Grand River Source Protection Area

ASSESSMENT REPORT

Chapter 24: City Guelph and Guelph/Eramosa Township Tier 3 Water Budget and Risk Assessment

Pre-consultation Draft

Version #

June 12, 2025

Executive Summary

The vulnerable areas in the G-GET Tier 3 Assessment are represented by four WHPA-Qs and an IPZ-Q. The largest WHPA-Q is circular, with a diameter of approximately 20 kilometres and extends around the City of Guelph and surrounding townships. The extent of the WHPA-Q to the southwest toward the City of Cambridge was delineated based on the results of the G-GET Tier 3 Assessment and the Region of Waterloo Tier 3 Assessment completed for the municipal wells in the City of Cambridge (Matrix and SSPA, 2014).

The Tier 3 Assessment scenarios demonstrated that the City of Guelph's Queensdale Well is unable to pump at future rates under both average and drought conditions. All other municipal wells of the City of Guelph and the Guelph/Eramosa Township in Rockwood and Hamilton Drive are likely to be able to pump at their current and future rates under all conditions, but there is a high level of uncertainty with the results for the City of Guelph's Arkell Well 1. The scenario results are supported by historical operating experience in the City of Guelph where many of the wells have pumped at rates equivalent to their future rates over prolonged periods of time. The primary municipal water supply aquifer is protected in most areas by the Vinemount Member aquitard, which reduces the vulnerability of the supply to drought. While all Tier 3 municipal wells except the Queensdale Well are expected to meet their future rates, water levels at Arkell Well 1, Arkell Well 8, Arkell Well 14, Arkell Well 15, Burke Well, Carter Well, Emma Well, and Rockwood Well 3 may be more susceptible to drought conditions. This result demonstrates the water quantity risks to the City of Guelph's water supply and, although only Queensdale Well exceeded the safe water level in the drought scenario, redistributing pumping to other wells might not mitigate the significant risk level without other Risk Management Measures.

Even with the recent permitting of all Arkell Spring Ground wells, the City of Guelph's water supplies may not have the capacity to meet the 2031 estimated water demand due to the predicted impacts at the Queensdale Well. Furthermore, the City of Guelph will require all wells to be pumped at their future rates, leaving little redundancy in the system. Redundancy is required to allow for the rehabilitation and maintenance of one or more wells, loss of one or more wells due to contamination, or long-term interference from other water users.

There is a potential that pumping may decrease groundwater discharge to wetlands and coldwater streams. Results from the steady-state model indicated decreases of 10 percent or more in groundwater discharge to coldwater streams, such as the South Branch of Blue Springs Creek, Chilligo/Ellis Creek, and Hanlon Creek. There are also predicted reductions of shallow groundwater levels greater than 1 m around Provincially Significant Wetlands (PSWs) in the northwest, northeast, and southeast areas of the City of Guelph. As a result, WHPA-Q-A and the IPZ-Q would be assigned a moderate risk level even if the drawdown threshold had not been exceeded at the Queensdale Well (resulting in a significant risk level). In addition, there is a high level of uncertainty with respect to the predicted impacts to coldwater streams and wetlands.

Significant threats to drinking water quantity were identified as a result of assigning a significant risk level to the WHPA-Q and IPZ-Q. These threats included 7,537 consumptive water takings (e.g., municipal and non-municipal takings) and 17.4 square kilometres of recharge reduction areas.

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A Tier 3 Water Budget and Risk Assessment was completed for the City of Guelph and the Guelph/Eramosa Township municipal drinking water systems (G-GET Tier 3 Assessment) (Matrix, 2017). The purpose of the study was to:

- Evaluate the current and future sustainability of the municipal water supply wells and surface water intake; and
- Identify potential water quantity threats to the municipal drinking water supplies.

Map 24–1 shows the locations of the municipal supply wells and the surface water intake included in this study.

The G-GET Tier 3 Assessment was initiated in 2008 for the City of Guelph as one of the first Tier 3 Assessments in the Province. Initially, the project included:

- A physical characterization of the groundwater and surface water systems;
- Hydrogeologic field work, including drilling of deep bedrock monitoring wells to address knowledge gaps;
- The development and calibration of numerical modelling tools that were founded on the physical characterization; and
- The application of those tools to assess water quantity risks to the municipal supply wells and intake.

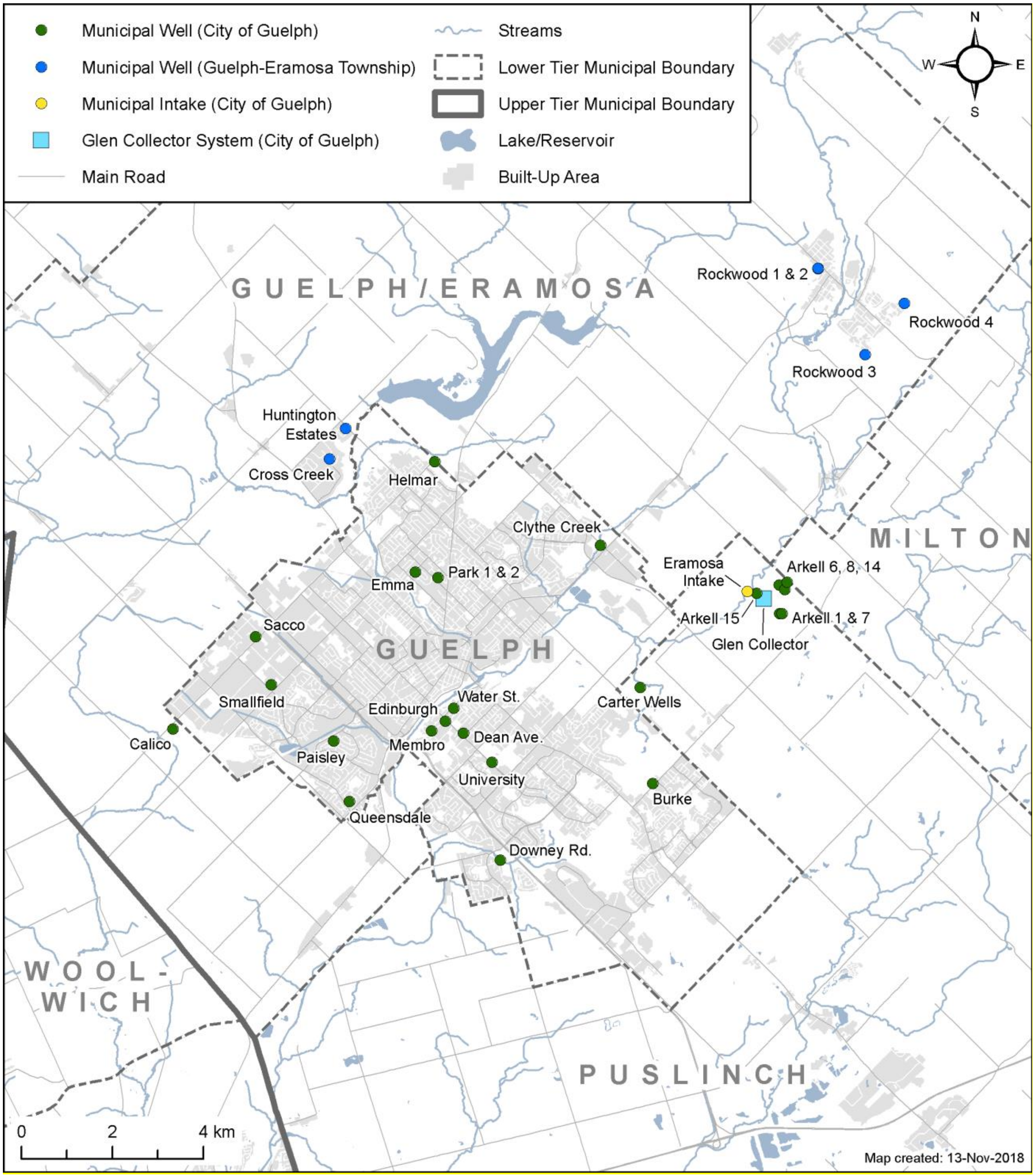
The assessment was finalized in 2017. During the 9-year study period, the Tier 3 Assessment was expanded to include:

- Municipal supply wells servicing Rockwood and Hamilton Drive in Guelph/Eramosa Township. This included additional physical characterization, and refinement and calibration of the numerical groundwater flow model;
- Model updates in the areas of the Dolime Quarry and Aberfoyle to leverage the availability of additional data in these areas; and
- Model updates to ensure consistency with the Region of Waterloo Tier 3 Assessment (Matrix and SSPA, 2014) that was simultaneously being completed and to address areas where there was overlap between the two study areas.

24.1 Background

Tier 3 Assessments must be completed following the Technical Rules under *Clean Water Act, 2006*. The Tier 2 Water Budget Study, completed across the Grand River watershed (AquaResource 2009a, 2009b), showed a moderate water quantity stress level in the subwatersheds containing the City of Guelph and Guelph/Eramosa Township municipal water supplies. This moderate stress level triggered the requirement for the G-GET Tier 3 Assessment, which further evaluated the sustainability of these municipal water supplies.

Map 24–1: Guelph-Guelph/Eramosa Tier 3 Study Area



24.2 Study Area

The Study Area (**Map 24–2**) was selected to encompass the entire groundwater system that influences the City of Guelph and Guelph/Eramosa Township municipal water supply wells. This area includes the City of Guelph, and portions of the Townships of Puslinch, Guelph/Eramosa and Centre Wellington and the Town of Erin (in Wellington County), the Township of East Garafraxa (in Dufferin County), the City of Cambridge and the Township of Woolwich (in the Region of Waterloo), and the Town of Milton (in Halton Region). The Study Area is bounded to the west by the Grand River, a natural groundwater flow boundary, and to the east by the Niagara Escarpment.

24.3 Groundwater and Surface Water Characterization

The majority of the Study Area (**Map 24–2**) is located within the west central portion of the Grand River watershed. Subwatersheds of the Credit River drain the land to the northeast along the eastern boundary of the Study Area. Subwatersheds of the Halton and Hamilton Conservation Authority jurisdictions are located to the southeast. Surface water features such as rivers, streams, lakes, and wetlands affect shallow groundwater flow and are an important part of understanding groundwater-surface water interactions.

24.3.1 Topography and Surface Water Features

Ground surface topography (**Map 24–3**) varies from a high of approximately 500 metres above sea level (masl) on the crest of the Orangeville Moraine in the north, to a low of approximately 220 masl in the southeast, south of the Niagara Escarpment. The topography is characterized by deep river valleys that have eroded into the landscape, and Quaternary landform features including northeast to southwest trending moraines (Orangeville, Breslau, Paris, Galt, and Moffat), eskers (Guelph, Ariss, and Eramosa), and northwest to southeast trending drumlins.

Immediately surrounding the Rockwood and Hamilton Drive areas of Guelph/Eramosa Township and the City of Guelph are the Speed River, Eramosa River, and Mill Creek subwatersheds. In addition to rivers and creeks, there are several large flood control reservoirs. These include Belwood Lake Reservoir located in the northwest portion of the Study Area, and Guelph Lake Reservoir within the Guelph/Eramosa Township, north of Hamilton Drive and the City of Guelph. In the Halton Region to the southeast, the Mountsberg Reservoir lies south of Highway 401, and in the southern part of the Study Area, the Valens Reservoir lies along the east side of the Grand River watershed boundary. The only natural lake found in the Study Area is Puslinch Lake, a kettle lake found south of Highway 401.

24.3.2 Geology and Hydrogeology

Bedrock Geology

The Paleozoic bedrock stratigraphy consists of sedimentary Silurian aged dolostones, shales, limestones, and associated interbedded sedimentary bedrock formations that dip regionally to the southwest. The uppermost bedrock formations are illustrated on **Map 24–4**. Bedrock outcrops at surface along the river valleys in Elora, Fergus, Rockwood, Eden Mills, and Guelph and in the eastern portion of the Study Area in Flamborough and Acton.

Table 24–1 lists the bedrock formations found in the Study Area from youngest (top) to oldest (bottom), provides a brief description of the bedrock (lithology), and the estimated thicknesses of the bedrock units.

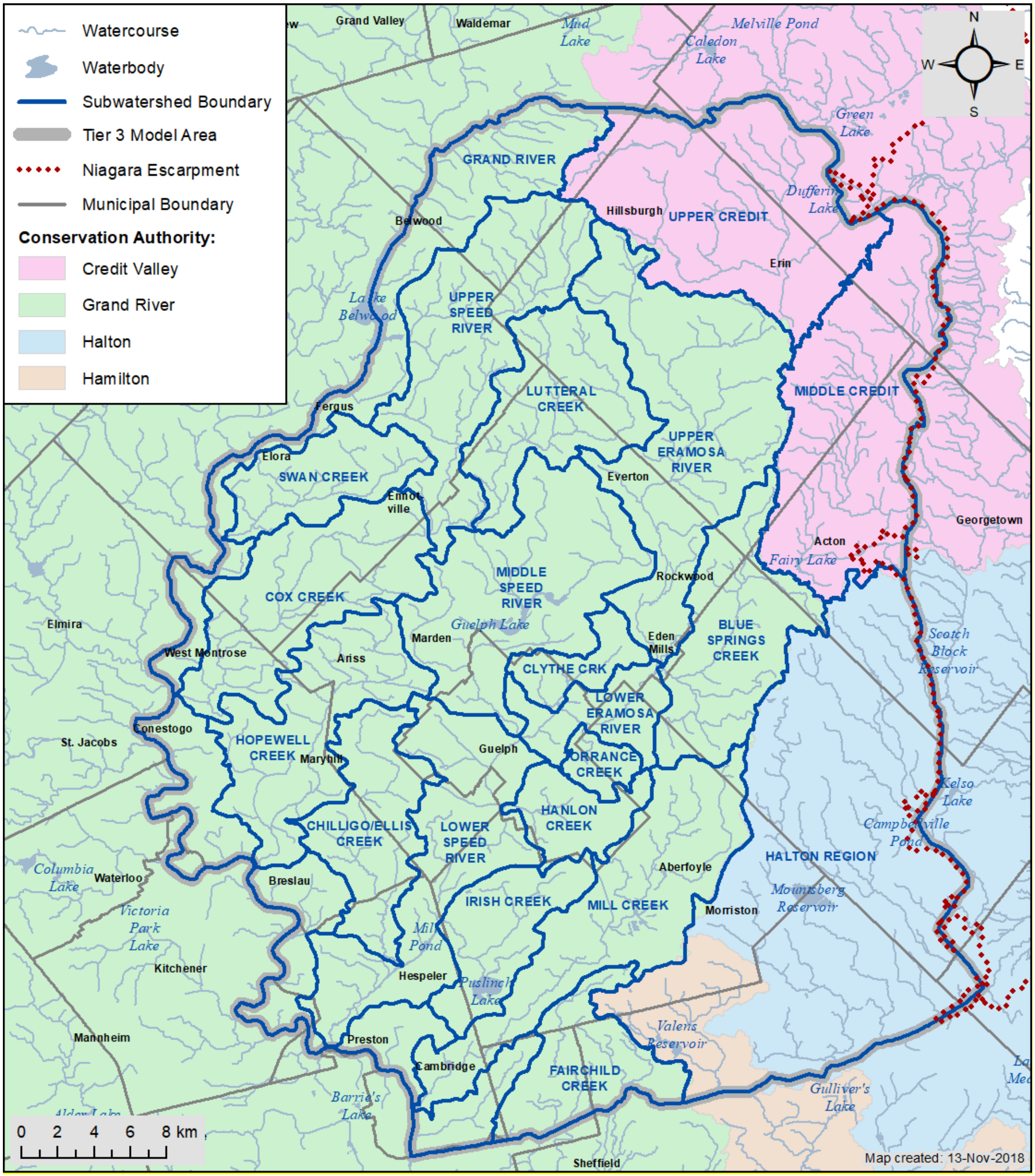
Table 24–1 : Bedrock Formations in the Study Area (Brunton, 2009)

Formation	Member	Lithology Description	Approximate Thickness (m)
Guelph	Hanlon / Wellington	Cream coloured, medium to thick bedded, fossiliferous grainstones, wackestones, and reefal complexes	Up to 62
Eramosa	Stone Road	Cream-coloured, coarsely crystalline dolostone	Up to 62
Eramosa	Reformatory Quarry	Light brown cream, pseudonodular, thick bedded, coarsely crystalline dolostone	5 to 50
Eramosa	Vinemount	Grey black, thinly bedded, fine crystalline dolostone with shaley beds	2 to 10
Goat Island	Ancaster / Niagara Falls	Ancaster-Grey, cherty, fine crystalline dolostone; Niagara Falls-Fine crystalline, cross-laminated crinoidal grainstone with small reef mounds	5 to 40
Gasport	Gothic Hill	Crossbedded crinoidal grainstone packstone with reef mounds and shell beds	25 to 70
Rochester / Irondequoit / Rockway / Merritton Formation	Rochester / Irondequoit / Rockway / Merritton Formation	Rochester Calcareous shale with carbonate interbeds; Irondequoit Thick medium bedded crinoidal limestone; Rockway Fine crystalline argillaceous dolostone with shaley partings; Merritton Fine crystalline dolostone with shaley partings	3 to 5
Cabot Head Formation	Cabot Head Formation	Non-calcareous shale interbedded with sandstone and limestone	10 to 39

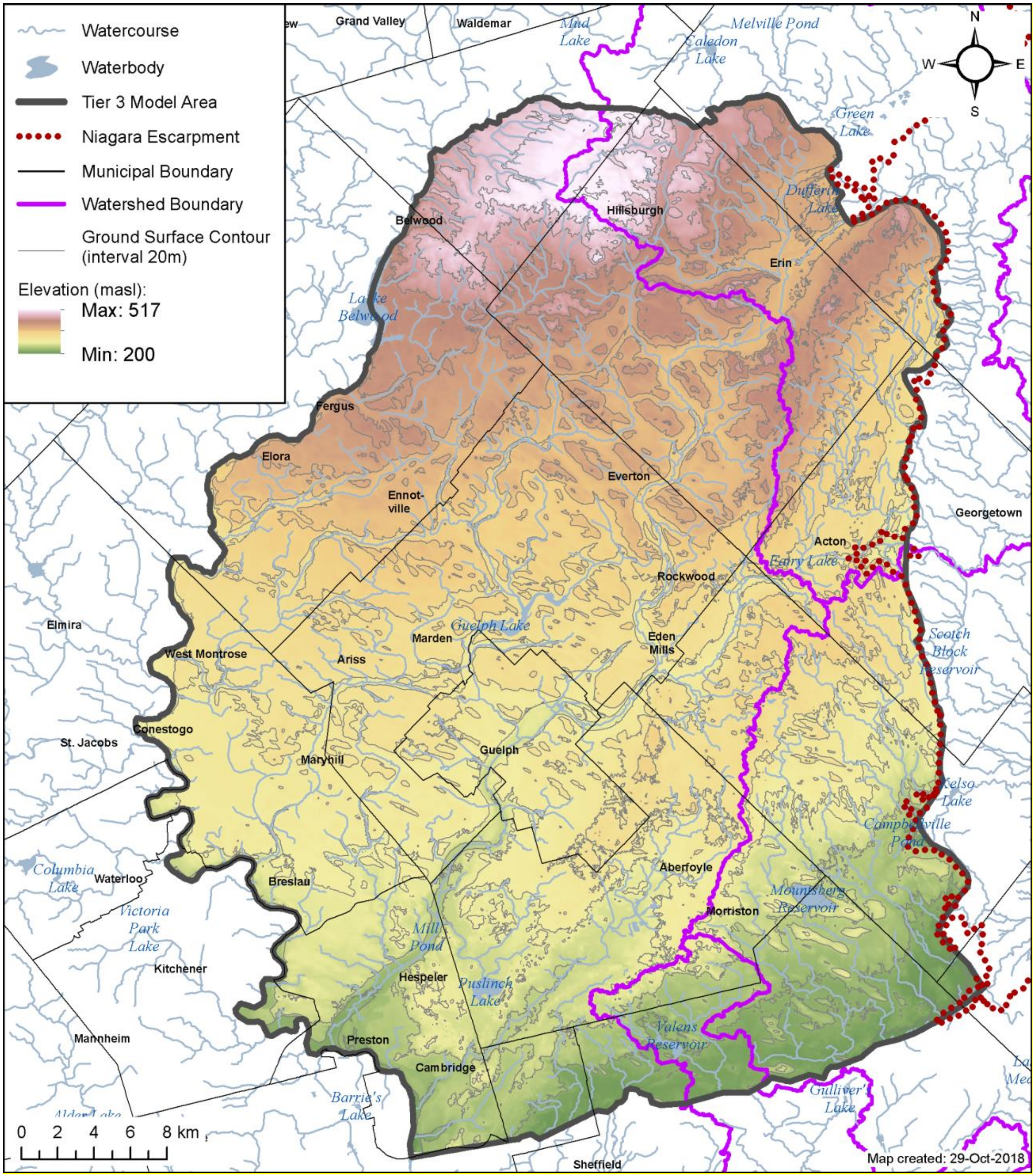
Overall, the bedrock formations described in **Table 24–1** form a thick (40 metres to 100 metres) and extensive aquifer system. The City of Guelph, City of Cambridge, Township of Centre Wellington, and the community of Rockwood in Guelph/Eramosa Township rely on the Gasport and Guelph Formation units for the majority of their potable drinking water supplies.

The Gasport Formation represents the most commonly used aquifer for groundwater supply within the Study Area. The Eramosa Formation overlies the Gasport Formation, and the Vinemount Member in particular consists of mud-rich dolostone beds that act as an aquitard limiting the lateral and vertical flow of water through the unit. The Vinemount Member is extensive and acts as an important aquitard throughout the Study Area although it was interpreted to have been removed by erosion in some areas (e.g., an area near Rockwood, between Blue Springs Creek and the Eramosa River)

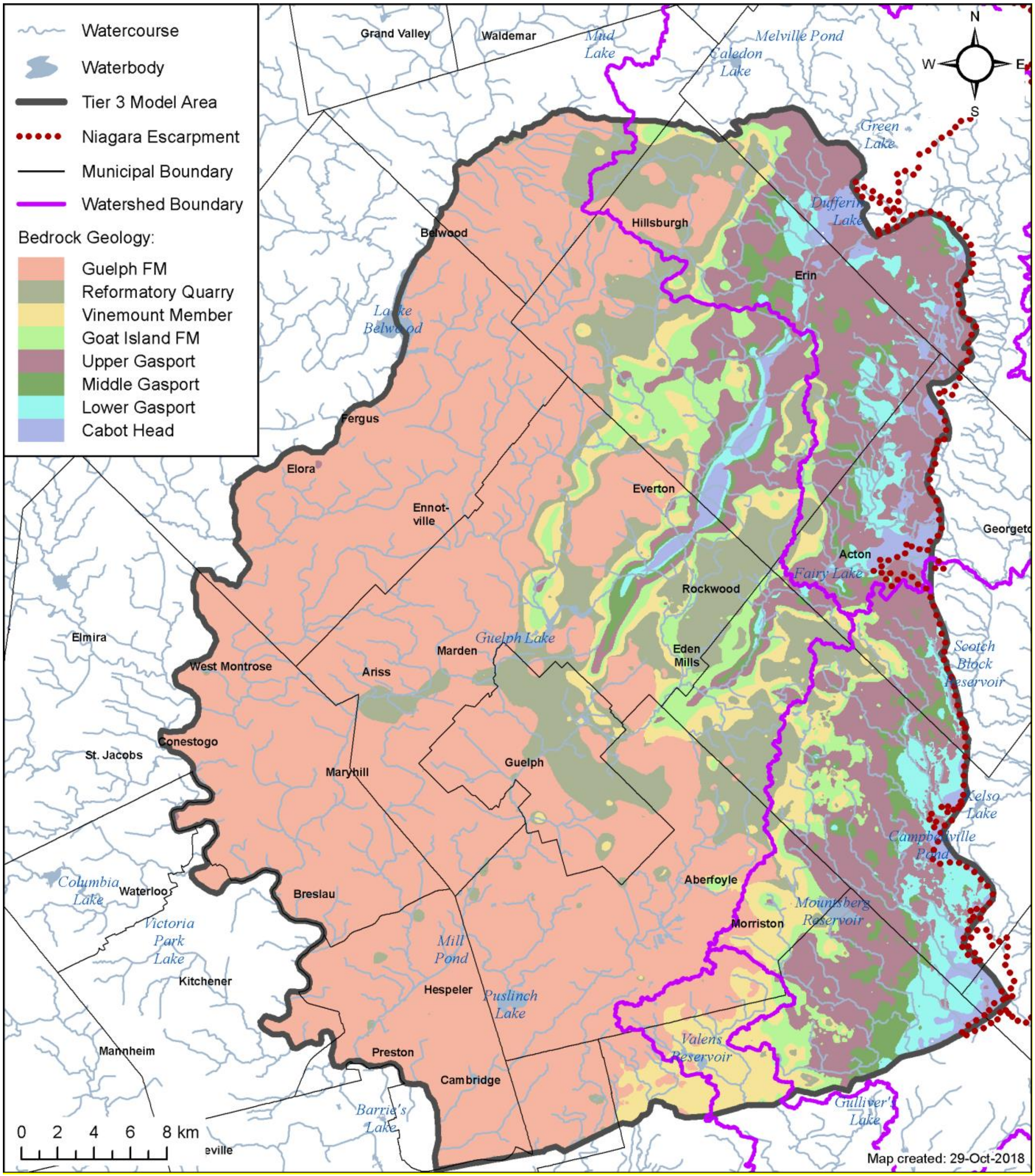
Map 24–2: Surface Water Features



Map 24–3: Ground Surface Topography



Map 24–4: Bedrock Geology



Physiography and Quaternary Geology

The major physiographic regions of the Study Area (**Map 24–5**) include the following:

- **Guelph Drumlin Field**: Located in the west and central area, the Guelph Drumlin Field is characterized by till drumlins fringed by gravel terraces and separated by swampy valleys (Chapman and Putnam, 1984).
- **Horseshoe Moraines:** This region covers the central eastern portion of the Study Area, east of the Guelph Drumlin Field and is characterized by the Galt and Paris moraines and old spillways with broad gravel and sand terraces and swampy floors (Chapman and Putnam, 1984).
- **Flamborough Plain:** The Flamborough Plain encompasses a small area in the southeast. It consists of limestone bedrock with little or no overburden cover and a few drumlins (Chapman and Putnam, 1984). The area is poorly drained and large swampy areas are common.
- **Waterloo Sandhills (Waterloo Moraine)**: The Waterloo Sandhills encompass a small area in the southwest. The surface is composed of well-drained sandy hills, some of them being ridges of sandy till while others are kames or kame moraines, with outwash sands occupying the intervening hollows (Chapman and Putnam, 1984).
- **Hillsburgh Sandhills / Orangeville Moraine:** The Hillsburgh Sandhills are a region of the Orangeville Moraine that are characterized by rough topography and sandy materials. The most elevated region in the area is the Orangeville Moraine, (Hillsburgh Sandhills; Chapman and Putnam, 1984). The surficial geology (**Map 24–5**) was mapped by various individuals including Karrow (1987, 1968) and compiled by the Ontario Geological Survey (2003). Surficial deposits are predominantly a combination of sand and gravel glaciofluvial and ice-contact stratified deposits, and silty to sandy tills that were laid down during glacial advance from the Lake Ontario basin. Overburden thickness ranges from 0 metre, where bedrock outcrops in incised river valleys and along the eastern Study Area boundary, to approximately 80 metre in buried bedrock valleys and on the Orangeville Moraine.

In addition to till units, other landform features such as moraines, eskers, drumlins, and kames are present. The Paris, Galt, Moffat, and Orangeville Moraines are composed primarily of till, but also contain associated ice contact stratified drift, outwash deposits, or a mixture of the three on the flanks of the moraines. Eskers and kames mapped within the area are composed of sand and gravel, and drumlins of the Guelph Drumlin Field are generally composed of tills or a mixture of till and stratified sediment (Barnett, 1992). Glaciofluvial deposits such as the Aberfoyle outwash channel along Mill Creek are composed of sand and gravel and are generally found in low-lying areas on the surfaces of the till plain or bedrock.

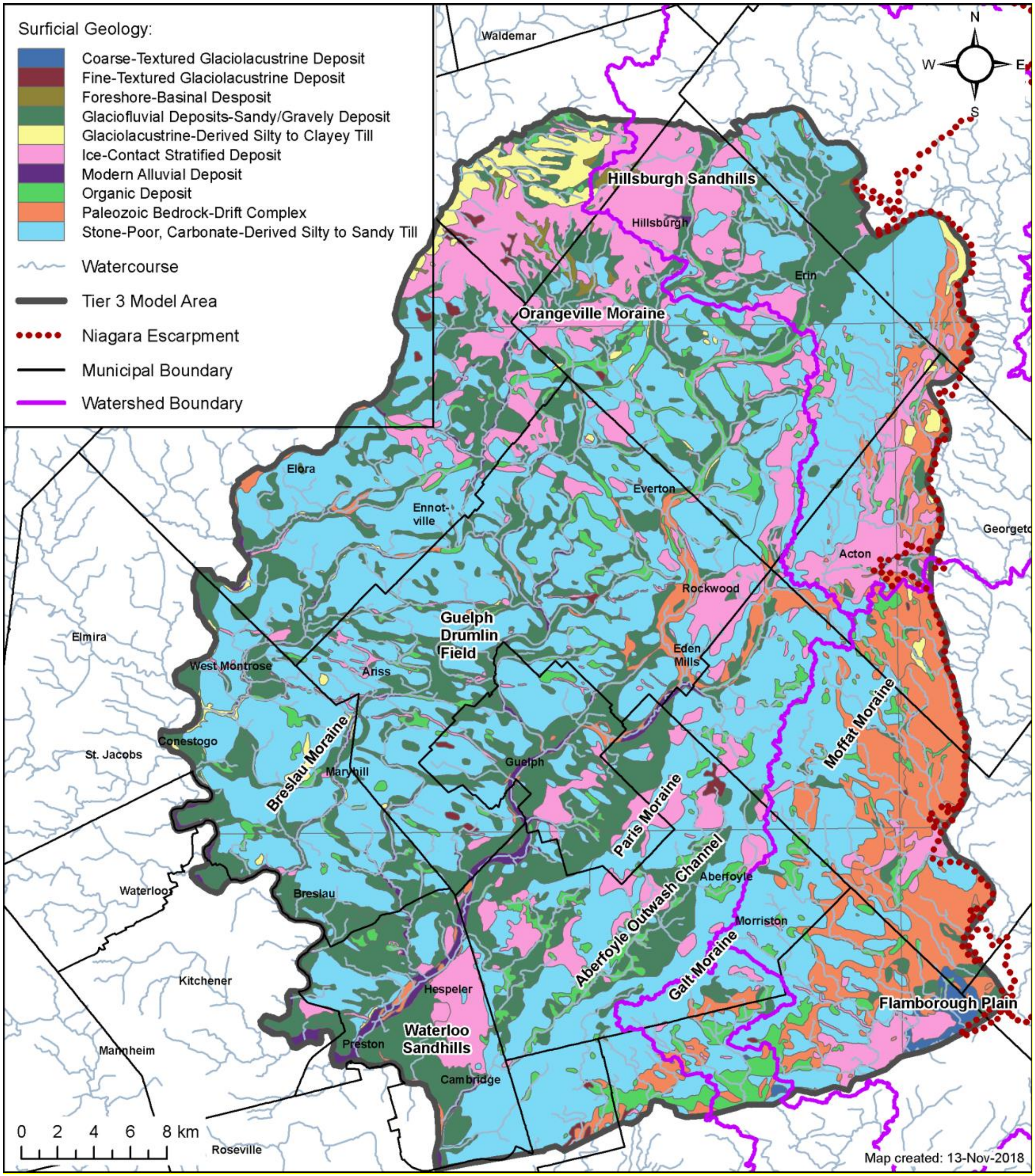
Hydrogeological Conceptual Model

Table 24–2 lists and describes 11 hydrostratigraphic units. These are based on geological units, identified within the Study Area. The G-GET Tier 3 groundwater flow model was developed to reflect these hydrostratigraphic units. While not listed in **Table 24–1** or **Table 24–2**, the Salina Formation (an interbedded dolostone unit with interbeds of shale, gypsum, and anhydrite) is present in the Study Area in the westernmost areas of Cambridge, and inferred to be present in the Breslau area (Golder, 2009). This formation is younger than the Guelph Formation but is not explicitly represented in the conceptual or numerical models due to its limited spatial extent. The Salina Formation was grouped together with the Guelph Formation, as the two units are interpreted to have similar hydrogeologic properties where the unit is present.

Table 24–2 Hydrostratigraphic Units in the Study Area

Hydrostratigraphic Unit	Geological Description	Specific Geologic Units
Upper Sand and Gravel Aquifer (Overburden A)	Outwash sand and gravel deposits and glacial tills	Coarse sand and gravel, Wentworth Till, Port Stanley Till, Fine-grained Sediments
Lower Till Aquitard (Overburden B)	Glacial tills (dense, sandy, silty) occasionally interbedded with discontinuous lenses of coarse sands/gravels	Wentworth Till, Port Stanley Till, Catfish Creek Till
Contact Zone Aquifer	Fractured bedrock and overlying basal unconsolidated deposits	Coarse, granular deposits overlying weathered bedrock
Bedrock Aquifer	Medium to thick bedded fossiliferous dolostone	Guelph Formation (incl. Eramosa Formation - Stone Road Member)
Bedrock Aquifer/Aquitard	Thickly bedded, coarsely crystalline dolostone	Eramosa Formation - Reformatory Quarry Member
Bedrock Aquitard	Thinly, shaley bedded, fine crystalline dolostone	Eramosa Formation - Vinemount Member
Bedrock Aquifer/Aquitard	Chert-rich, fine crystalline dolostone and cross-laminated crinoidal grainstone	Goat Island Formation
Bedrock Aquifer	Cross-bedded grainstone-packstone with sequences of reef mound and coquina lithofacies	Upper Gasport Formation
Bedrock Aquifer (High Permeability)	Cross-bedded grainstone-packstone with sequences of reef mound and coquina lithofacies; Highly transmissive with secondary porosity (cavities, vugs, fractures)	Middle Gasport Formation
Bedrock Aquifer	Cross-bedded grainstone-packstone with sequences of reef mound and coquina lithofacies	Lower Gasport Formation
Bedrock Aquitard	Shale interbedded with sandstone and limestone	Cabot Head Formation

Map 24–5: Physiography and Surficial Geology



24.3.3 Groundwater and Surface Water Interactions

Interaction between surface water and groundwater are generalized as follows:

- Precipitation infiltrates through shallow unsaturated soil, recharging the underlying aquifers.
- Surface water bodies and wetlands gain water from the discharging of shallow and deep groundwater.
- Surface water bodies and wetlands lose water to the underlying groundwater flow system by outflow.

The following sections describe the hydrological and ecological system characterization completed to support the assessment of groundwater and surface water interactions.

Groundwater Recharge

Groundwater recharge is a hydrologic process where water moves downward from the ground surface to the underlying groundwater flow system. This process usually occurs in the unsaturated zone below plant roots. Recharge is the remaining portion of precipitation left over after the subtraction of water returned to the atmosphere by evapotranspiration or transferred to stream channels by overland flow and interflow (above the groundwater system). The amount of groundwater recharge is influenced by the permeability of the ground surface; land use or vegetation; the depth, hydraulic conductivity and soil water storage characteristics of surficial overburden layers; and slope of the topography (if extremely steep).

Recharge for the Study Area was estimated using three surface water models for the three watershed areas present within the Study Area (i.e. the Grand River watershed, Credit River watershed, and watersheds under the jurisdiction of the Halton and Hamilton Conservation Authorities). Estimated recharge rates ranged from a low of 0 millimetres per year where groundwater discharges to some wetlands, to a high of 533 millimetres per year on hummocky regions associated with the Paris and Galt moraines that are underlain by sand and gravel.

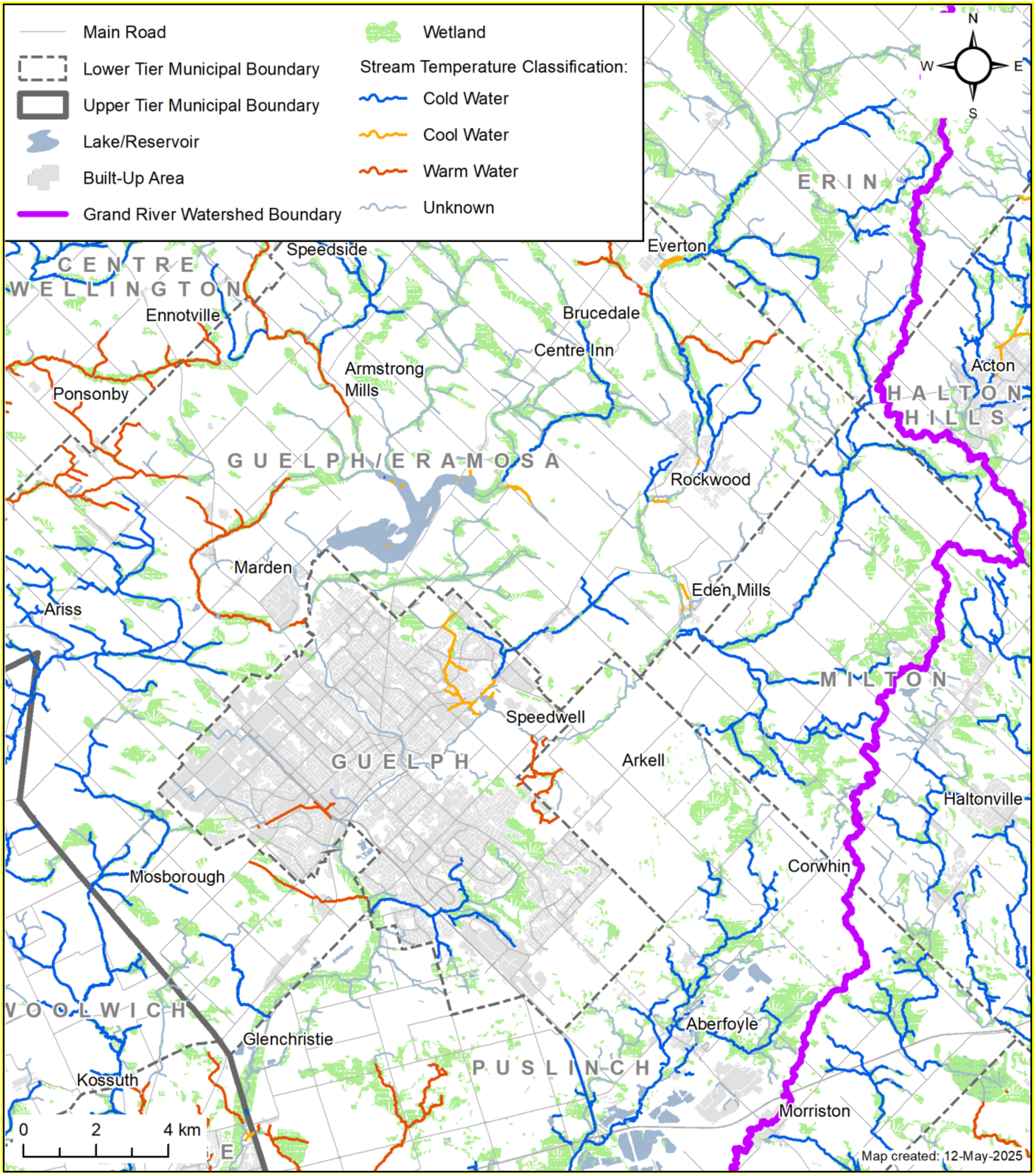
Groundwater Discharge and Ecological Resources

Groundwater discharge is important to sustaining coldwater and cool water fisheries as the upwelling areas are critical for fisheries spawning and maintaining a moderate temperature and flow in creeks and streams. Cold water fisheries have been mapped by the province (MNR, 2013) and Grand River Conservation Authority (GRCA; GRCA, 2013) in several stream reaches within the Study Area, particularly in the headwaters of the Grand River (**Map 24–6**). Coldwater fish communities are mapped in all or parts of: the Eramosa River, Blue Springs Creek, Clythe Creek, Hanlon Creek, Speed River, Ellis Creek, Mill Creek, and Hopewell Creek. Due to the presence of online ponds, some of the stream designations have changed from coldwater streams, to cool- or warm-water designations.

Provincially Significant Wetlands (PSWs) are identified by the province and mapped by a science-based ranking system. PSWs within the City of Guelph include Hanlon Creek

Swamp, Torrance Creek Swamp, Clythe Creek wetland, and Guelph-Northeast Complex. The latter is east of Hamilton Drive and extends into the Guelph/Eramosa Township. PSWs within the Eramosa River subwatershed include the Eramosa/Blue Springs Creek wetland (lying mostly in the Guelph/Eramosa Township south of Rockwood), Knatchbull wetland, Arkell-Corwhin wetland, Torrance Creek/Hamilton Corners wetland and Clythe Creek wetland. PSWs within the Speed River subwatershed include Hanlon Creek swamp and Halls Pond wetland. PSWs within the Mill Creek subwatershed include Mill Creek wetland and Arkell-Corwhin bog.

Map 24–6: Stream Classifications and Wetlands



24.3.4 Tier 3 Field Programs

Climate and Surface Water Monitoring

Climate and surface water monitoring was conducted at numerous locations within the Study Area. The Meteorological Service of Canada and the GRCA maintain climate stations, while the Water Survey of Canada and GRCA record streamflow at surface water flow monitoring stations.

A baseflow monitoring program was completed as part of the G-GET Tier 3 Assessment (Matrix, 2017) to supplement streamflow data collected by the Water Survey of Canada and GRCA. Baseflow is defined as the portion of streamflow that is derived from groundwater discharge. The purpose of the baseflow monitoring program was to provide estimates of groundwater discharge to enhance the understanding of the groundwater and surface water interaction, and to support the calibration of the groundwater flow model. Surface water flow measurements were collected at 32 locations along various streams and rivers. Flow measurements were scheduled following a minimum of four consecutive days without observed precipitation to minimize the proportion of runoff in streamflow. Baseflow was estimated using the “velocity-area” method utilizing an impeller or electromagnetic flow meter and measuring cross-sectional stream areas, and “timed volume flow method” utilizing a bucket and stopwatch. Concurrent with the baseflow measurements, surface water quality measurements such as pH, conductivity, and temperature were collected to provide a snapshot of water quality conditions.

Hydrogeologic Field Program

In addition to the City of Guelph’s ongoing groundwater monitoring program, an advanced hydrogeologic drilling and monitoring program was carried out as part of the G-GET Tier 3 Assessment. The purpose of the subsurface monitoring program was to obtain high-quality geologic and hydrogeologic information and to establish a network of deep monitoring wells outside the Guelph city limits. Eleven deep boreholes were drilled, logged, and investigated using geophysical methods to provide a complete stratigraphic profile from ground surface to the Cabot Head Formation. Hydraulic testing of the boreholes was completed utilizing packer tests, short term pumping tests, and FLUTe hydraulic conductivity profiling. Once borehole testing was completed, multi-level monitoring wells were installed at the 11 sites.

Water levels were monitored in all wells using a combination of automated data logging pressure transducers and manual measurements.

Water quality samples were collected in the field from four of the multi-level wells and analyzed for dissolved metals, nutrients, anions, and dissolved organic carbon.

In addition to ongoing monitoring and the Tier 3 Assessment monitoring program, aquifer response tests were carried out as part of hydrogeological investigations to support the ongoing management of municipal groundwater resources.

24.3.5 Land Use and Land Use Change

The Technical Rules (MOECC, 2016) identify reductions in groundwater recharge as potential Water Quantity Threats. The G-GET Tier 3 Assessment considered the impact of existing and future land development (as defined in the Official Plans) on groundwater recharge and municipal water sources. The assessment of the impact arising from land use development reflected changes in imperviousness (i.e., paved surfaces, such as roads and parking lots) but did not include an assessment of low impact development or other measures that may act to enhance groundwater recharge.

Existing land use representative of conditions in 2008 was determined using land use mapping provided by the Guelph/Eramosa Township, the City of Guelph, Region of Waterloo (for the Cambridge area), and by various municipalities for the surrounding rural areas. Satellite imagery from 2007 and 2008 was examined to confirm that planned development lands were not already developed in 2008.

Future land use to the year 2031 was mapped to reflect the 2013 Official Plan Amendment (OPA 81) for the County of Wellington, the 2012 Official Plan Amendment (OPA 48) for the City of Guelph, and the adjacent municipalities.

Future recharge reductions were identified by highlighting areas where land use is forecasted to change from those designated in the current land use and those designated on the Official Plans. The change in imperviousness from the current to the future land use type was estimated based on typical impervious values for land use classifications.

24.3.6 Water Demand

With some exceptions such as firefighting and livestock watering, any persons or organizations withdrawing water at a rate greater than 50,000 litres per day must apply for, and be granted, a Permit to Take Water (PTTW) from the Ministry of Environment, Conservation and Parks. This includes water takings permitted for municipal supply purposes, such as water obtained by the City of Guelph and Guelph/Eramosa Township 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.

Municipal Water Supply Systems

City of Guelph

The City of Guelph relies mainly on groundwater for its municipal supply demands; it obtains its water from 23 municipal wells and the Arkell Infiltration Gallery (hereinafter referred to as the Glen Collector) which is a shallow infiltration gallery (**Table 24–3** and **Map 24–1**). Not all of the wells are currently in use due to a lack of demand or water quality concerns. All of these wells, with the exception of the Edinburgh well, were used in the Tier 3 Assessment to meet future demands.

Table 24–3 City of Guelph Water Supply Wells (2013)

Quadrant	Well Name	Easting (NAD83)	Northing (NAD83)	Depth (m)	Formation Screened	Permitted Rate[1] (m^3/day)
Southeast	Glen Collector	N/A	N/A	N/A	Overburden	25,000
Southeast	Arkell 1	567944	4822434	20.1	Overburden/ Contact Zone	3,273
Southeast	Arkell 14	568096	4823126	40.5	Upper to Middle Gasport	9,504[3]
Southeast	Arkell 15	567440	4822878	30.5	Upper to Lower Gasport	9,504[3]
Southeast	Arkell 6	567934	4823061	41.2	Upper to Middle Gasport	9,504[3]
Southeast	Arkell 7	567993	4822436	43.3	Upper to Middle Gasport	9,504[3]
Southeast	Arkell 8	568055	4822971	42.1	Upper to Middle Gasport	9,504[3]
Southeast	Burke	565157	4818701	79.6	Guelph to Middle Gasport	6,546
Southeast	Carter Wells	564870	4820808	20.7	Guelph	6,547
Southwest	Dean Ave.	560997	4819805	57.2	Upper to Middle Gasport	2,300
Southwest	Downey Rd.	561798	4817015	73.8	Upper to Middle Gasport	5,237
Southwest	Edinburgh[2]	560594	4820066	69.5	Upper to Middle Gasport	3,000
Southwest	Membro	560293	4819861	73.2	Upper to Middle Gasport	6,050
Southwest	University	561613	4819168	64.3	Upper Gasport	3,300
Southwest	Water Street	560773	4820356	60.0	Upper to Middle Gasport	3,400
Northeast	Clythe Creek[2]	564031	4823927	58.9	Reformatory Quarry to Lower Gasport	5,237
Northeast	Emma	559931	4823351	46.0	Upper to Middle Gasport	3,100
Northeast	Helmar	560357	4825777	79.6	Upper to Middle Gasport	3,273
Northeast	Park 1 and 2	560430	4823231	57.0	Upper to Middle Gasport	10,300
Northwest	Paisley	558126	4819636	80.2	Upper to Middle Gasport	3,200
Northwest	Calico	554602	4819900	64.0	Upper Gasport	5,237
Northwest	Queensdale	558482	4818297	74.4	Guelph to Upper Gasport	5,237
Northwest	Sacco[2]	556416	4821929	95.7	Guelph to Middle Gasport	1,640
Northwest	Smallfield[2]	556748	4820866	102.1	Guelph to Lower Gasport	1,964

Notes: [1]Effective as of 2013
[2]Not operating at the time of this assessment
[3]Each well is individually permitted up to 9,504 m^3/day; however, the combined permitted rate is 28,800 m^3/day

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. The Eramosa River intake is allowed to operate between April 15 and November 15 of each year according to the conditions of its PTTW.

Guelph/Eramosa Township

The residents of Rockwood and Hamilton Drive rely entirely on the groundwater wells listed in **Table 24–4** for their potable water supplies. At the time of this assessment, there were three existing bedrock wells in Rockwood. A fourth bedrock well, not included in the G-GET Tier 3 Assessment, was added to the water supply system in 2020. 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.

Table 24–4 Rockwood and Hamilton Drive Water Supply Wells

Location	Well Name	Easting (NAD83)	Northing (NAD83)	Formation Screened	Permitted Rate (m^3/day)[1]
Rockwood	Rockwood Wells 1 & 2	568785	4830026	Middle Gasport	1,965
Rockwood	Rockwood Well 3	569833	4828156	Middle Gasport	1,310
Rockwood	Rockwood Well 4	570671	4829240	Upper to Middle Gasport	1,310
Hamilton Drive	Cross Creek	558038	4825840	Upper to Middle Gasport	812
Hamilton Drive	Huntington	558405	4826512	Upper to Middle Gasport	916

Notes: [1]Permitted Rates are from 2008 to 2015.

Other Municipalities

The study area includes additional municipal water supply wells not directly evaluated in the G-GET Tier 3 Assessment (**Map 24–7**). Adjacent municipalities that use groundwater for supply include the Township of Woolwich (Maryhill), Township of Centre Wellington (Fergus/Elora), Town of Erin (Hillsburgh/Erin), Township of Halton Hills (Acton), and City of Cambridge. In addition, there are a number of communal water supplies in the area including Mini-Lakes, Irish Creek Estates, McClintock's Trailer Park, and Mill Creek Camping and Country Club.

Halton Region operates municipal wells within the Credit River watershed; these wells were evaluated within the Halton Hills Tier 3 Assessment (AECOM and AquaResource, 2014). The Region of Waterloo operates municipal drinking water wells within the City of

Cambridge, and these wells were studied as part of the Region of Waterloo Tier 3 Assessment (Matrix and SSPA, 2014).

Municipal Water Demand

As part of the Tier 3 Assessment, current and future quantities of water were estimated for each existing and planned groundwater well or intake. The current (or existing) demand was estimated as the average annual pumping during 2008 for the City of Guelph and during 2009 to 2010 for Rockwood and Hamilton Drive in Guelph/Eramosa Township.

Existing Water Demand – City of Guelph

The existing water demand for the City of Guelph in this Tier 3 Assessment was represented as the average annual pumping rates from the 2008 calendar year, approximately 47,700 metres cubed (m^3) per day (**Table 24–5**). This compares to a maximum total permitted amount of approximately 132,600 m^3 per day. The sustainable capacity of the system, as evaluated by the Water Supply Master Plan (Earth Tech et al., 2006) and the City of Guelph Water Services Division, is approximately 89,900 m^3 per day (**Table 24–5**). Maximum daily demands can be much higher than average daily demands due to outdoor water use, industrial use, or other municipal water uses. The estimated sustainable capacity may be affected by climatic conditions (i.e., drought), well interference, and well efficiency such that the total capacity may not be always available.

Table 24–5 City of Guelph Municipal Water Demand

Well Name	Rates (m^3/day)				
	Existing Demand (Average 2008)	Max. Permitted Pumping	Estimated Capacity[1]	Future Demand (2031)	
				Avg Annual Conditions	Drought Conditions
Arkell 1	730	3,273	2,000	1,400	1,400
Arkell 14	0	28,800[3]	28,800	3,300	4,400
Arkell 15	0			3,300	4,400
Arkell 6	3,774			4,900	5,300
Arkell 7	3,689			4,900	5,300
Arkell 8	3,694			4,900	4,900
Burke	5,385	6,546	6,500	6,000	6,300
Calico	748	5,237	1,100	1,100	1,100
Carter Wells	2,004	6,547	5,500	4,000	4,400
Clythe Creek	0	5,237	3,000[2]	2,200	2,200
Dean Ave.	1,215	2,300	1,500	1,500	1,500
Downey Rd.	3,940	5,237	5,100	5,100	5,200
Edinburgh[4]	0	3,000	0	0	0
Emma	2,273	3,100	2,800	2,100	2,400
Helmar	500	3,273	1,500	1,100	1,200
Membro	3,036	6,050	6,000	4,200	4,300
Paisley	762	3,200	1,400	800	1,000
Park 1 & 2	5,897	10,300	8,000	6,400	6,900
Queensdale	702	5,237	2,000	2,000	2,000
Sacco	0	1,640	1,150[2]	1,150	1,150
Smallfield	0	1,964	1,400[2]	1,400	1,400
University	1,648	3,300	2,500	2,500	2,500
Water Street	1,184	3,400	2,700	2,300	2,400
Total (Wells)	**41,181**	**107,641**	**82,950**	**66,550**	**71,550**
Glen Collector	6,500	25,000	6,900	6,900	1,892
Total	**47,681**	**132,641**	**89,850**	**73,450**	**73,442**

Notes: [1] Estimated Sustainable Rates from Water Supply Master Plan (Earth Tech, et al. 2006), up to the maximum permitted rate

[2] Sustainable Rate estimated by City of Guelph Water Services Division
[3] Each well is individually permitted up to 9,504 metres cubed (m^3) per day; however, the combined permitted rate is 28,800 m^3 per day.
[4] The City of Guelph is not planning to use Edinburgh due to water quality concerns.

Future Rates - City of Guelph

Two different sets of future rates were developed for individual wells and the Glen Collector to accommodate the following:

1) Future rates under average annual conditions, and

2) Future rates under low water (drought) conditions.

Table 24–5 summarizes the future rates under average annual and drought conditions for each well and the Glen Collector. Matrix (2017) described the methods used to establish the rates for each well.

The sum of the future rates for the City of Guelph's drinking water system is 73,450 cubic metres per day.

A second set of future rates under drought conditions were required to compensate for a decrease in discharge from the Glen Collector during low water periods. During drought conditions, the City may have to pump less from the Eramosa intake resulting in a lower yield from the Glen Collector. The total future demand for the water supply system under drought conditions is 73,442 metres cubed per day.

The estimates of future demand under average and drought conditions (**Table 24–5**) represent the average-day demands and are less than the estimated capacity of the total system (89,850 m^3 per day) and maximum permitted taking (132,641 m^3 per day). Maximum-day water demands (due to increased outdoor water use, industrial use, or other municipal water uses) may be 34% higher (i.e., peaking factor of 1.34) than the estimated average-day water demand amount, according to projections in the City of Guelph's Water Conservation and Efficiency Strategy Update (RMSi, 2009). It is important to consider these short-term extremes in pumping when assessing a well's ability to accommodate additional demand.

Water Demand - Rockwood and Hamilton Drive

Existing municipal demand for the Rockwood and Hamilton Drive wells was calculated based on the average demand from 2009 and 2010 for each municipal well (except Rockwood Well 4, which had not yet started production) (**Table 24–6**).

Table 24–6 Guelph/Eramosa Township (Rockwood and Hamilton Drive) Municipal Water Demand

Location	Municipal Well	Aquifer	Rates (m^3/day)		
			Maximum Permitted	Existing Demand (Avgerage 2009 to 2010)	Future Rate (Avgerage and Drought)
Rockwood	Rockwood Well 1	Middle Gasport	1,965	283	396
Rockwood	Rockwood Well 2	Middle Gasport	1,965	262	367
Rockwood	Rockwood Well 3	Upper to Middle Gasport	1,310	422	572
Rockwood	Rockwood Well 4	Upper to Middle Gasport	1,310	N/A	572
Hamilton Drive	Cross Creek	Upper to Middle Gasport	812	87	90
Hamilton Drive	Huntington	Upper to Middle Gasport	916	92	95
Total			6,313	1,146	2,092

N/A - rate not available. Rockwood Well 4 was not yet in operation.

The future rates estimated for Hamilton Drive were determined from a water use study completed for the Guelph/Eramosa Township which forecast demand until the year 2020 (Watson and Associates Economists Ltd., 2011). The future rates estimated for Rockwood were determined using water use forecasts that would be required to reach the build-out of Rockwood in 2026 (Burnside, 2013).

Table 24–6 summarizes the final set of future rates for each well in Rockwood and Hamilton Drive. These rates were used for both average and drought conditions in the Risk Assessment scenarios. In Rockwood, the future rate was estimated to be 1,907 m^3 per day, whereas that for Hamilton Drive was estimated to be 185 m^3 per day. For both systems, the total future rate is less than the total permitted rate.

Non-Municipal Water Demand

In addition to municipal water takers, there are also a number of large non-municipal permitted water takers within the Study Area (**Map 24–7**). Groundwater takings are typically 100% consumptive (i.e., consumptive factor of 1), since it is seldom returned to the groundwater system, but rather discharged to surface water systems. Other water uses, such as for irrigation, have a consumptive factor less than 1, where some water would percolate beneath the evaporative root zone and return to the groundwater system.

Table 24–7 summarizes the permitted rates and estimated consumptive demands by water use sector for the whole Study Area. The maximum permitted use totals

351,032 m^3 per day while the estimated consumptive water demand for the Study Area is 63,092 m^3 per day.

Table 24–7 Summary of Permitted Rates and Consumptive Demands by Water Use Sector for Study Area (2008)

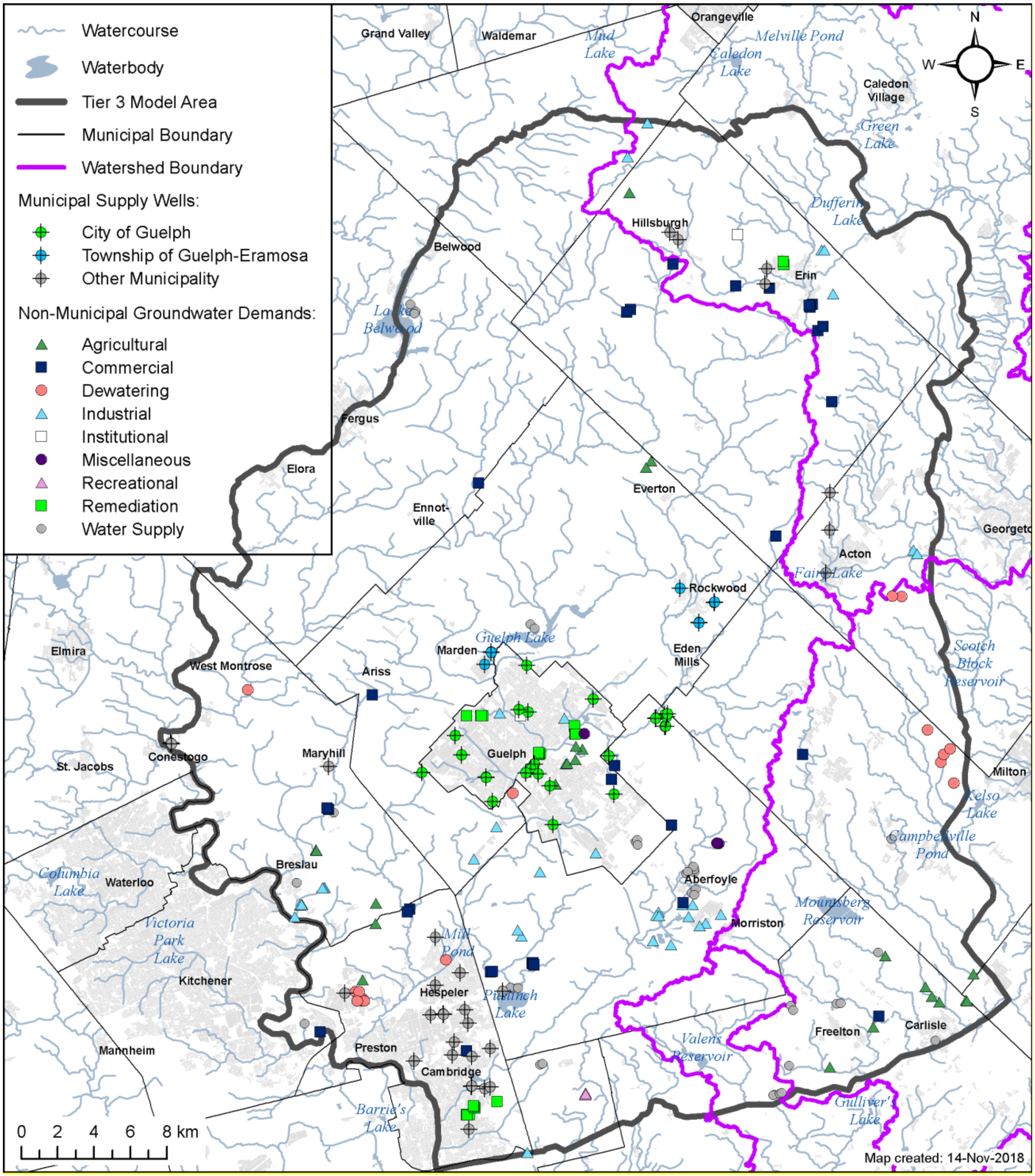
Specific Purpose	Maximum Permitted (m^3/day)	Percentage of Total Permitted Takings	Consumptive Demand (m^3/day)	Difference (Maximum Permitted minus Consumptive) (m^3/day)
Pits and Quarries	191,710	52%	20,356	171,353
Aggregate Washing	82,716	22%	3,124	79,592
Aquaculture	16,564	5%	15,072	1,492
Golf Course Irrigation	17,913	5%	3,068	14,845
Communal	10,893	3%	5,512	5,381
Other - Industrial	10,246	3%	4,472	5,774
Other - Agricultural	5,894	2%	610	5,284
Field and Pasture Crops	5,475	1%	415	5,060
Bottled Water	5,057	1%	3,093	1,964
Sod Farm	4,696	1%	239	4,457
Groundwater	2,183	1%	1,853	330
Other - Water Supply	2,178	1%	267	1,911
Fish Ponds	1,962	<1%	2	1,960
Campgrounds	1,785	<1%	448	1,337
Food Processing	1,760	<1%	311	1,449
Other - Remediation	1,483	<1%	960	523
Mall / Business	1,316	<1%	1,316	0
Other - Dewatering	899	<1%	213	686
Heat Pumps	885	<1%	821	64
Nursery	328	<1%	46	282
Brewing and Soft Drinks	553	<1%	0	553
Manufacturing	529	<1%	529	0
Other - Institutional	137	<1%	137	0
Cooling Water	110	<1%	53	57
Construction	100	<1%	8	92
Schools	100	<1%	83	17
Other - Commercial	64	<1%	52	12
Irrigation	60	<1%	32	28

Specific Purpose	Maximum Permitted (m^3/day)	Percentage of Total Permitted Takings	Consumptive Demand (m^3/day)	Difference (Maximum Permitted minus Consumptive) (m^3/day)
Total	351,032	100%	63,092	303,011

Note: Permits were current as of 2008 and obtained from the *Permit to Take Water Database* (MOE, 2008)

Matrix (2017) provides additional details for each of the permits, as well as the methods used to represent the non-municipal water takings in the models.

Map 24–7: Municipal and Non-Municipal Groundwater Demands in the G-GET Study Area



24.4 Risk Assessment

24.4.1 Model Development

As part of the Tier 3 Assessment, surface water and groundwater modelling tools were developed to help assess the sustainability of the municipal water sources. The models were developed based on a detailed characterization of the groundwater and surface water systems, and they were refined around wells to a level supported by available data. The models were calibrated to represent typical operating conditions under average (steady-state) and variable (transient) pumping conditions.

Surface Water Flow Model

The Grand River Tier 3 surface water model simulates runoff, recharge, evapotranspiration, and streamflow across the Grand River watershed. The model was built using the GAWSER (Guelph All-Weather Sequential-Events Runoff) code and was adapted for continuous hydrological simulation and applied to estimate groundwater recharge rates across the Grand River watershed. This continuous model was previously applied by the GRCA as part of the Grand River Tier 2 Water Budget (AquaResource, 2009a) and Subwatershed Stress Assessment (AquaResource, 2009b).

The GAWSER model was refined within the G-GET Tier 3 Assessment Study Area (Matrix, 2017) to better represent current land use and groundwater recharge rates, and to improve the simulated streamflow in the Eramosa River (supplying the City of Guelph's surface water intake). The GAWSER model refinements focused on improving the calibration of the Mill Creek subwatershed, Upper Speed River watershed, Eramosa River watershed, and Blue Springs Creek subwatershed. The land areas associated with these drainage areas represent a large proportion of the Study Area and are key groundwater recharge areas associated with the municipal drinking water supplies. The results suggested the average and transient groundwater recharge rates estimated by the GAWSER model are reasonable over the long-term and suitable for use in the Tier 3 Assessment.

Groundwater Flow Model

To assess the potential impacts of increased municipal groundwater demands on other water uses, a detailed conceptual model of the geologic, hydrogeologic, and hydrologic systems was developed with particular focus on the areas surrounding municipal well fields. A FEFLOW (Diersch, 2006) groundwater model was constructed to represent the interaction between the groundwater system and the surface water system.

Model calibration is a process whereby model parameters are adjusted within physically acceptable limits until the model simulations reflect actual measured conditions. The groundwater model was calibrated to long-term steady-state conditions and to transient conditions that included the simulation of a long-term pumping test (City of Guelph) and shorter-term tests (Rockwood and Aberfoyle). The groundwater flow model was calibrated to water level measurements from MECP domestic water wells records, City of Guelph and Guelph/Eramosa Township high-quality monitoring wells, and other high-quality wells that are part of other studies. The model was also calibrated to low streamflow targets estimated from baseflow observations and streamflow gauge data collected by the GRCA, Water Survey of Canada, and others at locations spread throughout the Study Area.

Additional information on the surface water and groundwater flow model development and calibration is provided in Matrix (2017).

24.4.2 Risk Assessment Results

The groundwater flow model was used to delineate Water Quantity Wellhead Protection Areas (WHPA-Q) and a Water Quantity Intake Protection Zone (IPZ-Q). These areas were delineated where the quantity of water available to municipal drinking water systems could be affected by other existing, new, or expanded water takings. Four WHPA-Qs were delineated surrounding the municipal wells for G-GET (**Map 24–8**) and one IPZ-Q was delineated as the upstream contributing area for the Eramosa intake (**Map 24–9**).

A set of Risk Assessment scenarios were developed to represent the municipal future rates and current and future land uses (as defined by the Official Plans). The calibrated groundwater flow model was used to estimate both the changes in water levels (drawdown) in the municipal supply aquifer and the impacts to groundwater discharge and baseflow under average and drought climate conditions.

The Queensdale Well was predicted to be unable to pump at its future rate during average climate and drought conditions. As a result, the WHPA-Q that encompasses the Queensdale Well (WHPA-Q-A; **Map 24–8**) was assigned a significant risk level. As the IPZ-Q and WHPA-Q-A are interconnected through the Glen Collector and the artificial recharge system that is supplied by the Eramosa River Intake, the IPZ-Q was also assigned a significant risk level.

Simulated groundwater discharge reductions were examined for the average climate and increased demand scenario. There are six locations where baseflow is simulated to be reduced by 10 percent or more:

- Torrance Creek - 41 percent
- Chilligo/Ellis Creek at Wellington Road 32 - 32 percent
- Hanlon Creek South Tributary at Highway 6 - 31 percent
- Blue Springs Creek South Branch at 28th Side Road - 27 percent
- Hanlon Creek at Waterfowl Park - 19 percent
- Hanlon Creek at Highway 6 - 11 percent

As Chilligo/Ellis Creek, Blue Spring Creek, and Hanlon Creek are classified as coldwater streams and have simulated baseflow reductions of 10 percent or more, a Water Quantity Risk Level classification of moderate should have been assigned to the WHPA-Q-A. However, due to the Queensdale Well's inability to pump at its future rate, a Risk Level of significant had already been assigned.

The Technical Rules (MOECC, 2016) state that an uncertainty assessment on the assignment of a risk level to the WHPA-Q and IPZ-Q is required. If a WHPA-Q or IPZ-Q is assigned a risk level of moderate based on the scenarios assessed, it should then be adjusted to a significant risk level if the uncertainty analysis characterizes the uncertainty as high and a sensitivity analysis suggests that the risk level of the WHPA-Q or IPZ-Q could be significant. As WHPA-Q-A and the IPZ-Q were already assigned the highest possible risk level (i.e., significant) based on predicted exceedance of the drawdown threshold at the Queensdale Well, an uncertainty analysis on predicted impacts to coldwater streams or PSWs could not increase the risk level any higher. However, an uncertainty analysis was still carried out to guide future efforts on increasing the certainty of model predictions.

The uncertainty with respect to the impacts on discharge to cold water streams and PSWs was found to be high; however, this uncertainty did not impact the risk level that was already designated as significant.

There was a high level of uncertainty with respect to the predicted ability of Arkell Well 1 to pump at its future rate under existing and future land uses during drought conditions. At the maximum predicted drawdown, it had limited available drawdown remaining in the well, about 0.1 metres. Considering that Arkell Well 1 is screened within shallow overburden units and is highly influenced by recharge, which itself is a high source of uncertainty, it is concluded that this well may not be able to pump at the future rate under drought conditions. If the predicted drawdown at the Queensdale Well had not already triggered a significant risk level, this high uncertainty in the predicted results at Arkell Well 1 would have triggered it.

The uncertainty with respect to the predicted drawdown at other municipal wells, including the Queensdale Well, is low. This is due to the iterative refinements made to the hydrostratigraphic model of the groundwater flow system over a number of years and a numerical model that is well-calibrated to water levels measured at high-quality observation wells. The model results are also consistent with well capacity estimates based on traditional hydrogeology analytical techniques.

24.4.3 Significant Water Quantity Threats

Under the source protection program, the Province identified 22 activities that are prescribed as drinking water threat activities. For WHPA-Qs and IPZ-Qs with a significant risk level, all existing and new consumptive water takings located within the areas that draw water from within the WHPA-Q or the IPZ-Q or activities that reduce groundwater recharge are classified as Significant Drinking Water Threats. **Table 24–8** summarizes the Significant Water Quantity Threats identified within the WHPA-Q (**Map 24–10**) and IPZ-Q (**Map 24–11**). These consumptive takings and recharge reduction areas are classified as Significant Drinking Water Threats to water quantity regardless of their location within the WHPA-Q. Municipal permitted water takings are classified as Significant Drinking Water Threats because increases in municipal pumping from a well may result in the water level in that same well to decline below its safe threshold. In total, there were 7,537 significant consumptive water taking threats and 17.4 kilometres squared of significant recharge reduction threats identified within the WHPA-Q and IPZ-Q.

Table 24–8 Summary of Significant Water Quantity Threats (current to 2012)

Threat Group	Vulnerable Area	
	WHPA-Q-A	**IPZ-Q**
Municipal	29	12
Non-municipal Permitted	71	13
Non-municipal, Non-permitted[1]	5,153	2,671
Total	5,253	2,696
Recharge Reduction[2]	16.3 km^2 (5.3% of Groundwater Vulnerable Area A)	1.0 km^2 (0.4% of Surface Water Vulnerable Area)
Total[3]	Total number of significant threats identified within all Vulnerable Areas of the Water Quantity Risk Assessment	7,537[4]

Notes:

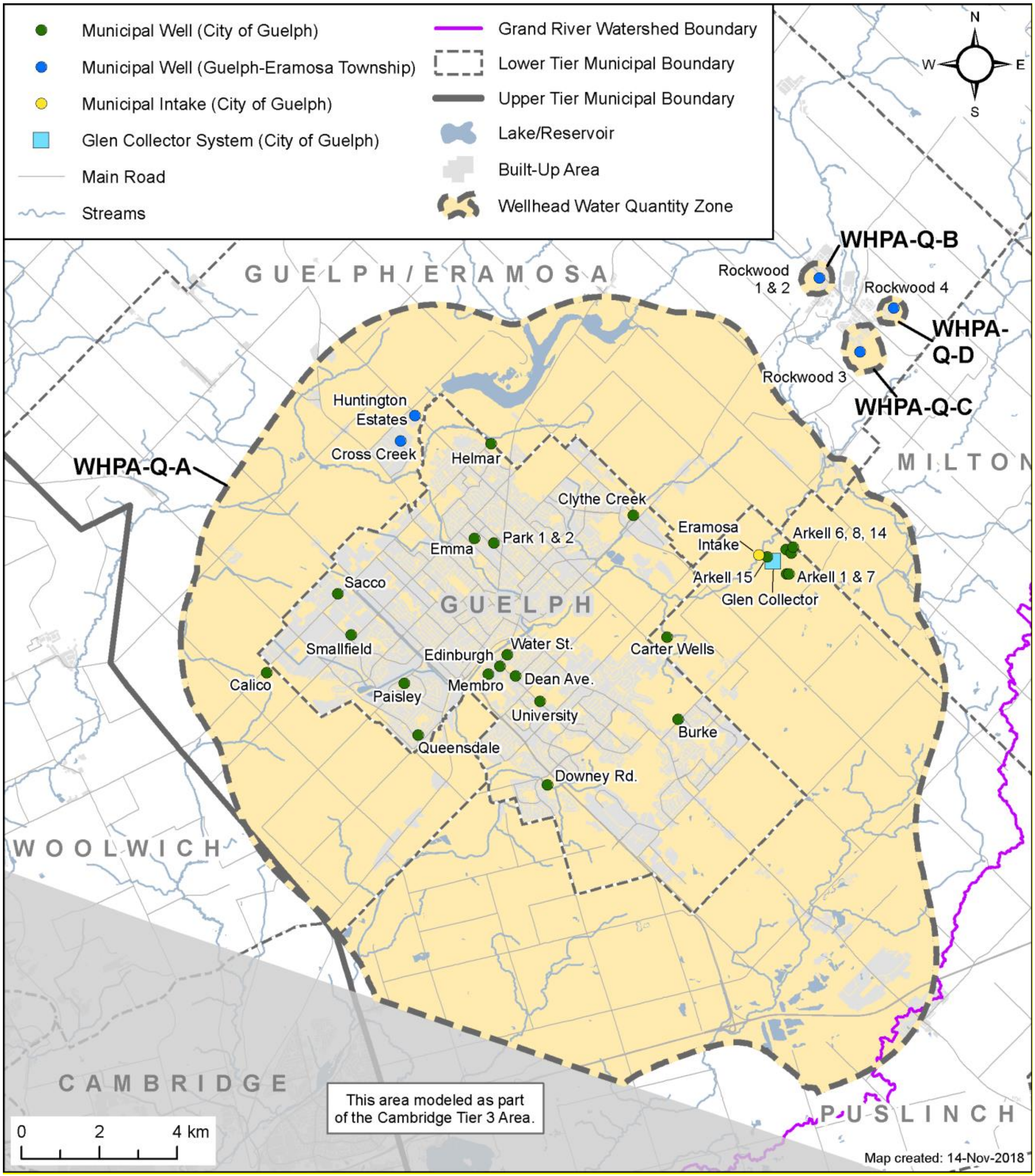
[1]Only domestic water wells recorded in the Water Well Information System database (MOE, 2012) are included. These are exempt from permitting if they are taking less than 379,000 litres per day.

[2]Recharge reduction threats are summarized by identifying the total area represented by Recharge Reduction Polygons and as a percentage of the total area of interest

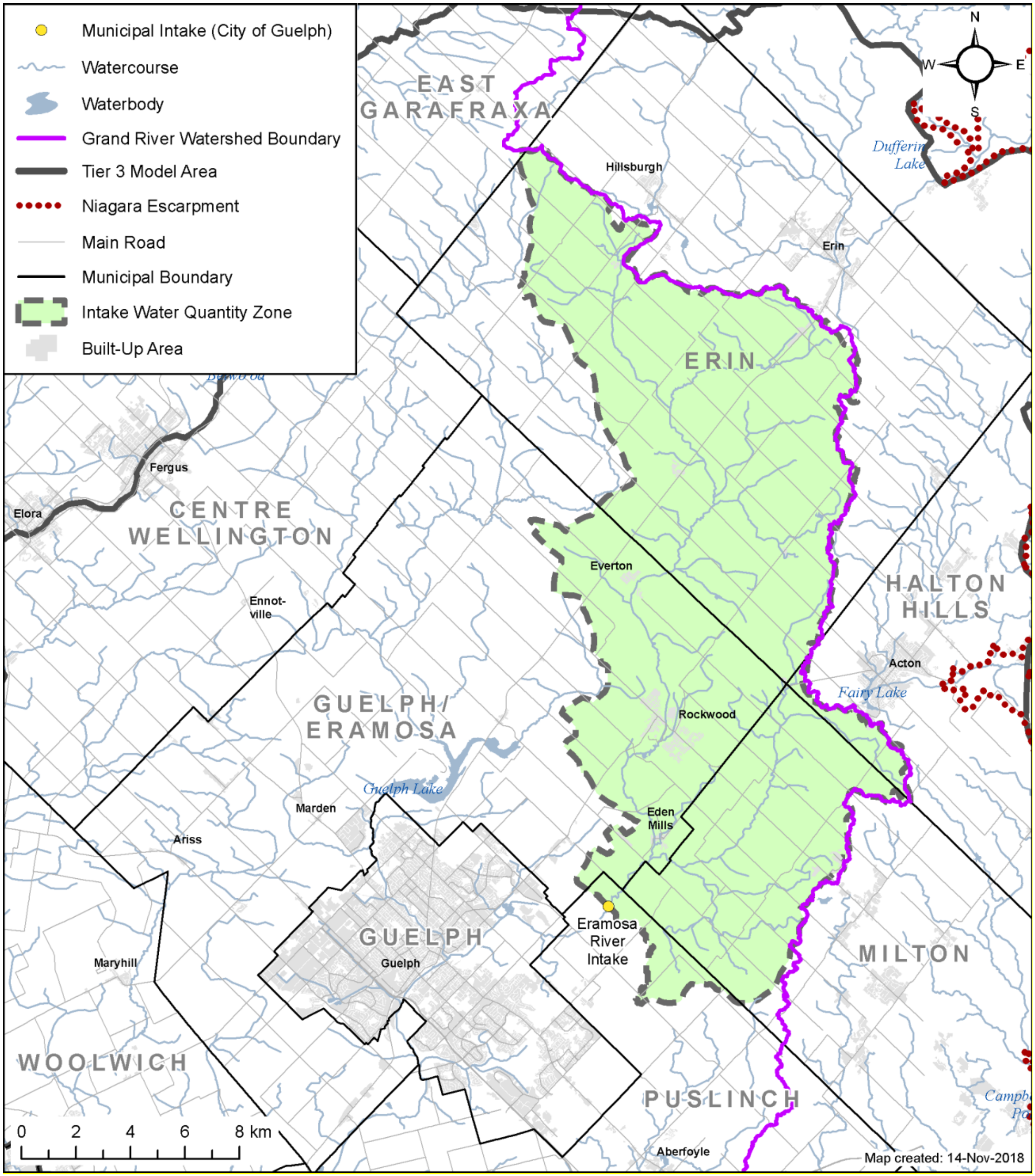
[3]Total number of significant threats does not include individual Recharge Reduction Polygons as those threats have been identified on a per-area basis.

[4]Total number of significant threats identified within all WHPA-Qs and IPZ-Q is not equal to the sum of significant threats from each individual WHPA-Q and IPZ due to overlapping areas where some threats lie within both the WHPA-Q and IPZ-Q.

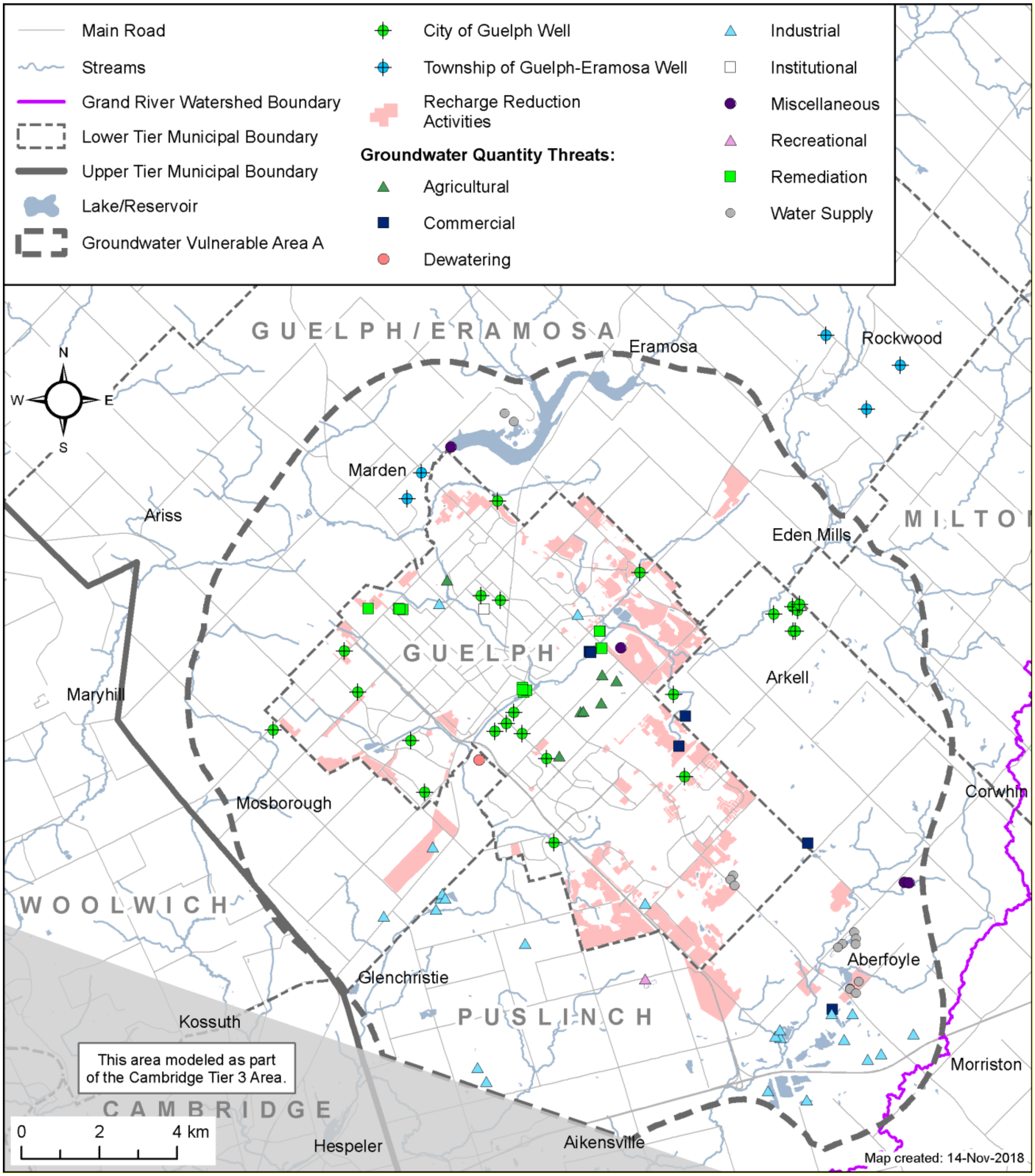
Map 24–8: WHPA-Qs Delineated in the Tier 3 Assessment



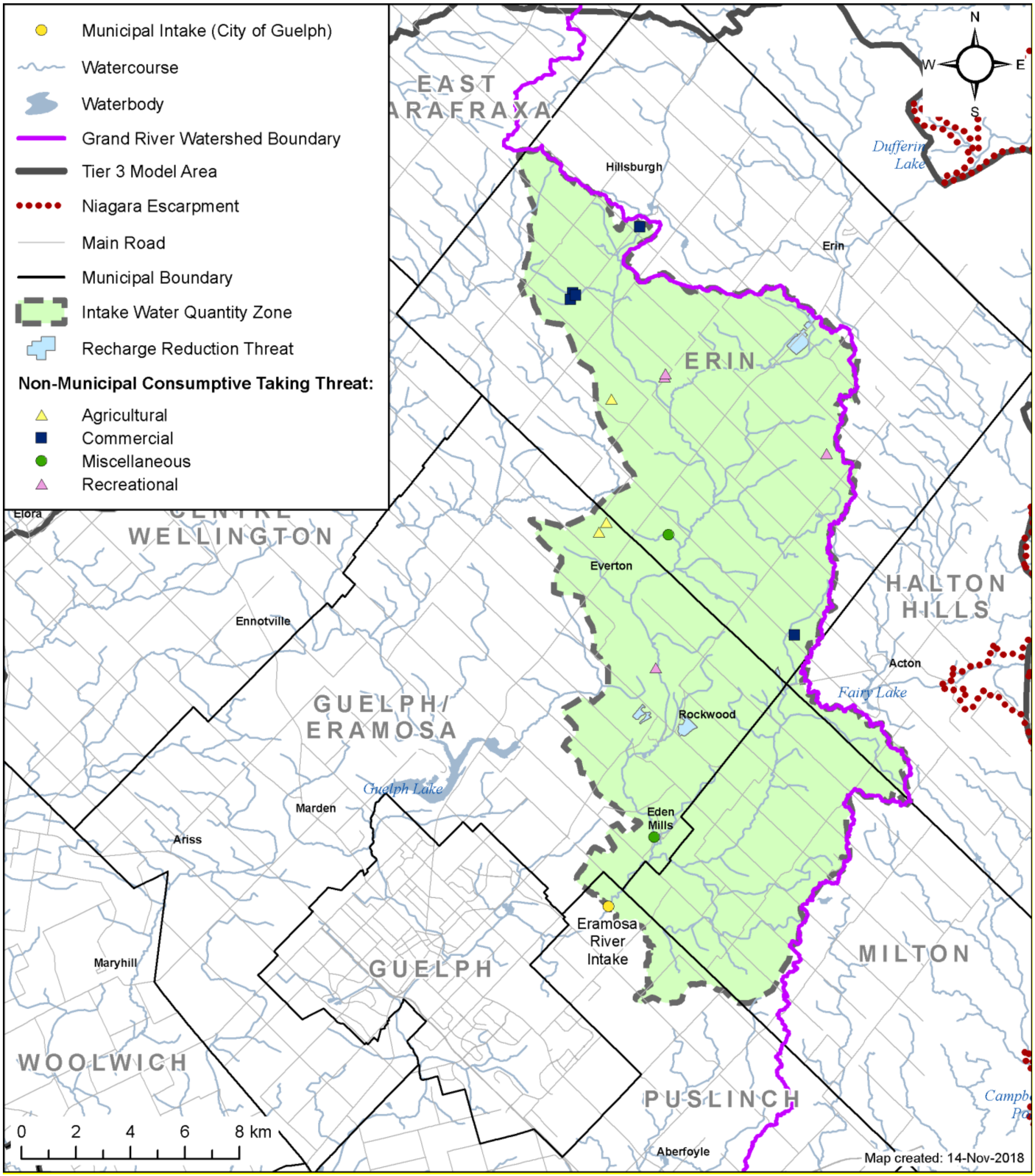
Map 24–9: IPZ-Q Delineated in the Tier 3 Assessment



Map 24–10: WHPA-Q Significant Water Quantity Threats



Map 24–11: IPZ-Q Significant Water Quantity Threats



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