Grand River Source Protection Area

ASSESSMENT REPORT

Chapter 8: Region of Waterloo

April 1, 2025

CHAPTER 8: REGION OF WATERLOO SECTIONS

Chapter 8 of the Assessment Report, including each municipal well system for the Region of Waterloo, is separated into eight section documents as follows:

CURRENT DOCUMENT:

- **Section 8.7** – Limitations, Data Gaps and Uncertainty
- **Section 8.8** – Summary

REMAINING DOCUMENTS:

- **Section 8.1** – Water Quality Risk Assessment
- **Section 8.2** – Waterloo Area Wellfields (Erb Street, William Street, and Waterloo North wells)
- **Section 8.3** – Kitchener Area Wellfields (Mannheim (East, West, ASR and Peaking), Greenbrook, Strange Street, Parkway, Strasburg, Pompeii, Woolner and Wilmot Centre)
- **Section 8.4** – Hidden Valley Intake
- **Section 8.5** – Cambridge Area Wellfields (Hespeler, Pinebush, Blair Road, Clemens Mill, Elgin Street, Middleton Street, Shades Mills, Fountain Street, and Willard)
- **Section 8.6** – Rural Area Wellfields (Ayr, Branchton Meadows, Elmira, Foxboro Green, Heidelberg, Linwood, Maryhill, New Dundee, New Hamburg, Roseville, St. Clements, Wellesley)

TABLE OF CONTENTS

LIST OF TABLES

8.0 REGION OF WATERLOO

8.7 Limitations, Data Gaps and Uncertainty

8.7.1 Peer Review

During the preparation of the Approved Assessment Report (LESPC, 2015), various technical reports describing the work completed were peer reviewed including reports regarding the Capture Zones, Vulnerability and Transport Pathways, Intrinsic Susceptibility Mapping and IPZ & WHPA-E Delineation reports. Many of the delineations and scorings had to be updated for this report to reflect changes in long-term water supply planning, but the technical methodologies applied to determine Transport Pathways and scoring of WHPA zones remained consistent with the original peer reviewed documents. In the cases of updates to Intrinsic Susceptibility and WHPA delineation, previously peer reviewed methodologies were improved upon. The improvements to the methodologies were made possible by the extensive work completed during the Tier 3 Water Quantity Risk Assessment, which had not yet been completed at the time of the previous Assessment Report.

Capture Zones

Capture Zones delineated for the Approved Assessment Report (AquaResource Inc., 2010) were Peer Reviewed by S.S. Papadopolous & Associates Inc. (SSPA) on April 14, 2010. SSPA commented that “In our opinion this is a superb report. It is clear that a significant effort and expertise has been devoted to this study. The approaches adopted for the groundwater modelling, and the particle tracking calculations that underlie the delineation of the wellhead protection areas, are appropriate and consistent with the Ontario Ministry of the Environment Draft Guidance Module 3 (October 2006).” Upon review of detailed comments a few areas of the modelling were identified as needing improvements.

Improvements to the capture zone analysis completed in the updated WHPA delineation included the incorporation of three unique uncertainty realizations described further in **Section 8.1.2** (Matrix, 2017a). Their inclusion addressed uncertainty inherent in the groundwater model calibration and the relatively high degree of uncertainty highlighted in the Approved Assessment Report (LESPC, 2015). By completing three separate realizations of the calibrated model, and including the particles tracks from all of the realizations into the WHPA delineation, the degree of uncertainty with the generated WHPAs was reduced.

Vulnerability and Transport Pathways

S.S. Papadopolous & Associates (SSPA) reviewed the report *Vulnerability Scoring of Wellhead Protection Areas, Regional Municipality of Waterloo* (Stantec, 2009c) and provided their comments to GRCA staff in a Peer Review Report dated April 19, 2010. In the Peer Review Report SSPA provided both general comments regarding the adequacy of the analyses and reporting, and detailed technical comments.

In terms of general comments, in the opinion of SSPA the report was considered to be acceptable. The Peer Review Report stated that: "the approaches adopted for the

vulnerability assessment are appropriate and consistent with the Technical Rules for the Assessment Report and with the Ontario Ministry of the Environment Draft Guidance Module 3 (October 2006). We concur with final vulnerability scores as mapped in Figures “C”."

A few items were identified within the detailed technical comments and editorial suggestions which were made to the relevant technical studies. The updated vulnerability scoring and transport pathway reports – described further in **Section 8.1.6** – applied the same methodology as the 2009 peer reviewed report by Stantec (Stantec, 2009c).

Intrinsic Susceptibility Mapping

Intrinsic Susceptibility Mapping for the Approved Assessment Report was reviewed by S.S. Papadopolous & Associates Inc. (SSPA) on February 22, 2010. SSPA commented that “the evaluations provide a reliable large-scale impression of the relative vulnerability of the shallow and deeper aquifers in the Region of Waterloo”. Upon review of more detailed editorial comments it was felt that no changes to the mapping were required in the technical studies used to help prepare the Approved Assessment Report.

In this update to the Assessment Report, the modified ISI approach described in **Section 8.1.6** of this report was completed using the hydrostratigraphic layers and vertical hydraulic conductivity values incorporated in the models. This approach capitalizes on the conceptual understanding of hydrostratigraphy between borehole locations, and does not rely on discrete wells or clustered points, which are common downfalls of the traditional ISI method. The modification to the methodology represents a more fulsome interpretation over the previously peer reviewed work.

IPZ Delineation

IPZ and WHPA-E Delineations for all but the Blair Road Wellfield were Peer Reviewed by Mr. Hugh Whiteley on January 28, 2010 and February 10, 2010. Upon review of this work Mr. Whiteley commented that “I find this section of the report to be generally clearly written, logically presented and the procedures used in accordance with the technical rules. The comments that follow deal with minor points related to completeness and clarity in this report and do not involve any change in the procedures or the results obtained.” Upon review of Mr. Whiteley’s more detailed editorial comments it was felt that no changes were required to the technical studies used to help prepare the Assessment Report. The methodology applied to the delineation and scoring of the WHPA-E for the Blair Road Wellfield was similar to the earlier peer reviewed study.

8.7.2 Limitations and Uncertainty

The Rules identify four factors that should be considered in the assessment of uncertainty associated with the delineation of vulnerable areas. These include: the nature, extent and type of data used; the ability of the models to represent the hydrologic function; quality assurance in the process; and, the degree and extent of model calibration. In addition, the Rules specify that the uncertainty analysis should quantify the accuracy to which the vulnerability scoring assesses the relative

vulnerability of the underlying hydrogeologic or hydrologic features. An uncertainty analysis was completed for each component of the vulnerability analysis. The following tables provide a summary of the uncertainty analysis undertaken for the groundwater **(Table 8.7—78)** and surface water (**Table 8.7—79**) vulnerability assessments.

Table 8.7—1: Uncertainty of Groundwater Vulnerability Analysis

Uncertainty Criteria	ISI Mapping	Model Design and Capture Zone Delineation – ASR MODFLOW Model	Model Design and Capture Zone Delineation – Regional FEFLOW® Model	Pathways and Vulnerability
Data Sources	• WRAS[1] • GRCA DEM • RMOW Hydrogeologic Conceptual Model[2] • Tier 3 Numerical Model Hydrostratigraphy	• Water level data from 2006 to 2010 during static and initial operation of ASR • MOE water well records, WRAS Database • Aquifer Recharge (Frind and Sudicky, 1977) • Pumping Records for Municipal Wells • Pumping Test and Field Results – Specific Yield and Hydraulic Conductivity Values (where available)	• RMOW Hydrogeologic Conceptual Model • WRAS • Pumping Records for Municipal Wells • Hydrogeologic Consulting Reports for Municipal Wells • GRCA Private Wells Database • GRCA GAWSER models • River Gauging Station Recorded Values • Tier 3 Characterization Reports • Pumping Test and Field Results	• WRAS • Municipal Infrastructure • Pits and Quarries • Septic Systems • Stormwater Infiltration Systems • Deep Excavations / Deep Underground Parking Structures
Uncertainty:	**LOW**	**LOW**	**LOW**	**LOW**
Plan to Address High Uncertainty:				
Method Applicability	• Accepted Methodology • Approach specific to municipal aquifers	• Accepted Methodology • Inherent uncertainty due to conceptualization of aquifers and assignment of properties to model	• Accepted Methodology • Inherent uncertainty due to conceptualization of aquifers and assignment of properties to model	• Accepted Methodology • Pathways evaluated relative to risk • Density of pathways considered in scoring • Assigned Categories

Uncertainty Criteria	ISI Mapping	Model Design and Capture Zone Delineation – ASR MODFLOW Model	Model Design and Capture Zone Delineation – Regional FEFLOW® Model	Pathways and Vulnerability
	•Inherent uncertainty in areas of sparse geologic data	•Two year transient simulation of injection, pauses and pumping simulates gradients specific to an ASR system	•Particle tracking completed with 4 calibrated models to address inherent uncertainty in assignment of properties •Forward and backward particle tracking applied	
Uncertainty:	**LOW**	**LOW**	**LOW**	**LOW**
Plan to Address High Uncertainty:				
QA/QC	•Logic checks were performed to ensure the susceptibility mapping was consistent between the aquifer units •Qualitative checks and local knowledge	•Water balance •Qualitative checks based upon local knowledge	•Water balance •Comparison to GRCA regional water budget model •Reverse/forward particle tracking methods used •Qualitative checks to previous models and local knowledge	•Field verification •Logic checks were performed to ensure consistency with ISI mapping
Uncertainty:	**LOW**	**LOW**	**LOW**	**LOW**
Calibration	N/A	•Many calibration targets for water levels in both steady state and transient conditions	•Multiple calibration targets for water levels and surface water flows •Multiple calibrated model realizations	N/A
Uncertainty:	**LOW**	**LOW**	**LOW**	**LOW**

Uncertainty Criteria	ISI Mapping	Model Design and Capture Zone Delineation – ASR MODFLOW Model	Model Design and Capture Zone Delineation – Regional FEFLOW® Model	Pathways and Vulnerability
Overall Uncertainty:	**LOW**	**LOW**	**LOW**	**LOW**

[1] Water Resources Analysis System (WRAS) database of borehole and well records.
[2] RMOW hydrogeologic conceptual model refined from the Ontario Geologic Survey geologic model for the Waterloo Moraine

The overall uncertainty associated with the groundwater vulnerability analysis is low. A high uncertainty was associated with the data sources and method applicability for capture zone delineations. Several comments about this uncertainty are provided below:

- Sources of data for the ISI mapping are considered to have a low uncertainty largely due to reliance on the Region's *Water Resources Analysis System* (WRAS) database which represents a 20-year compilation of high quality borehole information derived from extensive geologic mapping and hydrogeologic studies undertaken as part of the Region's Water Resources Protection Strategy and the Tier 3 Characterization work.
- The methods used to complete the ISI mapping, capture zone delineations and pathways assessment are accepted methodologies included in the Technical Rules (MOE, 2009b). The modification to the standard ISI method to incorporate interpolated layer thickness between boreholes based on detailed data collection and analysis during the Tier 3 characterization studies improved the reliability of the ISI layers. Multiple calibrated realizations of the models applied to the capture zone delineation further increased the reliability of the capture zone results by addressing some of the uncertainty inherent in groundwater models. Notwithstanding the above, there is still some low level uncertainty associated with the capture zone assessments due to the assumptions made to develop the model structure, establish boundary conditions and establish the hydrogeologic properties of the model.
- Extensive quality assurance and quality checks (QA/QC) were undertaken in all components of the evaluation including field verification of the status of many of the boreholes; as such the uncertainty associated with this category is low.
- Extensive calibration targets were established for the capture zone assessments including statistical water level targets for the entire model as well as statistical targets for the Wellfield areas and for higher quality calibration wells. The Moraine Model was also calibrated to numerous base flow targets for most of the surface water streams in the area based on information obtained from the GRCA. The high quality and extent of the calibration targets resulted in a low level of uncertainty for the model calibration.

Table 8.7—2: Uncertainty of Surface Water Vulnerability Analysis

Uncertainty Criteria	IPZ-1 and IPZ-3	IPZ-2 and WHPA-E Delineation	Vulnerability
Data Sources	•GRCA Watercourse Mapping •GRCA Regulation Limit Mapping	•GRCA Watercourse Mapping •GRCA Regulation Limit Mapping •In-situ data (dye tracer)	N/A
Uncertainty:	**LOW**	**LOW**	**LOW**

Uncertainty Criteria	IPZ-1 and IPZ-3	IPZ-2 and WHPA-E Delineation	Vulnerability
Method Applicability	•Accepted Methodology •Straight forward GIS mapping exercise	•Accepted Methodology •Hydraulics not well understood in some areas	•Accepted Methodology •Assigned vulnerability factors
Uncertainty:	**LOW**	**HIGH**[1] **LOW**[2]	**LOW**
QA/QC	GRCA Data	•Comparison to other models	•Logic checks were performed to ensure consistency with the range of factors
Uncertainty:	**LOW**	**LOW**	**LOW**
Calibration	N/A	•Calibrated to flow regime during dye tracer test	N/A
Uncertainty:	**LOW**	**LOW**	**LOW**

[1] Pompeii, Woolner, W10, Greenbrook
[2] Willard, Mannheim, Shades Mills, Blair Road

The overall uncertainty with respect to delineation of IPZ-1 and IPZ-3 areas is considered low primarily because of the relatively straight forward method. For the IPZ-2 and WHPA-E calculations, the overall uncertainty was low for Willard, Mannheim, Blair Road and Shades Mills but high for Pompeii, Woolner, W10 and Greenbrook. The high uncertainty for these systems is primarily due to the complicated hydrology and hydraulics of the contributing systems. Data sources, QA/QC and calibration approaches had a low uncertainty for all these systems.

8.8 Summary

The scale of assessment and mapping in the Region of Waterloo is unique due to the large population being supported by primarily groundwater resources. Accordingly, there are several observations that need to be considered when evaluating the information in this report as follows:

- WHPAs and IPZs near Kitchener, Cambridge and Waterloo cover large areas due to the large municipal systems in densely populated areas, but the Region of Waterloo also includes many rural systems that provide water to smaller settlement areas and towns. Within urban areas, where land parcels are smaller, the protection areas associated with wells or wellfields also sometimes overlap, resulting in many more properties with potential threats to source water.
- The rules for scoring the vulnerability of the IPZ at the Hidden Valley Surface Water Intake do not allow consideration of the large raw water reservoir that provides an additional 48-hour protection time for the surface water intake. Similarly, the rules for the GUDI wells do not account for the additional natural filtration due to the subsurface geologic materials that provide additional response time – in some cases on the order of days – to shut off a well compared to a two-hour surface water response time.
- The WHPAs in this report were updated from the previous assessment report to incorporate hydrogeologic knowledge obtained through completion of the Region of Waterloo's Tier 3 characterization and modeling work. Detailed hydrogeologic assessments were undertaken at many of the Region's Wellfields and results were included in reports as well as compiled in a hydrogeologic information database. Numerous improvements to the previous Regional Groundwater Models were made during the Tier 3 assessment work.
- The Region of Waterloo's Updated Water Supply Master Plan was also completed since the previous Assessment Report (Stantec, 2015). Simulated pumping rates applied during the delineation of the WHPAs were updated from the previous Assessment Report in accordance with the Updated Water Supply Master Plan.

Threats and Issues Summary

Threat ranking scores were calculated for all properties found within the source water protection areas with the exception of urban residential properties on municipal wastewater servicing. The following points summarize the significance of these results:

- The identification of significant threats does not necessarily indicate any impact to the water supply as this assessment only looks at the potential for impact. Similarly, the identification of these threats does not necessarily mean that property owners are mishandling chemicals on their property because "credit" for using appropriate handling practices is not considered in the risk assessment formula stipulated in the regulations but will be considered instead in the Source Protection Plan implementation stages.

- A total of 24 Significant Conditions were identified within wellhead protection areas.
- No Significant Threat Conditions or Issues were detected for the Hidden Valley Surface Water Intake.
- Water quality Issues were identified at eleven (11) Wellfields. Of these, two (2) Wellfields had water quality trends associated with nitrate, nine (9) had trends associated with sodium and/or chloride, and four (4) had trends associated with the organic solvent Trichloroethylene (TCE).
- All water quality Issues were previously known to Region staff. For each Issue, water quality monitoring, additional assessment, land management, and/or treatment strategies are underway. The water quality in the wells and reservoirs supplying water to the Region continue to meet all health-based Ontario Drinking Water Standards.
- For sodium, chloride, and nitrate the application of deicing salts and agricultural nutrients over large areas and in some cases at considerable distances from the supply wells are the primary sources of these chemicals.
- 19 of the 20 water quality Threat types (as identified in Reg. 287/07) are present in the Region, 18 of which are present as Significant Threats – the one exception is the Threat associated with aircraft de-icing chemicals.
- This assessment does not propose adding any “Local Threats” to the threat categories specified by Regulation.