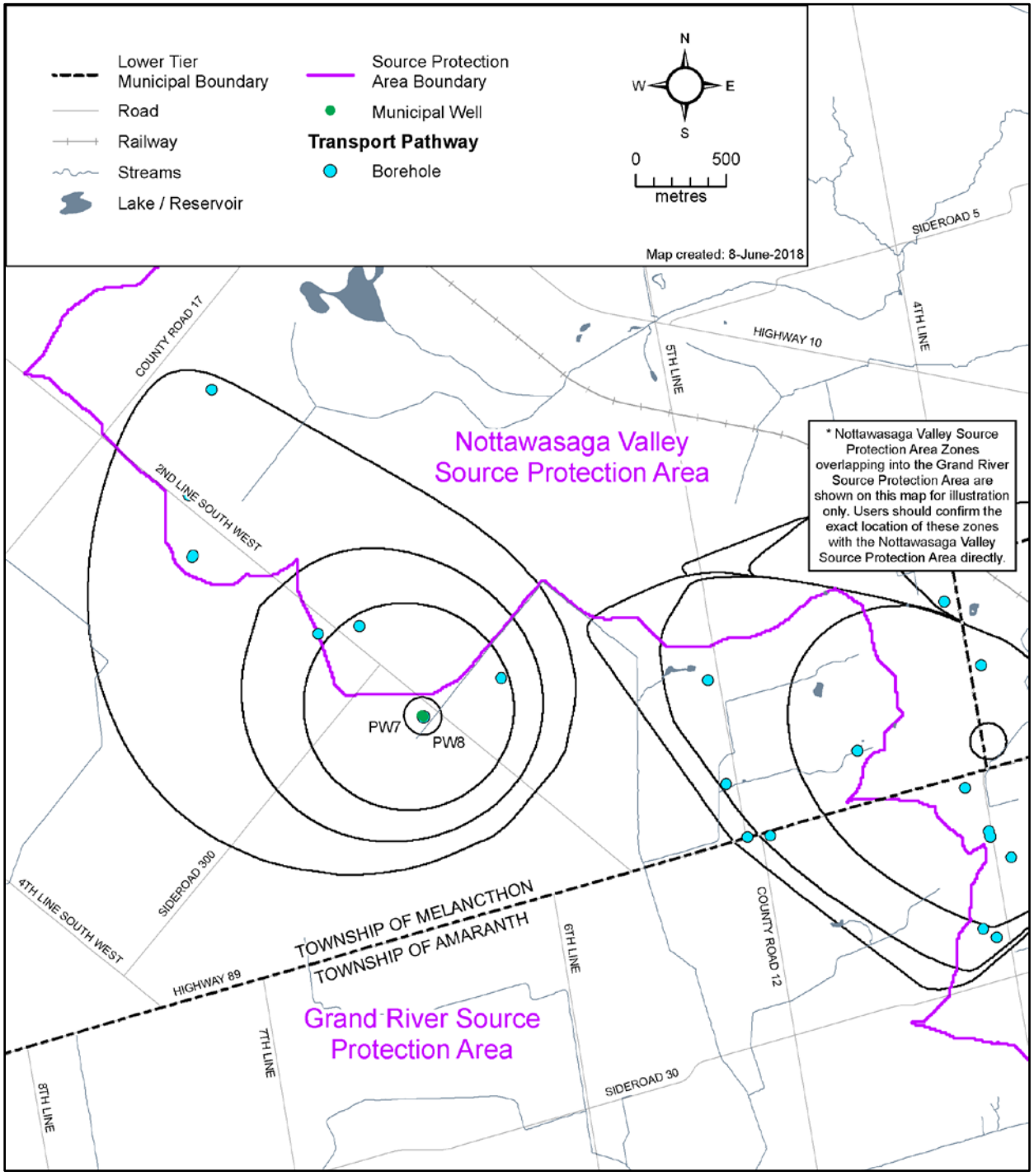
~~The vulnerability of the aquifer may be increased by any land use activity or feature that disturbs the surface above the aquifer, or which artificially enhances flow to that aquifer. In areas where transport pathways exist, the intrinsic vulnerability can be increased to reflect the higher vulnerability caused by the constructed pathway (i.e., from low to moderate or high, and moderate to high). In some cases the intrinsic vulnerability index is already high and cannot be further increased. Based on the assessed presence of transport pathways and modified vulnerability index, the resultant vulnerability score increases to reflect the identified enhanced vulnerability.~~

~~The vulnerability of the aquifer should only be increased to account for a transport pathway where there is sufficient confidence in the available data to justify increasing the vulnerability. The vulnerability should be adjusted to account for deep excavations, pits and quarries, etc., where it is documented that the features penetrate a confining unit or remove sufficient material and thus decrease the natural protection of the materials overlying the municipal aquifer. These areas are delineated based on supporting documentation including air photo interpretation and local knowledge of the study areas.~~

Adjusted Vulnerability Scoring for the Shelburne Wellhead Protection Area

The vulnerability within a 30 m radius of each of the wells identified within the WHPAs with a risk level of medium were increased by one category (i.e., from low to medium, or medium to high). The 30 m radius was selected in a previous study (Burnside, 2010), based on the recommended setback distance from contamination sources under O.Reg 903. Wells with a high risk level ~~would be~~are increased directly to the high vulnerability category~~; however, it should be noted that 2 of the 4 medium risk wells are located within WHPA-A, which has already been assigned the highest vulnerability score possible (10)~~. The vulnerability zone rating for the area around wells with a risk level of low was left unchanged.

Map 5-31: Shelburne Water Supply Transport Pathways



Uncertainty in the Wellhead Protection Area Delineation and Vulnerability Scoring for the Shelburne Water Supply

Results of an uncertainty analysis indicated that there is a relatively low uncertainty around the activities associated with WHPA delineation and associated vulnerability scoring.

No specific measurements of porosity were available for this study, so values for the various formations were estimated based on published values. Low values were used for the till confining units, thus resulting in greater velocities and shorter travel times. This approach produced results that were considered to be conservative and therefore reduced the uncertainty that the resulting WHPAs would be underestimated.

Of the recommended methods listed in the Technical Rules for Assessment Reports (MOE, 2009b), the WWAT component of the SWAT method is by far the most conservative. It is based on assessing true travel times using locally determined hydraulic properties that have been adjusted and refined through model calibration. The model that the WWAT analyses was based on was developed using recognized hydrogeologic and hydraulic principles and has been calibrated to match the observed heads and, more importantly, the model was calibrated to best match the observed directions of flow by carefully representing factors that influence flow patterns such as local variations in aquifer properties, recharge rates, aquifer and aquitard thickness, and continuity. However, as indicated by the discussions above, it is difficult to quantitatively assess the certainty of the ~~TOT~~ time-of-travel (TOT) zones in an unbiased way and it is even more difficult to assess uncertainty in the WWAT values within the TOT zones.

The use of WWAT zones to subdivide areas within the TOT zones adds another level of uncertainty because the WWAT results cannot be field-verified or easily tested. The assignment of high vulnerability scores to the 100-m radius, regardless of actual travel times, is an implicit recognition that the level of uncertainty is unacceptable when it comes to potential sources of contamination in close proximity to the wells. The creation of multiple small zones whose boundaries may shift (as pumping rates change or as new data become available) will also present a difficult challenge to municipal planners responsible for incorporating these discontinuous areas into long-term plans.

Water well records from the MOE WWIS dataset were used to evaluate possible transport pathways that could reduce the time of travel of contaminants to the municipal wells. This exercise relied heavily upon the location and construction details (depth and date of completion) within the database. There is an inherent level of uncertainty that is to be expected when using this data, including missing information or discrepancies between physical details. To be conservative, the preferential pathways exercise identified all of the data points, including the poor quality ones that might otherwise be filtered out. In addition, the quality of the construction (e.g., well riser height) was based upon the date of construction, with the assumption that all wells completed during the three periods (pre-1980, from 1980 to 1990, and post-1990) uniformly conformed to the standards and practices of their respective periods.

Managed Lands Within the Shelburne Wellhead Protection Area

Managed lands are lands that may receive Agricultural Source Material (ASM), Non-Agricultural Source Material (NASM) or commercial fertilizer and can be divided into 2 categories: agricultural managed lands (AML) and non-agricultural managed lands. Agricultural managed lands include cropland, fallow and improved pasture that may receive ASM. Non-agricultural managed lands may include golf courses, sports fields, residential lawns and other built-up grassed areas or turf that may have commercial fertilizers applied.

The managed land mapping was completed for those areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats (a score of 6 ~~Calculation of the percentage of managed lands was done in accordance with Part II, Rule 16(9) of the Technical Rules (MOE, 2009b). Similar to the calculation of impervious surfaces, mapping the percentage of managed lands area is not required where the vulnerability score for an area is less than the vulnerability score necessary for the activity to be considered a significant threat. Therefore, the percentage of managed lands was only calculated where the vulnerability score in each Wellhead Protection Area was 6 or greater. This criterion was used to determine the need to calculate managed lands surrounding the Shelburne Well PW7 in the Township of Melancthon (**Table 6-41**).~~

~~Table 5-41: Shelburne Wellhead Protection Areas with Vulnerability Scores of 6 or Higher~~

~~Township~~	~~Location~~	~~Well~~	~~WHPA-A~~	~~WHPA-B~~	~~WHPA-C~~	~~WHPA-D~~
~~Melancthon~~	~~Shelburne~~	~~PW7/PW8~~	~~Yes~~	~~Yes~~	~~Yes~~	~~No~~

~~*Methodology for Calculating Managed Land Percentage*~~

~~The percentage of managed lands was calculated using the following methodology (MOE, 2009a):~~

~~Using MPAC property data, parcels of land that were located entirely or partially within the wellhead protection areas with a vulnerability score of 6 or greater were selected for assessment.~~

~~Wooded areas, wetlands, drainage and pond features were removed from the selected parcels based on GIS data and aerial photography~~

~~The remaining parcels were categorised as either agricultural managed lands or non-agricultural managed lands based on aerial photography, MPAC data and SOLRIS land use data. The area of the agricultural managed lands was calculated and divided by the total area of parcels that intersected the WHPAs.~~

or higher).~~T~~ Managed lands were completed using the methodology outlined in Chapter 3, with the results for Shelburne wells PW7&8 summarized in~~o be consistent with previous studies in the area, residential lands were assumed to be comprised of 50% managed lands per parcel when calculating the amount of non-agricultural managed lands. Non-residential/non-agricultural lands were assumed to be 100% managed lands; this included golf courses, sports fields, lawns and other grassed areas. Wooded areas, wetlands, drainage and pond features were removed when calculating managed lands. The area comprised of NAMLs was calculated and divided by the total area of parcels that intersected the WHPAs. The total percentage of managed lands was calculated by dividing the sum of the agricultural managed lands and the non-agricultural managed lands areas by the total area of the parcels that intersected the WHPAs.~~

~~The results of the calculations for managed lands are presented in~~ **Table 5-32** and on **Map 5-32**. The coding of N/A indicates the vulnerability score in this area is 4 or less and therefore the area was not assessed.

Table 5-32: Managed Lands Percentage in the Shelburne Wellhead Protection Areas

~~Township~~Drinking Water System	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
~~Melancthon~~Shelburne	Melancthon	PW7/PW8	~~85.1%~~5.28%	~~71.8%~~69.28 %	~~80.3%~~92.70 %	N/A

Livestock Density within the Shelburne Wellhead Protection Area

Livestock density is used as a measure to determine the intensity of livestock animals and as such can be used as a measure of the potential for generating, storing and land applying agricultural source material. Similar to the managed land mapping, the livestock density for the Shelburne PW7&8 WHPAs was completed only in those areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats, using the methodology outlined in Chapter 3. Results are summarized in~~Livestock density in the Shelburne Well PW7 WHPAs is expressed in terms of nutrient units per acre (NU/Acre). This is calculated as the number of animals housed or pastured on a farm unit (expressed in terms of nutrient units) divided by the total area of agricultural managed land within a given area. As was the case with calculating the percentage of managed lands, livestock density analysis is only required for WHPAs with subareas having vulnerability scores greater than or equal to 6 (Technical Rule 16(10)). Livestock density was calculated by including all properties that were either partially or completely contained within the PW7 WHPAs. It is assumed that livestock density for PW8 would be the same as PW7 as the WHPAs are the same.~~

~~The method for calculating livestock density consisted of three main steps (MOE, 2009a):~~

1. ~~**Estimate the number of each category of animals present within the specified area.**~~
   ~~The first step involved identifying agricultural parcels that have livestock operations that were within or partially within the PW7 WHPAs. This was accomplished using the MPAC data coverage and 2010 SWOOP air photos. The type of livestock operations was identified using the MPAC farm classification system. Air photos were used to confirm the type of operations wherever possible, and to define the footprints of livestock buildings. Next, a direct calculation of Nutrient Units (NUs) was conducted using the conversion factors provided by the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) in MOE (2009a) and presented in **Table 4-2.** A direct enumeration of the number of animals was not necessary.~~

2. ~~**Convert the number of each category of animals into NUs, allowing all livestock to be compared on an equivalent unit of measure.**~~
   ~~Nutrient Units were estimated for each property based on the footprints of the livestock buildings, as discussed above.~~

3. ~~**Sum the total NUs within the specified area and divide by the area of agricultural managed land within the same specified area.**~~
   ~~The estimated NUs for livestock buildings on parcels of land that intersected each of the WHPA areas were totalled and divided by the total area of agricultural managed land that intersected the WHPAs (including both livestock and non-livestock farms). It was important to use to total NUs generated and the total parcel area, particularity when~~

parcels were only partially within the specified WHPA, because the resulting livestock density was pro-rated to the portion of the farm within the WHPA area.

Livestock densities were calculated for each of the applicable WHPAs and are presented in **Table 5-33** and **Map 5-33.**

Table 5-33: Livestock Density (NU/acre)

~~Township~~Drinking Water System	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
~~Melancthon~~Shelburne	Melancthon	PW7/PW8	0.0~~2~~	~~0.3~~0.09	~~0.2~~0.07	N/A

Percentage of Impervious Surface Area within the Shelburne Wellhead Protection Areas

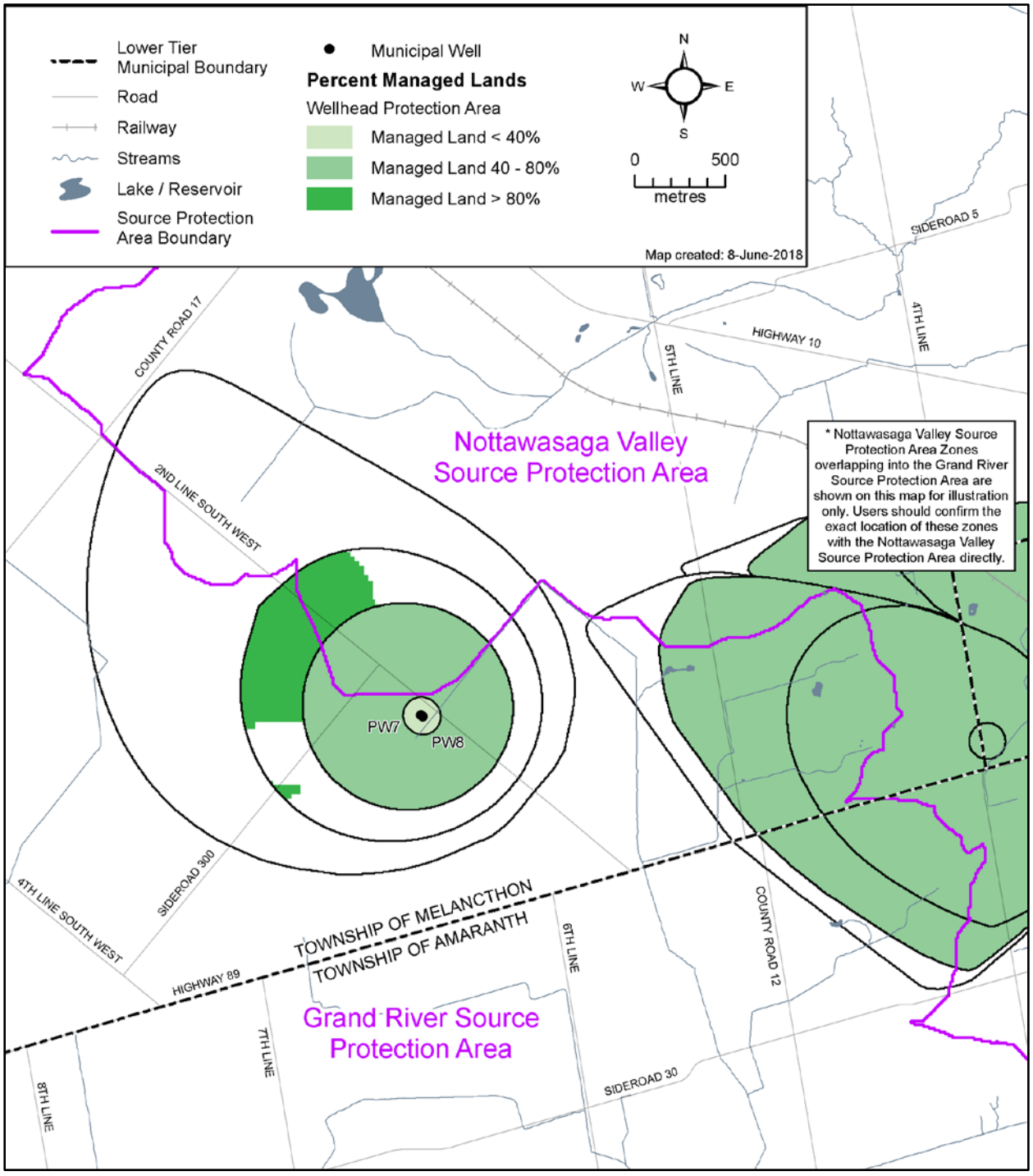
Percent impervious surface is used as a surrogate measure of the potential for the application of salt for the purposes of melting snow and ice. It measures the percentage of the study area covered by impervious surfaces where road salt would likely be applied (roads, sidewalks, and parking lots), but not those areas such as buildings, landscaped areas etc, where it would not be applied ~~(buildings, landscaped areas, etc)~~. The ~~calculation of~~area of impervious surface area for the Shelburne PW7 and PW~~&~~8 ~~Wellhead Protection Area~~WHPAs was calculated using~~ed~~ the moving window average approach, ~~which is described further~~as described in Chapter 3.

~~Under Technical Rule 16 (11), the percentage of impervious surface area within each vulnerable area must be calculated to evaluate possible threats posed by the application of road salt. The technical rules define impervious surface areas as highways and paved surfaces used for vehicular traffic and parking, as well as paved pedestrian paths. The percentage of impervious surface area was determined by using a 1km square grid, centred over the vulnerable areas (as per Rule 17), and calculating the percentage of impervious area within each grid cell.~~

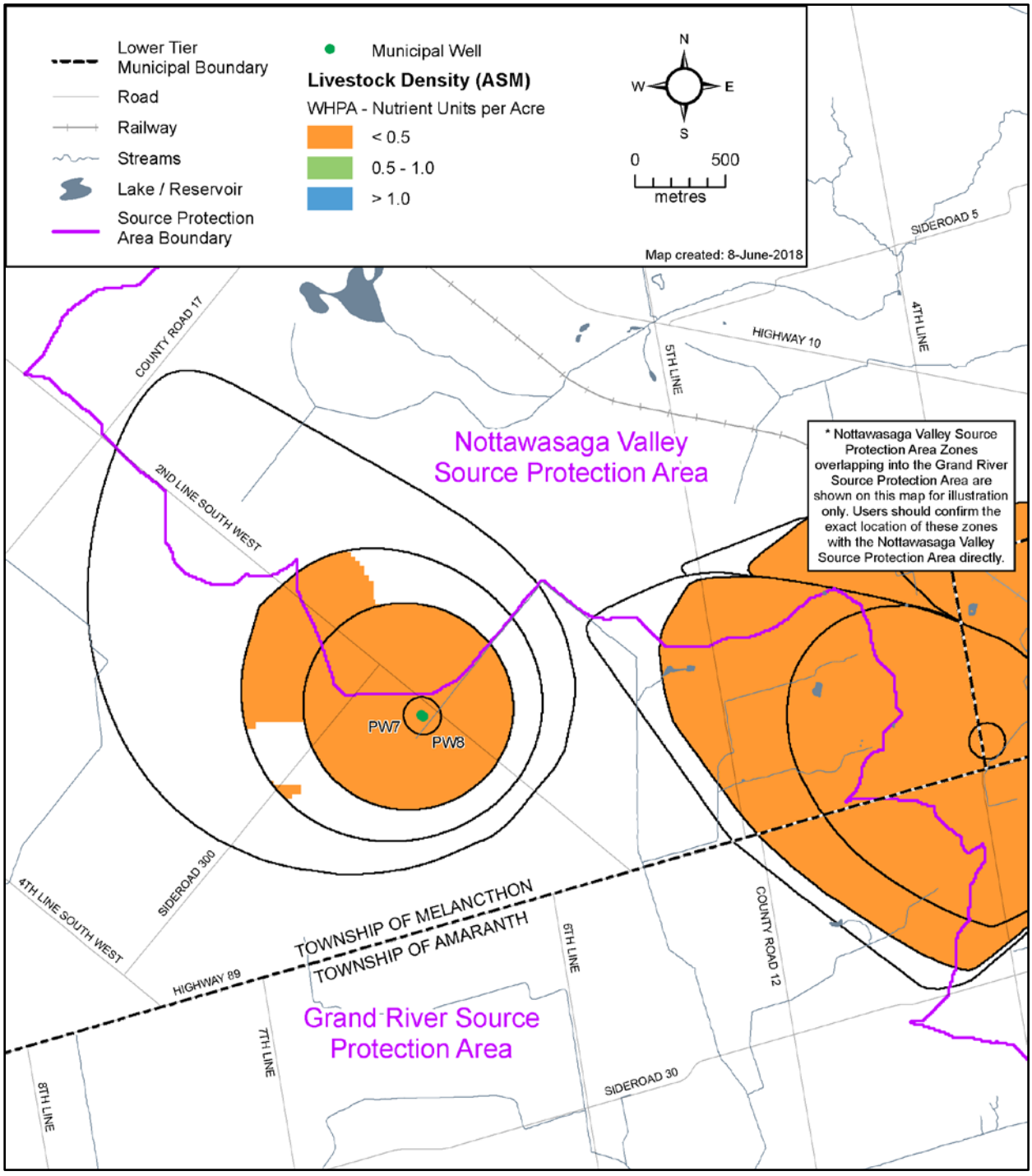
~~To estimate the impervious surface area, SOLRIS V1.2 (MNR, 2008) land use data was analyzed. The data are on a 5 by 5 m grid and were also used to estimate imperviousness for the hydrologic model. The imperviousness associated with each SOLRIS land use code was used to assign percent impervious to each grid cell. One exception was that the imperviousness assigned to the transportation code was increased to 100%. Finally, the imperviousness values for the 5m grid were aggregated to the 1km square grid.~~

The percentage of total impervious surface areas within the Shelburne Well~~s~~ PW7 and PW8 WHPA~~s~~ is presented in **Map 5-34**.

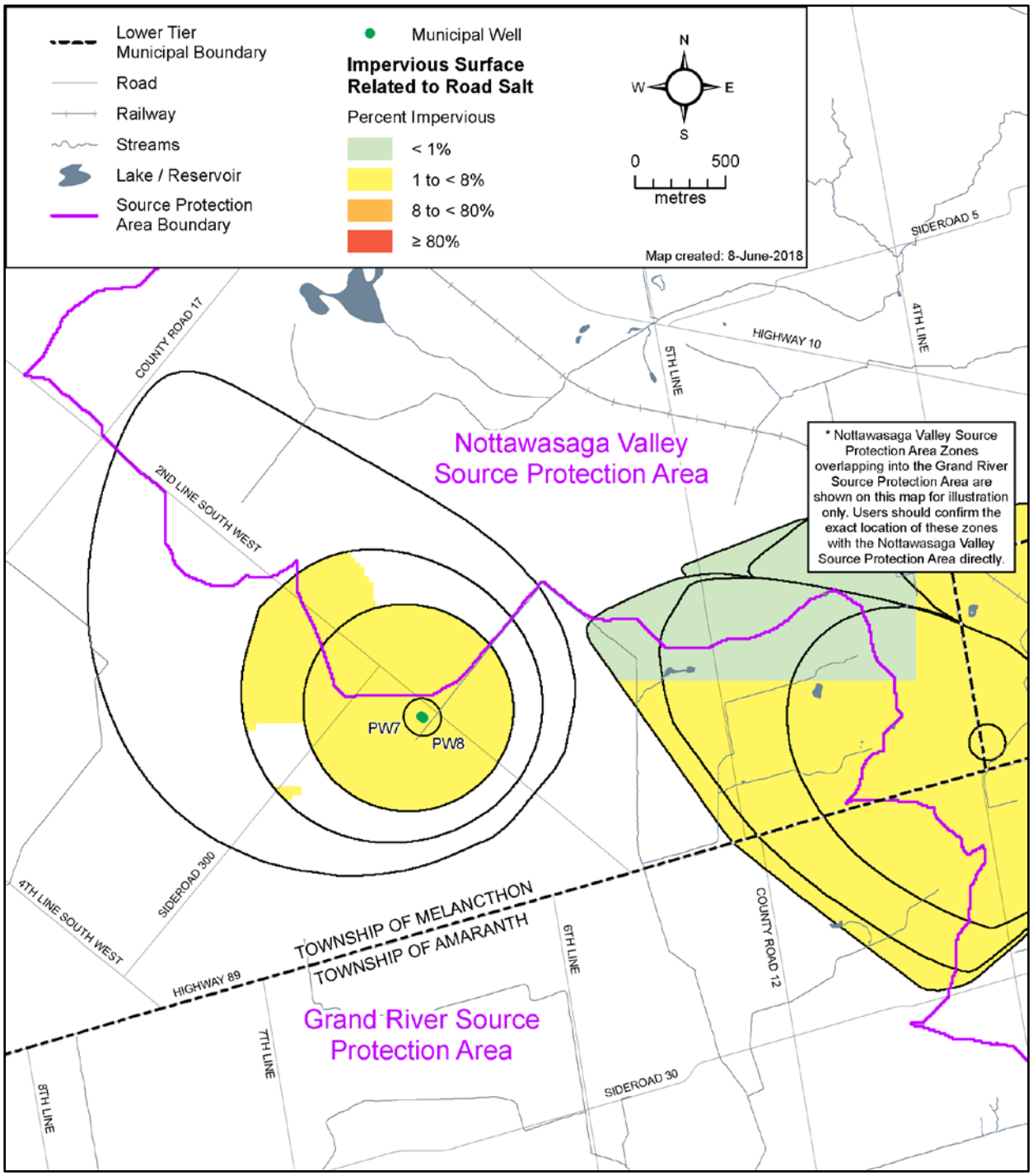
Map 5-32: Shelburne ~~Well PW7~~ Wellhead Protection Areas Percent Managed Lands



Map 5-33: Shelburne ~~Well PW7~~ Wellhead Protection Areas Livestock Density



Map 5-34: Shelburne ~~Well PW7~~ Wellhead Protection Areas Percent Impervious Surface



5.4.3 Drinking Water Threats Assessment

The Ontario Clean Water Act, 2006 defines a Drinking Water Threat as "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 a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat."

~~The Technical Rules (MOE, 2009) list five ways in which to identify a drinking water threat:~~

~~a) Through an activity prescribed by the Act as a Prescribed Drinking Water Threat;~~

~~b) Through an activity identified by the Source Water Protection Committee as an activity that may be a threat and (in the opinion of the Director) a hazard assessment confirms that the activity is a threat;~~

~~c) Through a condition that has resulted from past activities that could affect the quality of drinking water;~~

~~d) Through an activity associated with a drinking water issue; and~~

~~e) Through an activity identified through the events based approach (this approach has not been used in this Assessment Report).~~

~~Activities that Are or Would be Drinking Water Threats in the Wellhead Protection Areas~~

~~Ontario Regulation 287/07, pursuant to the *Clean Water Act*, provides a list of Prescribed Drinking Water Threats that could constitute a threat to drinking water sources. **Table 5-44Table 6-44** lists the activities that are prescribed drinking water threats. Listed beside the prescribed drinking water threats are the typical land use activities that are associated with the threat.~~

~~In addition, there is one local threat that has been identified in the Lake Erie Source Protection Region: the transportation of oil and fuel products through a pipeline. To locate and learn about nearby pipelines, visit the Canadian Energy Pipelines Association's interactive pipeline map at http://aboutpipelinesmap.com.~~

~~A spill of oil and fuel products could result in the presence of petroleum hydrocarbons or BTEX in groundwater. The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act,* was approved as a local threat. The letter of approval from the Director of the Source Protection Programs Branch and table of hazard ratings is found in **Appendix D.**~~

~~Table 5-44: Drinking Water Threats~~

~~Prescribed Drinking Water Threat~~ ~~Ontario Regulation 287/07 s.1.1.(1)~~		**~~Land Use / Activity~~**
~~1~~	~~The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the~~	~~Landfills – Active, Closed Hazardous Waste Disposal~~

Table 5-44: Drinking Water Threats

	Environmental Protection Act.	Liquid Industrial Waste
2	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage Infrastructures Septic Systems, etc.
3	The application of agricultural source material to land.	e.g. manure, whey, etc.
4	The storage of agricultural source material.	e.g. manure, whey, etc.
5	The management of agricultural source material.	aquaculture
6	The application of non-agricultural source material to land.	Organic Soil Conditioning Biosolids
7	The handling and storage of non-agricultural source material.	Organic Soil Conditioning Biosolids
8	The application of commercial fertilizer to land.	Agriculture Fertilizer
9	The handling and storage of commercial fertilizer.	General Fertilizer Storage
10	The application of pesticide to land.	Pesticides
11	The handling and storage of pesticide.	General Pesticide Storage
12	The application of road salt.	Road Salt Application
13	The handling and storage of road salt.	Road Salt Storage
14	The storage of snow.	Snow Dumps
15	The handling and storage of fuel.	Petroleum Hydrocarbons
16	The handling and storage of a dense non-aqueous phase liquid.	DNAPLs
17	The handling and storage of an organic solvent	Organic Solvents
18	The management of runoff that contains chemicals used in the de-icing of aircraft.	De-icing
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.	Private water taking
20	An activity that reduces the recharge of an aquifer.	Impervious Surfaces
21	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm animal yard.	Agricultural Operations
Local Drinking Water Threat		**Land Use / Activity**
The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of the Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act.* [1]		Oil pipeline

1: As confirmed by the letter from the Director of the Source Protection Programs Branch in Appendix D.

Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Shelburne Water Supply

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in

Appendix C. The information above can be used with the vulnerability scores shown in **Map** 5-30 to help ~~the public~~ determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 5-34 provides a summary of the threat levels possible in the Shelburne Well Supply for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), Pathogen, and Local Threats (Oil Pipelines). A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map** 5-30.

Table 5-34: Identification of Drinking Water Quality Threats in the Shelburne Wells PW7/8 Wellhead Protection Area

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A	10	✔	✔	✔
	WHPA-B	8	✔	✔	✔
	WHPA-B/C	6		✔	✔
	WHPA-C/D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✔		
	WHPA-D	2 & 4			
Pathogens	WHPA-A	10	✔	✔	
	WHPA-B	8		✔	✔
	WHPA-B	6			✔
	WHPA-C/D	Any Score			
Local Threat (Oil Pipelines)	WHPA-A	10	✔		
	WHPA-B	8		✔	
	WHPA-B/C	6			✔
	WHPA-C/D	2 & 4			

5.4.4 Conditions Evaluation for the Shelburne Water Supply

~~In addition to present land use activities, any conditions resulting from past activities are also considered drinking water threats. As described in the Technical Rules (MOE, 2009), the following conditions are considered drinking water threats to groundwater sources if located within vulnerable areas:~~

- ~~The presence of a non-aqueous phase liquid in groundwater in a HVA, SGRA or Wellhead Protection Area;~~
- ~~The presence of a contaminant in groundwater in a HVA, SGRA or a Wellhead Protection Area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in the table.~~

~~Conditions Evaluation for the Shelburne Water Supply~~

A review of available data regarding potential contamination within the WHPAs was completed. Data available included the National Pollutant Release Inventory, MOE Brownfields Site

Registry and MOE Waste Disposal Sites Inventory. Previous studies completed in the area by Burnside (2002, 2010) and Golder and ~~banks~~ Banks (2013) provided additional resources for screening for past and historic activities that could pose a threat to water quality.

No conditions resulting from past or historical activities were identified within the PW7 WHPAs based on the criteria established in Technical Rule 126 (EarthFX 2015).

5.4.5 Shelburne Water Supply Drinking Water Quality Issues Evaluation

~~The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)).~~

~~Once a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the issue within an Issue Contributing Area and manage these threats appropriately. If at this time the Issue Contributing Area can not be identified or the Issue can not be linked to threats then a work plan must be provided to assess the possible link.~~

~~If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are significant drinking water threats, regardless of the vulnerability.~~

~~*Methodology for Water Quality Issues Evaluation for the Shelburne Water Supply*~~

Drinking water issues were evaluated for Shelburne well PW7 through a review of water quality data collected during the initial well construction and assessment completed by Golder and Banks (2013) (EarthFX 2015). Water quality data were compared to the ~~ODWQS~~ Ontario Drinking Water Quality Standards (ODWQS) to identify those that were in exceedance and where possible data were assessed to identify any increasing trends in concentration.

Water Quality Issues Evaluation for the Shelburne Water Supply

All parameters analyzed were found to be below their respective ODWQS criteria, with the exception of total hardness. Total hardness ranged from 234 to 325 mg/L as calcium carbonate. These levels exceeded the Operational Guideline range of 80-100mg/L, provided in the Technical Support Document for the Ontario Drinking Water Standards, Objectives and Guidelines. Elevated levels of total hardness are typical of groundwater sourced from bedrock aquifers, and have been persistent in the Town of Shelburne's drinking water supply. Total hardness is considered to be an operational guideline/aesthetic objective that is often treated using household water softening system, as such it has not been identified as an issue.

The construction of well PW7 was motivated by reoccurring water quality problems related to arsenic in the other Town of Shelburne supply wells. The source of arsenic is assumed to be from naturally-occurring arsenopyrite in the Guelph Formation; PW7 is screened in the deeper Gasport Formation in hopes that the intervening low conductivity units will prevent the transport of arsenic to the deeper aquifer. Water quality samples collected during testing of PW7 were found to range from 0.4 to 3.8 µg/L, which ~~are~~were ~~below~~less than ~~the current~~ ODWQS of ~~25~~10 µg/L. However, it was noted that during the 72-hour pumping test arsenic concentrations increased from 0.9 to 3.6 µg/L. At this time arsenic is not considered to be an issue for the quality of drinking water from supply well PW7.

Summary of Water Quality Issues Evaluation for Shelburne Water Supply

Upon review of the available current drinking water quality data there are no identified Issues under Technical Rule 114 for ~~the~~ Shelburne Well PW7.

Limitations and Uncertainty for the Water Quality Issues Evaluation for the Shelburne Water Supply

The water quality data reviewed was limited to the sampling conducted in 2010 and an assessment of water quality trends could not be completed (EarthFX 2015).

5.4.6 Enumeration of Significant Drinking Water Quality Threats

~~As per the Technical Rules (MOE, 2009b), the enumeration of significant threats is required for the completion of the Assessment Report.~~ Details on the enumeration of drinking water threats are further discussed in Chapter 3.

~~*Data Sources for the Activity Threats Assessment of the Shelburne Water Supply*~~

~~The threats inventory was compiled using the data and information sources outlined below. The primary approach for compiling this inventory employed a method of associating land use activities to threat subcategories in the MOE Lookup Tables (LUTs). The major steps in this process include:~~

~~1. Consulting Municipal Property Assessment Corporation (MPAC) property codes and cross referencing codes with aerial photography from the South Western Ontario Orthoimagery Project (SWOOP, 2010) to assign land uses to each of the properties that intersect the PW7 WHPAs. Each property is then associated with a corresponding North American Classification System (NAICS) code.~~

~~2. The NAICS codes for each property were used to access the associated list of prescribed threats using the MOE LUTs.~~

~~3. The threats associated with each property were spatially assigned a vulnerability score based on the nature of the specific activity (e.g., point source of distributed) and its location in the delineated vulnerable areas, as well as the applicable circumstances defined in the Table of Drinking Water Threats.~~

The use of land use classification as a basis for evaluating threats is considered to be adequate, considering all of the properties within the PW7 WHPAs are classified as rural residential and/or agricultural.

Significant Drinking Water Quality Threats for the Shelburne Water Supply

~~As per the Technical Rules (MOE, 2009b), the enumeration of significant threats is required for the completion of the Assessment Report.~~ **Table** 5-35 summarizes the significant threats by circumstance ID identified in the ~~Wellhead Protection Areas~~WHPAs in the Township of Melancthon based on existing land uses.

Table 5-35: Town of Shelburne PW7 Well Supply Significant Drinking Water Quality Threats located in the Township of Melancthon

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
3	Application Of Agricultural Source Material (ASM) To Land	2	WHPA-A
8	Application Of Commercial Fertilizer To Land	2	WHPA-A
10	Application Of Pesticide To Land	2	WHPA-A
15	Handling and Storage Of Fuel	1	WHPA-A
Total Number of Properties		**3**	
Total Number of Activities		**7**	

1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

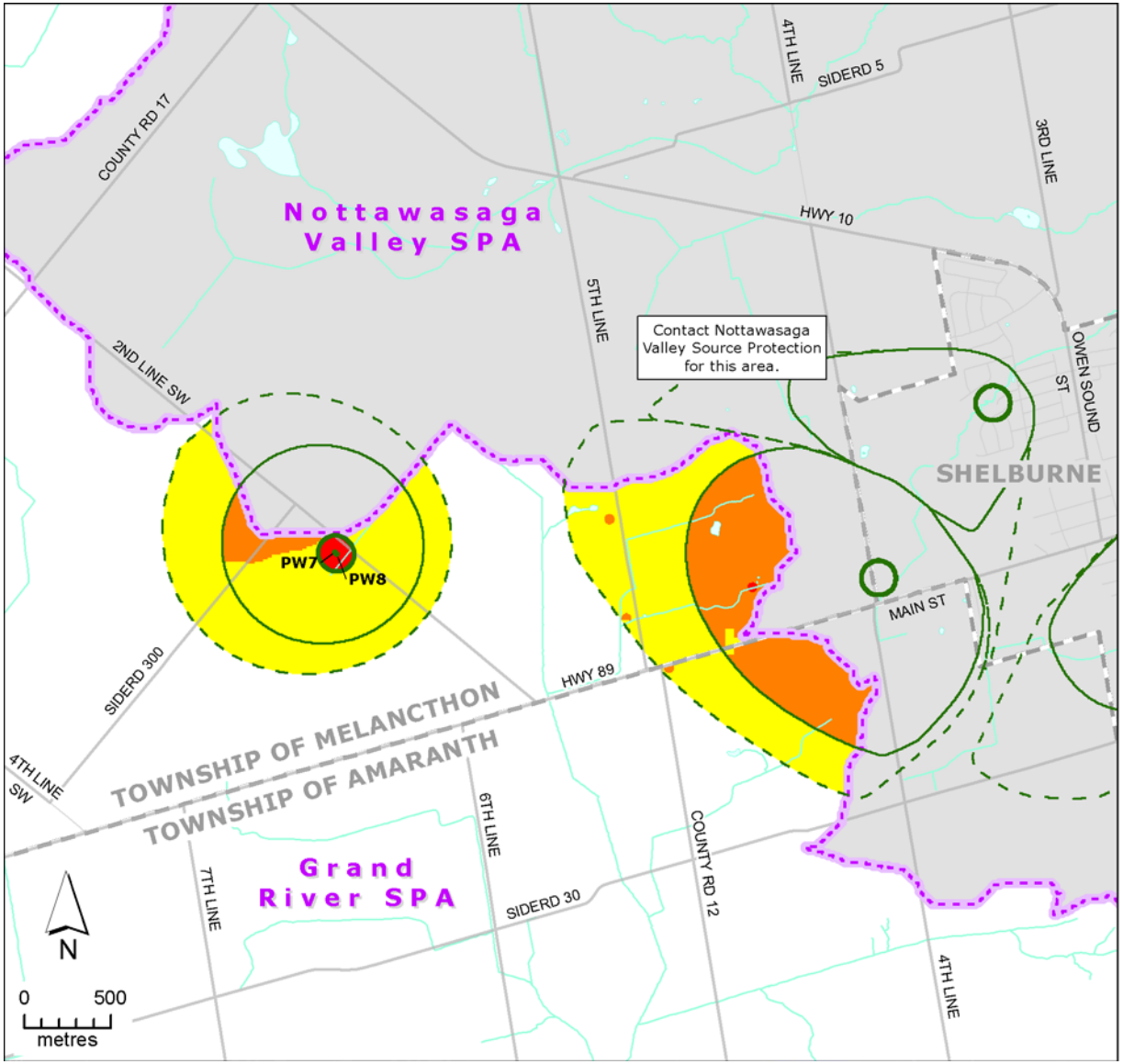
Note: Storm sewer piping is not considered to be part of a storm water management facility.

Limitations and Uncertainty for the Enumeration of Significant Drinking Water Threats for the Shelburne Water Supply

Using land use classification as a basis for evaluating threats does have limitations and wherever possible the land use base analysis has been supplemented with data from other sources.

To be consistent with other vulnerability and threat assessment studies for drinking water systems in the area, the technical document “Reducing Inconsistencies in Threat Subcategory Enumeration” (SGBLS, 2010) was used as reference. Because the available information for residential and agricultural lands rarely included storage or handling quantifies for chemicals or agricultural source materials, conservative assumptions were applied when evaluating the threat category (low, medium or significant) using the Tables of Circumstances. In some cases the SGBLS (2010) technical Bulletin provided more reasonable assumptions. Nevertheless, the use of land use classification for the evaluation of drinking water threats is associated with significant uncertainty and has been classified as high.

4.7 Schedule B: Dufferin County: Township of Amaranth, Shelburne Water Supply



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map: 10	8	2,4,6
1.	Waste Disposal	■	■	
2.	Sewage Systems	■	■	
3, 4.	Agricultural Source Material	■		
6, 7.	Non-Agricultural Source Material*	■		
8, 9.	Commercial Fertilizer*	■		
10, 11.	Pesticide	■		
12, 13.	Road Salt*	■		
14.	Storage of Snow	■		
15.	Fuel	■		
16.	DNAPLs	■	■	■
17.	Organic Solvents	■		
18.	Aircraft De-icing	■		
21.	Livestock Area	■		
Local Threat	Oil Pipelines	■		

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

- Well
- Road
- Minor River
- Lake / Main River
- Source Protection Area Boundary
- Lower Tier Municipal Boundary

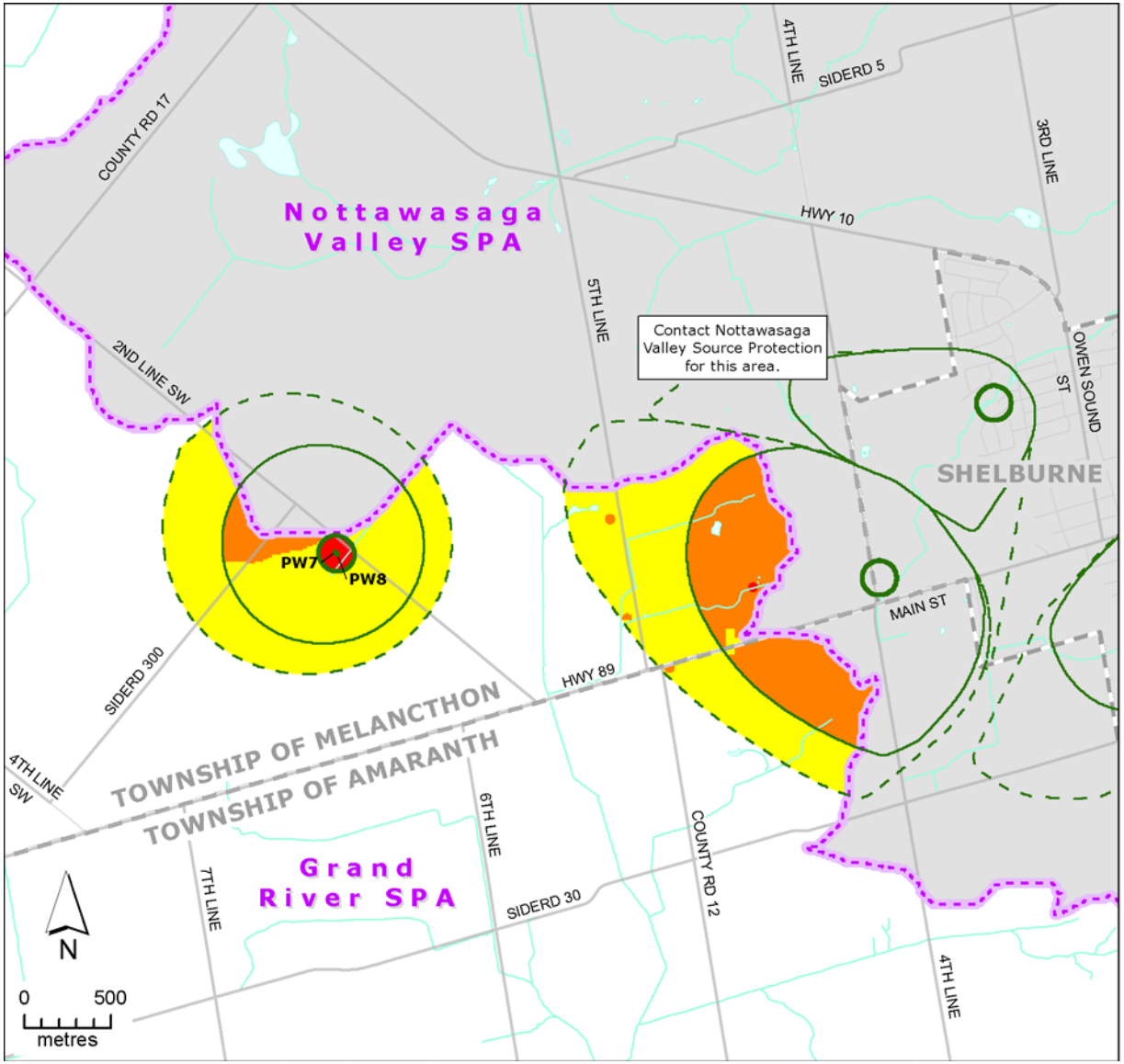
Wellhead Protection Zones:
- WHPA-A
- WHPA-B
- WHPA-C

Ontario

Grand River Conservation Authority

1. Updated June 8, 2018
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
3. This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.

6.6 Schedule A: Dufferin County: Township of Melancthon, Shelburne Water Supply



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map 10	8	2,4,6
1.	Waste Disposal	■	■	
2.	Sewage Systems	■	■	
3, 4.	Agricultural Source Material	■		
6, 7.	Non-Agricultural Source Material*	■		
8, 9.	Commercial Fertilizer*	■		
10, 11.	Pesticide	■		
12, 13.	Road Salt*	■		
14.	Storage of Snow	■		
15.	Fuel	■		
16.	DNAPLs	■	■	■
17.	Organic Solvents	■		
18.	Aircraft De-icing	■		
21.	Livestock Area	■		
Local Threat	Oil Pipelines	■		

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

- Well
- Road
- Minor River
- Lake / Main River
- Source Protection Area Boundary
- Lower Tier Municipal Boundary

Wellhead Protection Zones:
- WHPA-A
- WHPA-B
- WHPA-C

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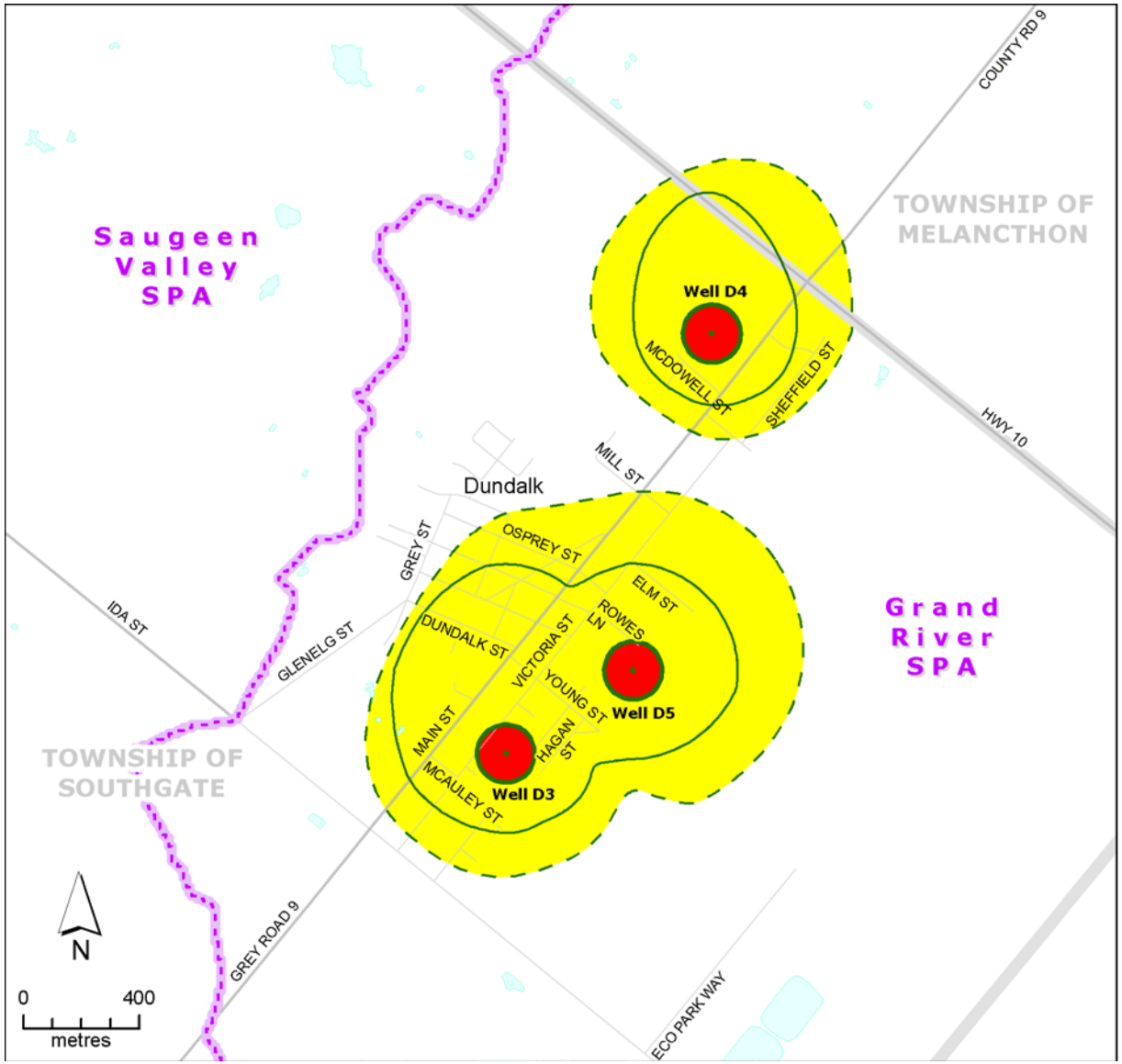
6.7 Schedule B: Dufferin County, Township of Melancthon: Dundalk Well Supply



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal			
2.	Sewage Systems			
3, 4.	Agricultural Source Material			
6, 7.	Non-Agricultural Source Material*			
8, 9.	Commercial Fertilizer*			
10, 11.	Pesticide			
12, 13.	Road Salt*			
14.	Storage of Snow			
15.	Fuel			
16.	DNAPLs			
17.	Organic Solvents			
18.	Aircraft De-icing			
21.	Livestock Area			
Local Threat	Oil Pipelines			

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

- Well
- Road
- Lake / Main River
- Source Protection Area Boundary
- Municipal Boundary

Wellhead Protection Zones:
- WHPA-A
- WHPA-B
- WHPA-C

Ontario

Grand River Conservation Authority

1. Updated April 12, 2018.
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
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