Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

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

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Report prepared for Lake Erie Source Protection Region, June 2018

June 14, 2018

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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).

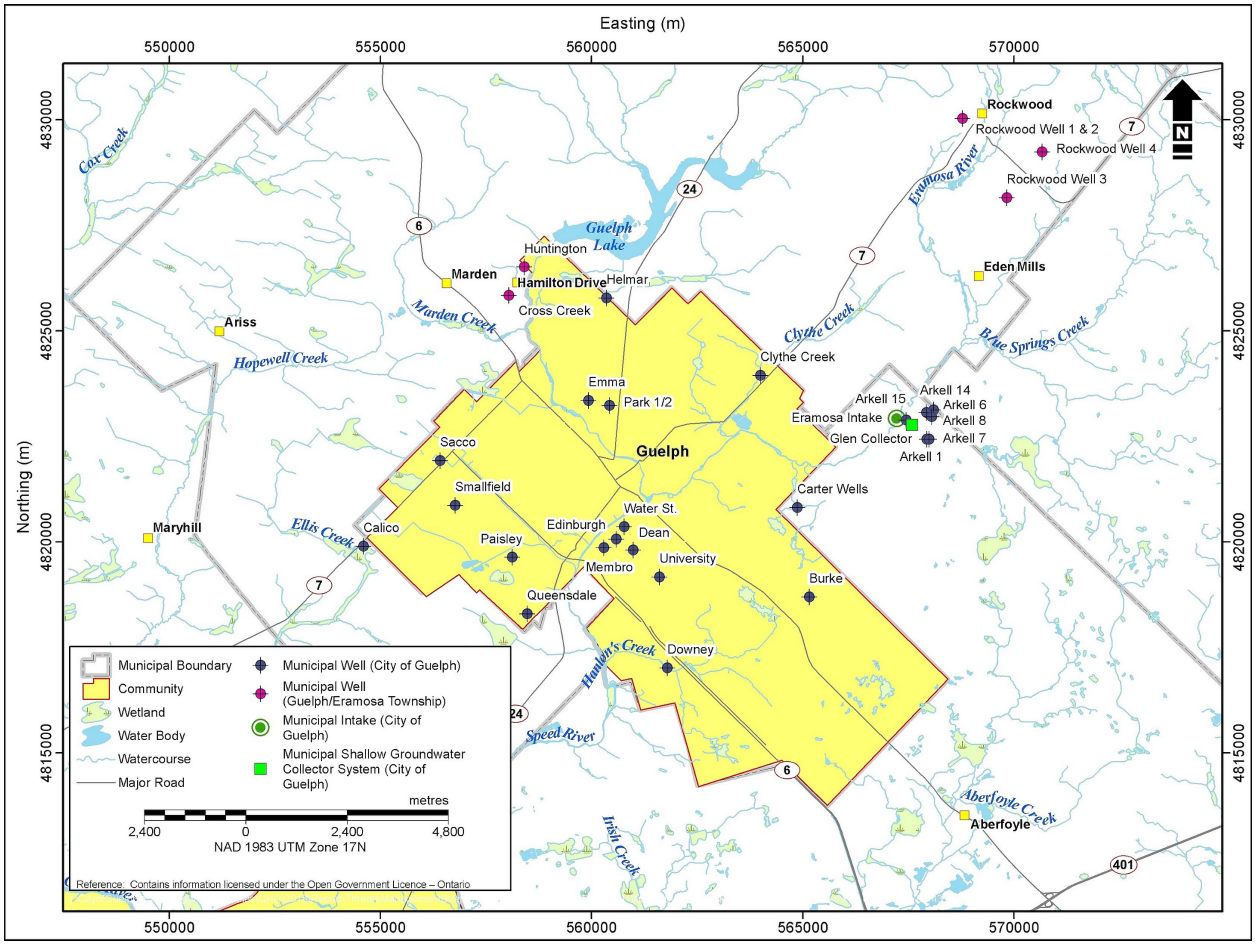

FIGURE 1 Tier Three Assessment Municipal Water Supply Systems

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).

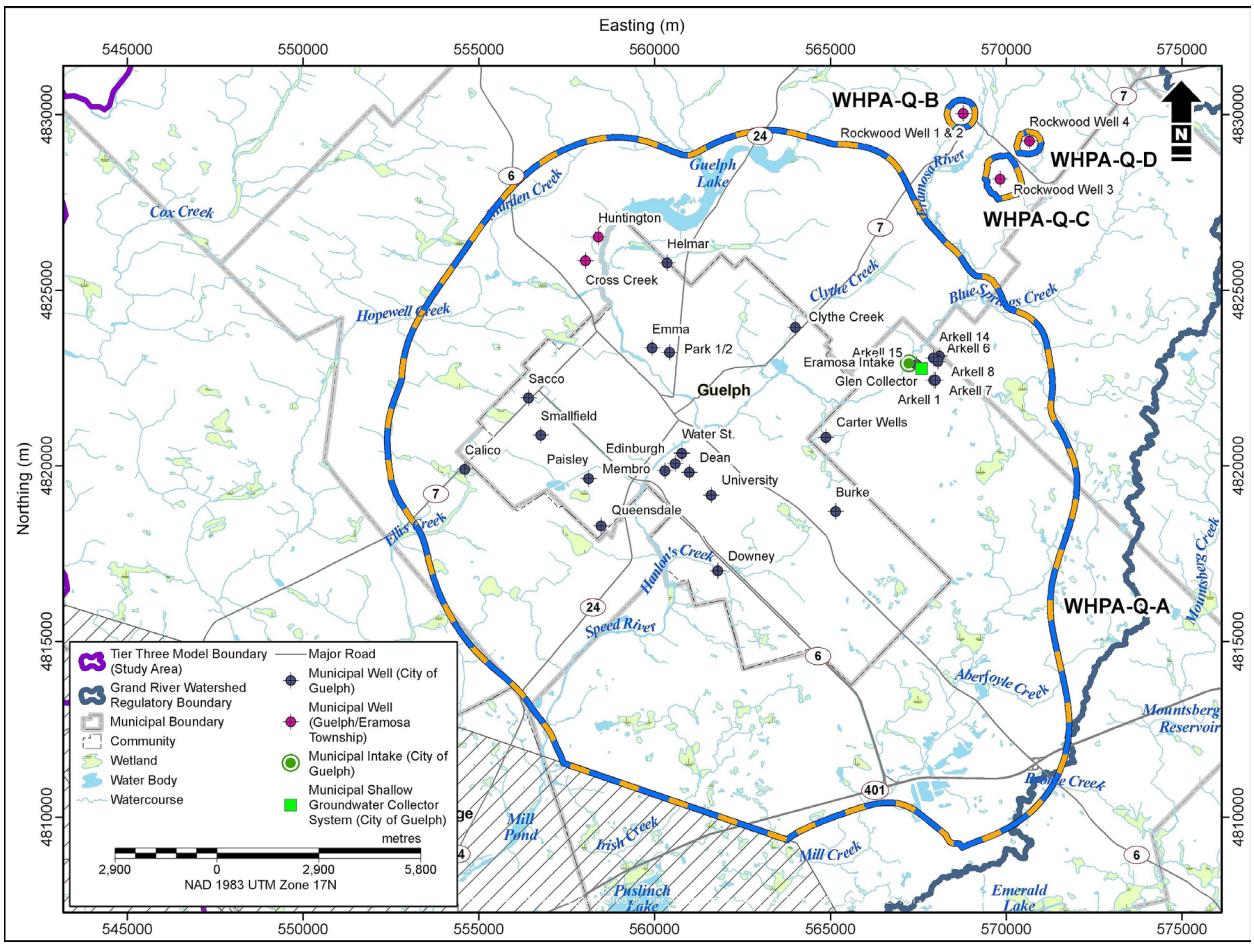

FIGURE 2 WHPA-Qs Delineated in Tier Three Assessment (Matrix 2017)

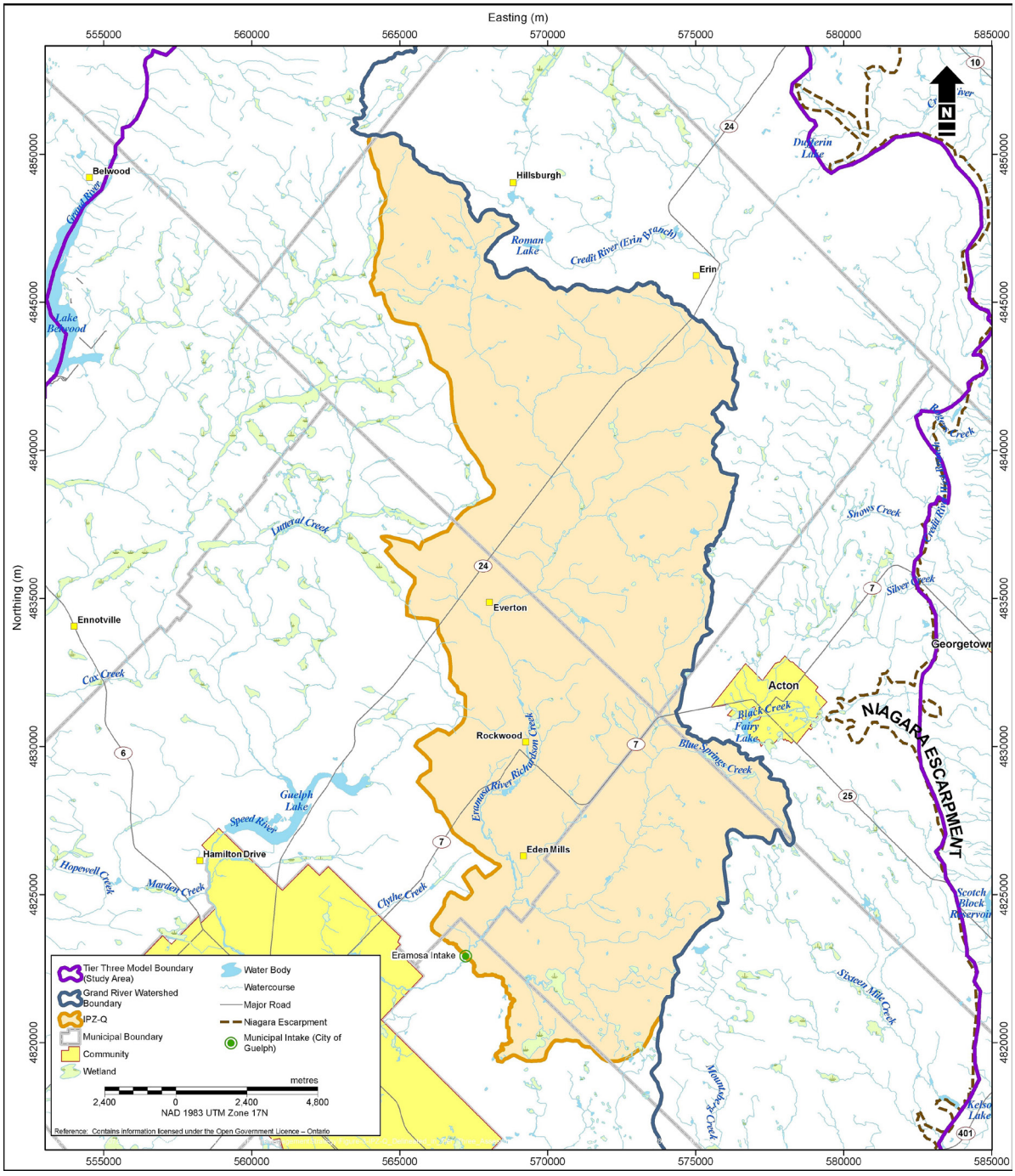

FIGURE 3 IPZ-Q Delineated in Tier Three Assessment (Matrix 2017)

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.

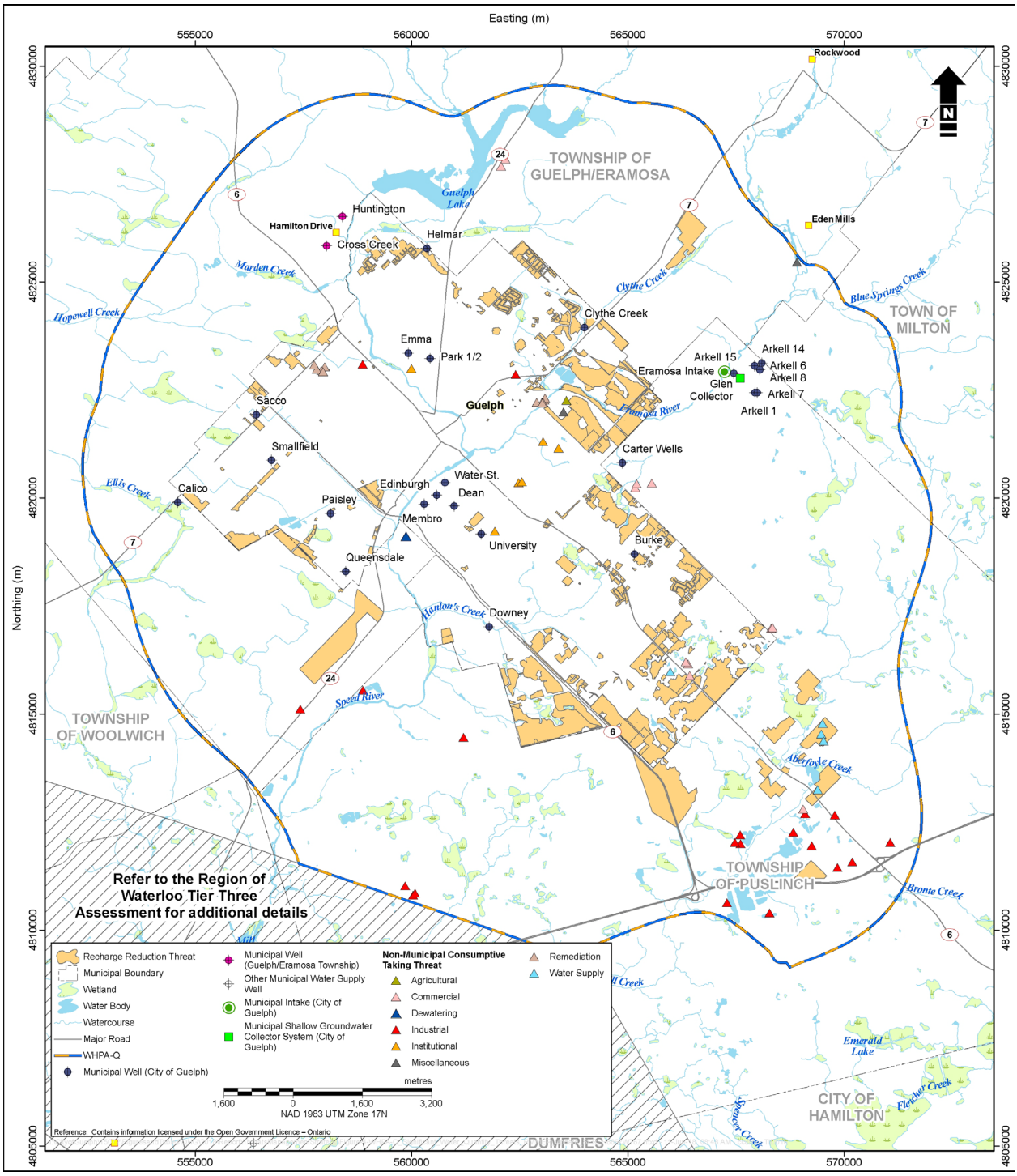

FIGURE 4 WHPA-Q Significant Water Quantity Threats (Matrix 2017)

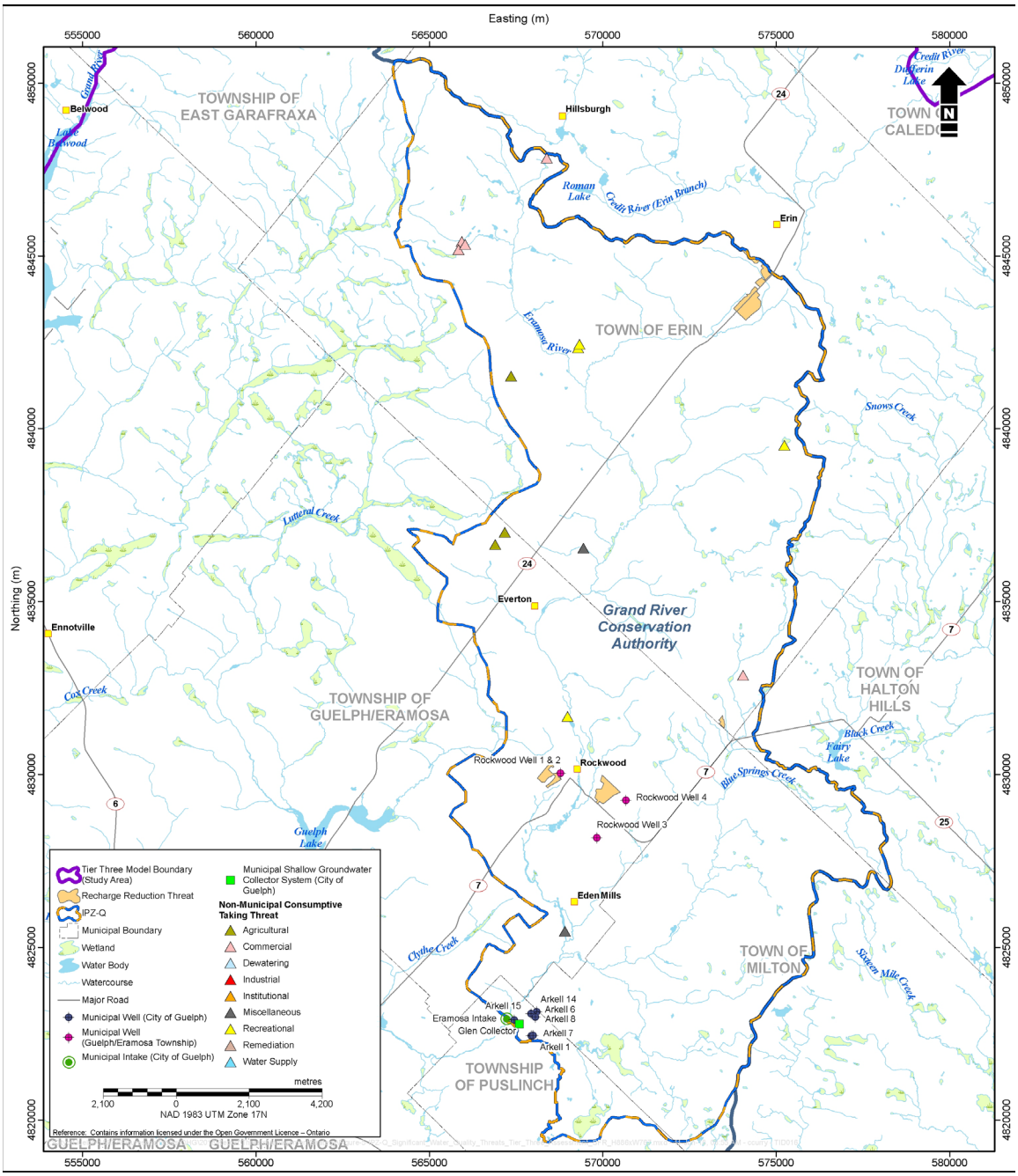

FIGURE 5 IPZ-Q Significant Water Quantity Threats (Matrix 2017)

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.

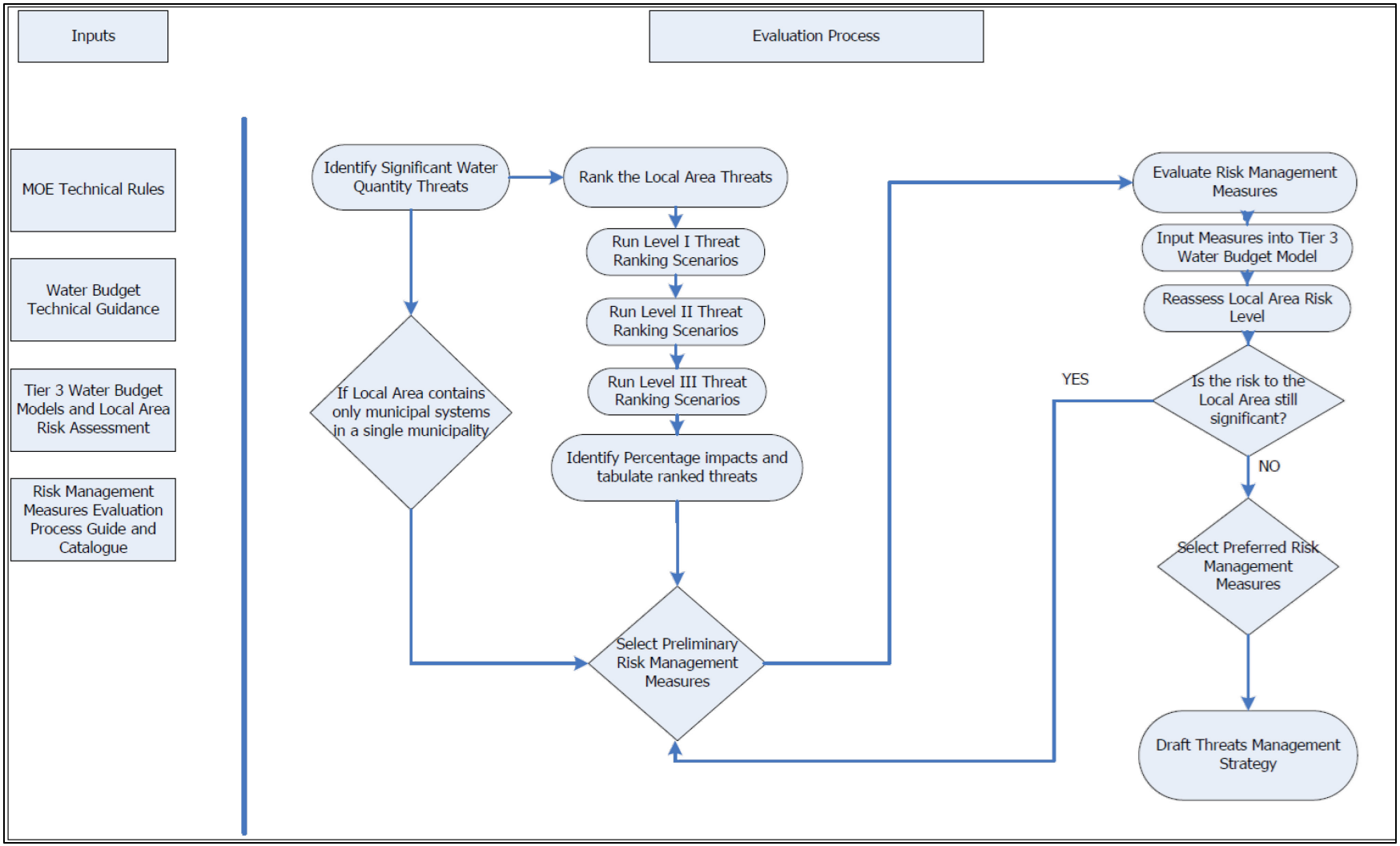

FIGURE 6 Risk Management Measures Evaluation Process Flow Chart (TRCA 2013)

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.

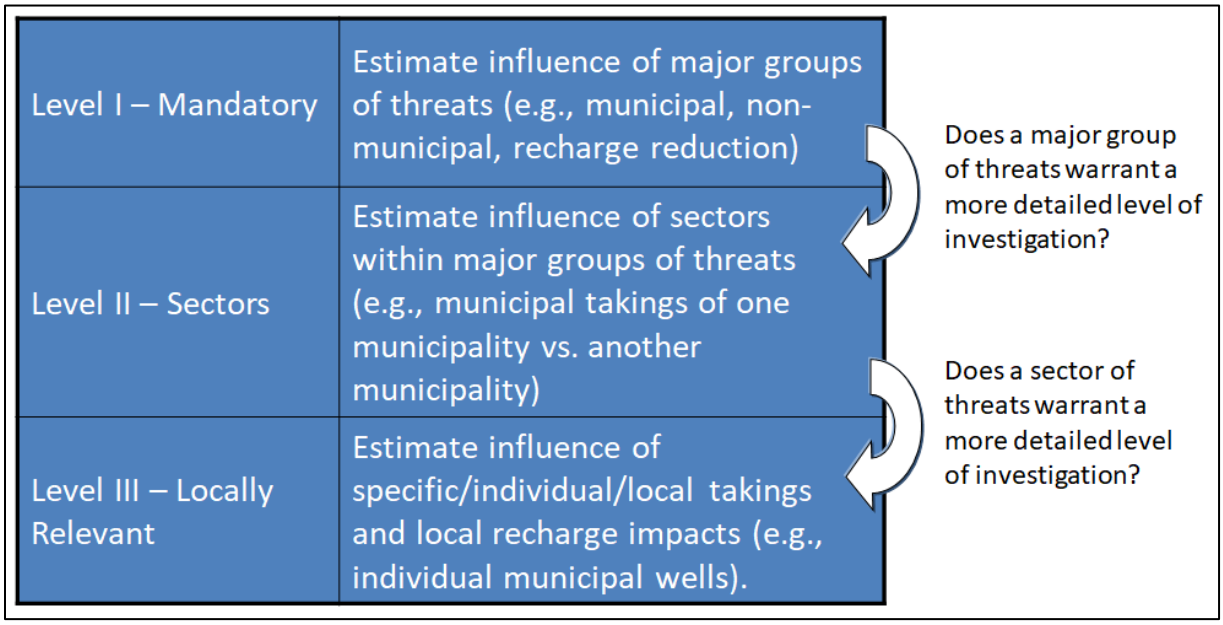

FIGURE 7 Three-stage Approach to Threats Ranking

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.

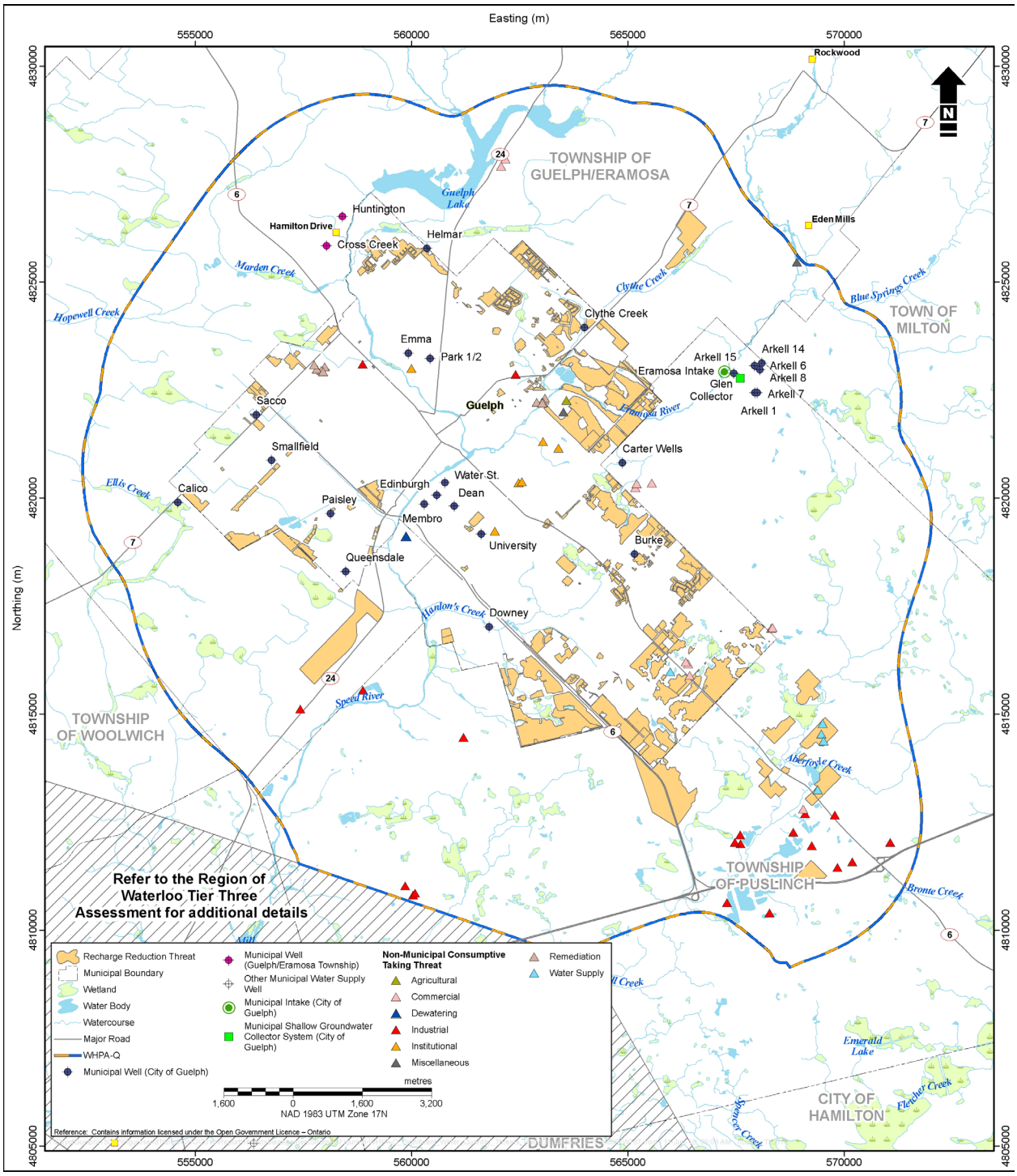

FIGURE 8 WHPA-Q Significant Water Quantity Threats - Risk Management Measures Evaluation Process 2017 Update

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.

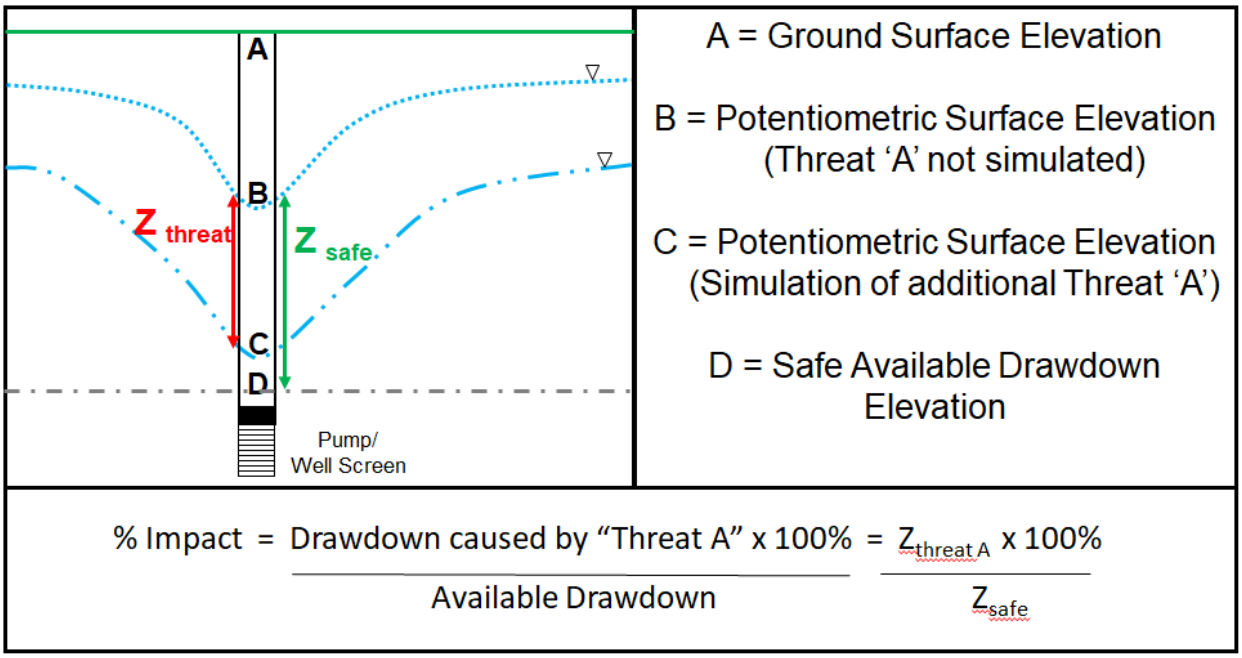

FIGURE 9 Graphical Representation of Percent Impact

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.

5 REFERENCES

AECOM and Golder Associates Ltd. (Golder). 2014. *The Corporation of the City of Guelph Water Supply Master Plan Update*. Draft final report prepared for The Corporation of the City of Guelph. Ontario. May 2014.

AquaResource Inc. (AquaResource). 2009a. *Integrated Water Budget Report, Grand River Watershed*. Report prepared for Grand River Conservation Authority. June 2009. https://www.sourcewater.ca/en/source-protection-areas/resources/Documents/Grand/Grand_Reports_WaterBudget_2009.pdf

AquaResource Inc. (AquaResource). 2009b. *Tier 2 Water Quantity Stress Assessment Report, Grand River Watershed*. Report prepared for the Grand River Conservation Authority. December 2009. https://www.sourcewater.ca/en/source-protection-areas/resources/Documents/Grand_Reports_WaterBudget_2009_Stress.pdf

Government of Ontario. 2018. *Clean Water Act, 2006.* Ontario Regulation 287/07. Last amendment 206/18. Consolidation Period from April 4, 2018 to the e-Laws currency date. http://www.ontario.ca/laws/regulation/070287

Government of Ontario. 2016. *Ontario Water Resources Act*. Ontario Regulation 387/04. Consolidation period from March 29, 2016, to e-laws currency date. http://www.ontario.ca/laws/regulation/040387

Kinkead Consulting Limited (Kinkead Consulting) and AquaResource Inc. (AquaResource). 2009. *Methodology for Identifying Large Consumptive Water Users: Great Lakes - St. Lawrence River Basin Sustainable Water Resource Agreement*. Report prepared for the Ontario Ministry of Natural Resources. Waterloo, Ontario.

Matrix Solutions Inc. (Matrix). 2017. *City of Guelph and Township of Guelph/Eramosa Tier Three Water Budget and Local Area Risk Assessment*. Report prepared for Lake Erie Source Protection Region. Breslau, Ontario. March 2017. https://www.sourcewater.ca/en/source-protection-areas/Guelph-and-Guelph-Eramosa-Tier-3.aspx

MTE Consultants Inc. (MTE). 2017. *Guelph Quarry, Final Permit to Take Water 5080-8TAKK2: 2016 PTTW Monitoring Report.* Report prepared for River Valley Developments Inc. and James Dick Construction Ltd. Kitchener, Ontario. April 25, 2017.

MTE Consultants Inc. (MTE). 2016. *Guelph Quarry, Final Permit to Take Water 5080-8TAKK2: 2015 PTTW Monitoring Report*. Report prepared for River Valley Developments Inc. and James Dick Construction Ltd. Kitchener, Ontario. April 20, 2016.

Ontario Ministry of the Environment (MOE). 2013. *Memorandum: Assignment of Water Quantity Risk based on the Evaluation of Impacts to Other Water Users*. Memorandum prepared for Source Protection Regions. Toronto, Ontario. December 2, 2013.

Ontario Ministry of the Environment (MOE) and Ontario Ministry of Natural Resources (MNR). 2010. *Technical Bulletin: Part IX Local Area Risk Level*. April 2010. 15 pp. https://ia601209.us.archive.org/22/items/std01079874.ome/std01079874.pdf

Ontario Ministry of the Environment and Climate Change. (MOECC). 2017. *Technical Rules: Assessment Report, Clean Water Act, 2006*. November 20, 2008. Amended on December 12, 2008 (administrative amendments), November 16, 2009 (EBR Posting Number EBRO10-7573), and December 2, 2013 (Technical Bulletin). Updated on June 23, 2017. Published on May 19, 2016. https://www.ontario.ca/page/technical-rules-assessment-report

Resource Management Strategies Inc. (RMSi). 2009. *Water Conservation and Efficiency Strategy Update* (WC&ES). Final Report. Report prepared for the City of Guelph. Guelph, Ontario. May 2009.

Stantec Consulting Ltd. (Stantec). 2009. "Guelph South Groundwater Supply Investigation, Final Report, City of Guelph, Ontario." Draft report prepared for the City of Guelph. Kitchener, Ontario. November 2009.

Toronto and Region Conservation (TRCA). 2014. *Water Quantity Risk Management Measures Catalogue*. Version: 7.0 -2014-07-24. Accessed in February 2018. http://trcagauging.ca/RmmCatalogue/QuantityIndex.aspx

Toronto and Region Conservation (TRCA). 2013. *Guide Water Quantity Risk Management Measures Evaluation Process*. Report prepared for The use of Source Protection Committees in preparation of the Source Protection Plans under the Clean Water Act. Downsview, Ontario. January 2013.