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# 6.0 WELLINGTON COUNTY

## 6.1 Township of Wellington North

### 6.1.1 Arthur Well Supply

The Township of Wellington North has two municipal water supply systems, one servicing the Town of Mount Forest and a second servicing the Town of Arthur. Within the Township of Wellington North, Arthur is the only community located within the Grand River watershed that is serviced by a municipal groundwater system. The serviced area is shown on **Map 6-1.**

The Arthur Well Supply system consists of 3 wells, 2 pump houses, 2 elevated water tanks and a distribution system. The municipal system supplies water to approximately 2,770 people within the community (Conestoga Rovers & Associates, 2009).

The Town of Arthur is currently serviced by three municipal production wells: 7B, 8A, and 8B. All three of the wells are completed in the deep overburden aquifer at approximately 46 m below ground surface. The upper surficial quaternary geology has been mapped as a clayey silt to silt till (Tavistock Till) which covers a large part of the area surrounding Arthur.

Well 7B is located to the west of Arthur along Highway 109 and Wells. 8A and 8B are located south of the Town of Arthur in a rural setting as presented on **Map 6-2**. The following tables, **Table 6-1** and **Table 6-2** provide a summary of the municipal drinking water system and average pumping rates.

**Table 6-1: Municipal Residential Drinking Water System Information for the Township of Wellington North in the Grand River Source Protection Area (Arthur Well Supply)**

| DWS Number | DWS Name | Operating Authority | GW or SW | System Classification[1] | Number of Users served[2] |
|---|---|---|---|---|---|
| 220000040 | Arthur Well Supply | Township of Wellington North | GW | Large Municipal Residential System | 2,770 |

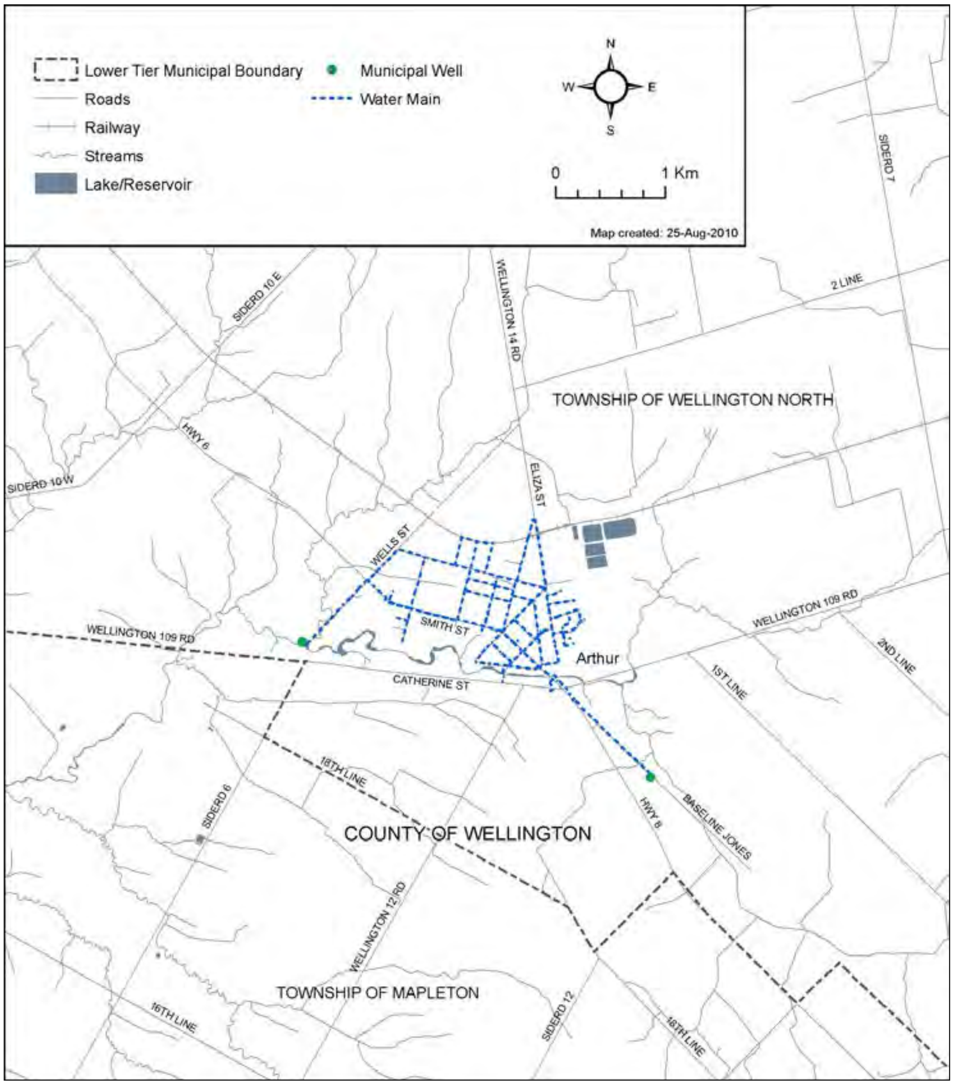
[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*
[2] Drinking Water System Regulation 170/03, 2009b

**Table 6-2: Annual and Monthly Average Pumping Rates for the Arthur Well Supply**

| Well or Intake | Annual Avg. Taking[1] ($m^3/d$) | Monthly Average Taking[1] ($m^3/d$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Well 7B | 120.9 | 185.92 | 66.6 | 266.87 | 220.69 | 132.23 | 84.82 | 96.95 | 136.18 | 64.97 | 10.46 | 100.2 | 85.19 |
| Well 8A | 639.0 | 713.6 | 701.15 | 528.86 | 496.94 | 782.69 | 689.01 | 645.88 | 433.64 | 655.37 | 820.05 | 824.52 | 375.78 |
| Well 8B | 145.1 | 1.97 | 20.47 | 42.48 | 148.93 | 3.06 | 162.12 | 197.13 | 537.56 | 214.15 | 2.52 | 2.33 | 408.79 |

[1] source: Township of Wellington North 2009 annual summary report

**Map 6-1: Arthur Well Supply Serviced Areas**



### 6.1.2 Vulnerability Analysis

***Delineation of Wellhead Protection Areas***

Wellhead Protection Areas (WHPAs) associated with the municipal water supply represents the areas within the aquifer that contribute groundwater to the well over a specific time period. Four Wellhead Protection Areas are specified, one a proximity zone and the others time-related capture zones:

- WHPA-A 100m radius from wellhead
- WHPA-B 2-year Time-of-Travel (TOT) capture zone
- WHPA-C 5-year time of travel capture zone
- WHPA-D 25-year time of travel capture zone.

Wellhead protection zones WHPA-E and WHPA-F are not included as part of this study because the water supply wells are not considered under the direct influence of surface water (GUDI).

***Arthur Wellhead Protection Areas***

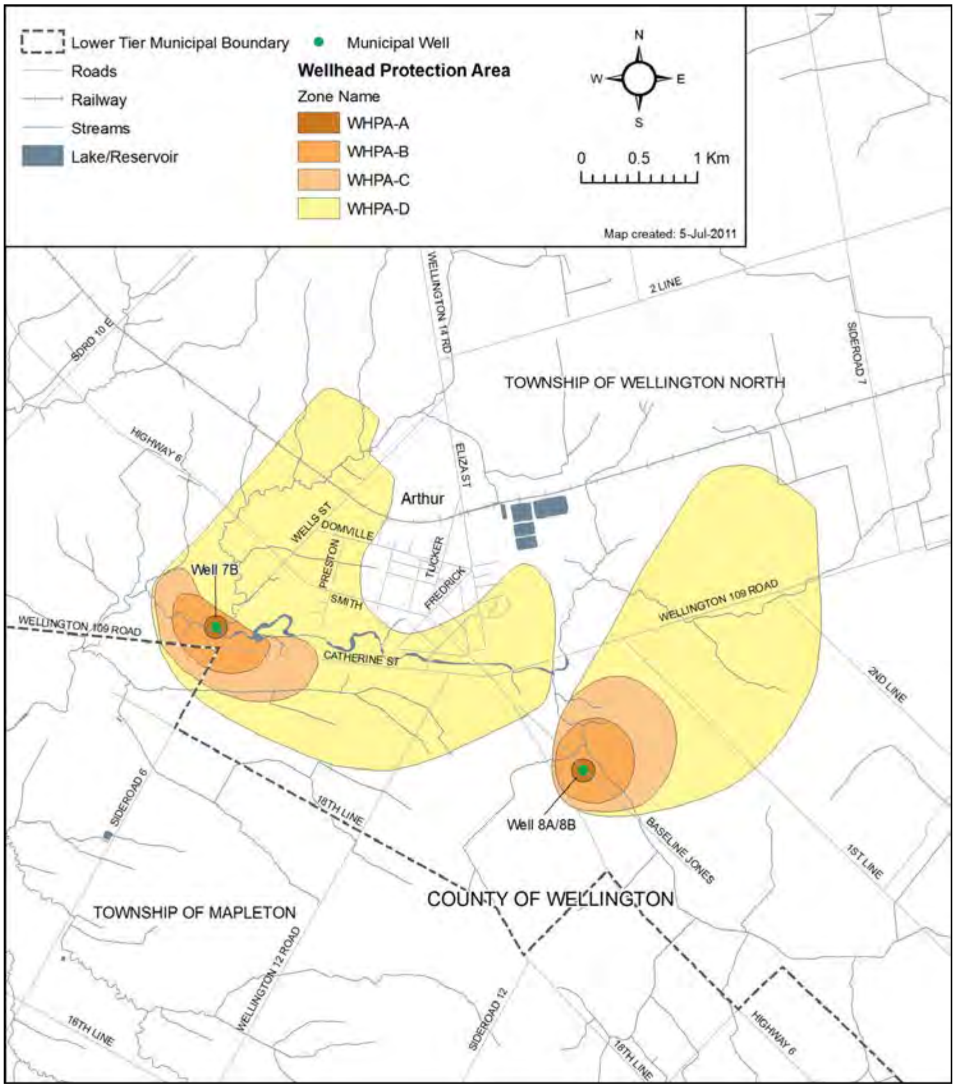
Existing Wellhead Protection Areas for the Township of Wellington North were developed by Golder Associates in 2005. Flow data for the Arthur system was reviewed, and updated flow projections were provided to Golder to develop the updated Wellhead Protection Areas. The models were also updated to reflect the new well system configuration for each of the systems. Wellhead Protection Areas for the Arthur Well Supply are presented on **Map 6-2**.

There are two distinct Wellhead Protection Areas for the Arthur 7B and Arthur 8A/B wells. The 25-year capture zone for Well 7B extends northeast encircling the urban footprint of Arthur, which is serviced by municipal sanitary sewers. The 25-year time of travel capture zone (Zone D) for Well 7B wellhead protection area has a total land area of approximately 6.16 $km^2$. The land with the 25-year time of travel capture zone encompasses a portion of the urban area and extends into rural areas to the northeast and southeast and consists of residential, commercial, cemetery, industrial, forested, and agricultural lands.

The 25-year capture zone for Arthur Wells 8A/B also extends northeast approximately 3.1 km outside the city to the east. The Conestoga River and its tributaries transect both Wellhead Protection Areas, and are within approximately 50 m from Well 7B and 200 m from Wells 8A/B. Land use overlying the Wellhead Protection Areas is primarily rural agricultural, although Zone D of Well 7B Wellhead Protection Area encroaches into the urban area. A few private septic systems and storm water infiltration features were identified within the 2-year capture zones (Zone B), and several water wells are mapped throughout the Wellhead Protection Area extents. Two historic waste disposal sites were also identified in Zone D of the Well 7B Wellhead Protection Area. ~~Vulnerability scores were adjusted accordingly to account for these transport pathways as discussed later in this section.~~

Projected pumping rates for Arthur Wells 8a/8b is approximately 350 $m^3$/day greater than for Arthur Well 7b. However, due to the nature of the flow paths, the 25-year time of travel capture zone (Zone D) for Wells 8a/8b has a total land area of approximately 4.74 $km^2$, which is slightly less than the Well 7b Wellhead Protection Area.

**Map 6-2: Arthur Well Supply Wellhead Protection Areas**



***Vulnerability Scoring in Wellhead Protection Areas***

The objective of the groundwater vulnerability analysis is to assess the vulnerability of the municipal wells from surface and near-surface sources of contamination and provide quantification of the relative vulnerability of the source water aquifer within each Wellhead Protection Area through a vulnerability scoring process, in accordance with the Assessment Report Regulation and Technical Rules.

The groundwater vulnerability scoring process involves four main steps:

1. Mapping wellhead protection areas based on defined fixed-radius and time-of-travel (TOT) capture zones.
2. Categorization of areas of intrinsic groundwater vulnerability as high, medium, or low according to the natural susceptibility of the source water aquifer to becoming contaminated.
3. Adjustments to the intrinsic vulnerability of the aquifer based on the presence of constructed transport pathways, where warranted.
4. Subdivide wellhead protection areas by the boundaries of the adjusted intrinsic vulnerability and assign groundwater vulnerability scores based upon the relative location within the Wellhead Protection Area.

Wellhead protection zones WHPA-E and WHPA-F are not included as part of this study because the water supply wells are not considered under the direct influence of surface water (GUDI).

***Modelling Approach for the Arthur Well Supply***

For all municipal wells included in the study, computer based three-dimensional groundwater flow models were used to delineate the extent of each protection zone determined by time-of-travel to the wellhead. This involved the refinement of time of travel analysis conducted as part of the 2001 MOE Groundwater Studies Initiative (Conestoga Rovers and Associates, 2007 and 2009).

While numerical models account for the three-dimensional flow through the groundwater system, the time of travel analyses were used to define the zones within the wellhead protections areas. With the exception of WHPA-A, which is based solely on proximity to the well or well field, the shape of the time of travel capture zones are determined primarily by the regional groundwater flow pattern, variations in aquifer properties, proximity to surface water features in contact with the aquifer system, and mutual interference between wells.

Time of travel capture zones were refined under this study using surveyed well locations, updated operational schedules (current as 2009), and updated forecasted pumping rates that account for future growth within each Wellhead Protection Area. Forecasted 2021 water demand was estimated based on the average 5-year pumping rate (2001 through 2006) and annual population growth rates reported in official plan documents, or as provided by municipal representatives.

Aquifer Vulnerability Index (AVI) assessed under the MOE Provincial Groundwater Studies Program initiated in 2001 was used in this study to categorize areas of intrinsic groundwater vulnerability as high, medium, or low within each Wellhead Protection Area. The AVI method provides a basic approach for decision-making, which considers the hydraulic conductivity of the pathway for water infiltrating from the ground surface and, in considering the uppermost significant aquifer, has respect for the shallow groundwater. Each category inversely reflects the relative amount of protection provided by the physical features that overlie the aquifer closest to the ground surface (e.g., overlying strata, their hydraulic conductivities and thicknesses).

The AVI maps generated under the provincial program are regionally-derived products based largely on water well records, local geology and other hydrogeological data.

***Vulnerability Scoring for the Arthur Wellhead Protection Areas***

The Aquifer Vulnerability Index (AVI) mapping was developed for bedrock and deep overburden aquifers in the Municipality of Wellington North by Golder in 2006. Detailed methods for vulnerability scoring is outlined in Chapter 3.

Each Wellhead Protection Area was subdivided by the boundaries of the adjusted groundwater vulnerability index mapping. Based on the intersection, vulnerability scores ranging from 2 (low vulnerability) to 10 (high vulnerability) were generated across each Wellhead Protection Area, providing a relative indication of the intrinsic susceptibility of the underlying aquifer to contamination from drinking water quality threats. ~~The following vulnerability scores are presented below in **Table 7-3.**~~ The ~~unadjusted~~ intrinsic vulnerability is shown on **Map 6-3.**

~~**Table 7-3: Wellhead Protection Area Vulnerability Scores – ISI/AVI**~~

| ~~WHPA Protection Zone~~ | ~~Broader Landscape Intrinsic Groundwater Vulnerability~~ | | |
|---|---|---|---|
| | ~~High~~ | ~~Medium~~ | ~~Low~~ |
| ~~WHPA-A: 100 m radius~~ | ~~10~~ | ~~10~~ | ~~10~~ |
| ~~WHPA-B: 2-year TOT~~ | ~~10~~ | ~~8~~ | ~~6~~ |
| ~~WHPA-C: 5-year TOT~~ | ~~8~~ | ~~6~~ | ~~4~~ |
| ~~WHPA-D: 25-year TOT~~ | ~~6~~ | ~~4~~ | ~~2~~ |

~~Typically, vulnerability scores are higher closer to the well. WHPA-A is mapped as one continuous sensitivity area, and applies to all potential contaminants. Within this zone there is no consideration given to the results from the vulnerability assessment – the intrinsic vulnerability score is solely based on proximity to the supply well or well field.~~

~~The initial vulnerability scoring for Arthur is included on **Map 7-4.**~~

***Identification of Transport Pathways and Vulnerability Adjustment***

Transport pathways are features that may increase the aquifer's vulnerability. Natural pathways, such as fracturing and karsts features, were considered in the regional ISI/AVI index mapping.

The existing potential threat source databases developed by WHI (2003) and Golder (2005) under previous provincial studies along with land use inventories completed under this study were used as a starting point to identify transport pathways within each Wellhead Protection Area. Available water well record databases, provincial and municipal mapping, aerial photography, and other source mapping data were also reviewed to determine the location of these features. Some additional databases used to identify transport pathways include the Ontario Drinking Water Information System (DWIS) database, oil and gas well inventories, Provincial Groundwater Monitoring Network (PGMN) database, the MNR NRVIS and Ontario Geologic Survey (OGS) pits and quarries inventories, and the MOE Sewage Treatment Plant (STP) inventory. Sewer and water-serviced subdivision and settled areas were determined through searches of government databases and cooperation with municipal representatives. Developed properties without sewer or water service were typically assumed to have septic systems.

***Transport Pathways in the Arthur Wellhead Protection Areas***

The following is a summary of the identified transport pathways:

- Municipal sewer infrastructure and septic systems;
- Well clusters and excavations (including construction and aggregate pits); and
- A large industrial property is located on the southern section of town where there are many excavations and what appear to be several dug settling ponds exist.

The transport pathways for the Arthur Wellhead Protection Areas are shown on **Map 6-4.**

~~***Adjustments to Vulnerability to Account for Transport Pathways***~~

~~The bypassing of the natural protection of an aquifer due to the presence of one or more transport pathways will essentially increase the relative vulnerability of the aquifer (i.e., from low to medium or high, or medium to high). Where an aquifer is already determined to be of high intrinsic vulnerability, no further increase is possible. It should be recognized that these adjustments only relate to the physical characteristics of the pathway from potential sources of contamination to the aquifer(s). In other words, they are applied independent of any consideration for specific chemicals of concern.~~

***Adjusted Vulnerability Scoring for the Arthur Wellhead Protection Areas***

Four factors were considered prior to adjusting the vulnerability of an area: (1) hydrogeological conditions, (2) the type and design of a pathway, (3) cumulative impact (density) of pathways, and (4) the extent of any assumptions used in the assessment.

Hydrogeologic conditions defining the intrinsic vulnerability of the aquifer, including type of aquifer, type and thickness of overburden materials, and groundwater flow conditions were considered within each WHPA and relevance of the existing ISI/AVI index mapping. These conditions were considered in conjunction with the type and design of the pathway, where known. The cumulative impact of multiple transport pathways (density and type of pathways) within a grid cell was also considered for vulnerability score adjustment. The spatial distribution of the constructed pathways provides a general indication of the aerial extent across which the vulnerability modifier should be applied, while the density of the constructed pathways provides a general indication of the likelihood of a constructed pathway providing a connection between a surface (or near surface) source of contamination and the aquifer of interest. It was assumed that a greater density of transport pathways (e.g., a cluster of private wells) represents a greater probability of contaminants being transported from the ground surface into the aquifer. As such, where multiple pathways were identified, or where multiple pathways were assumed, groundwater vulnerability was adjusted accordingly to reflect greater vulnerability.

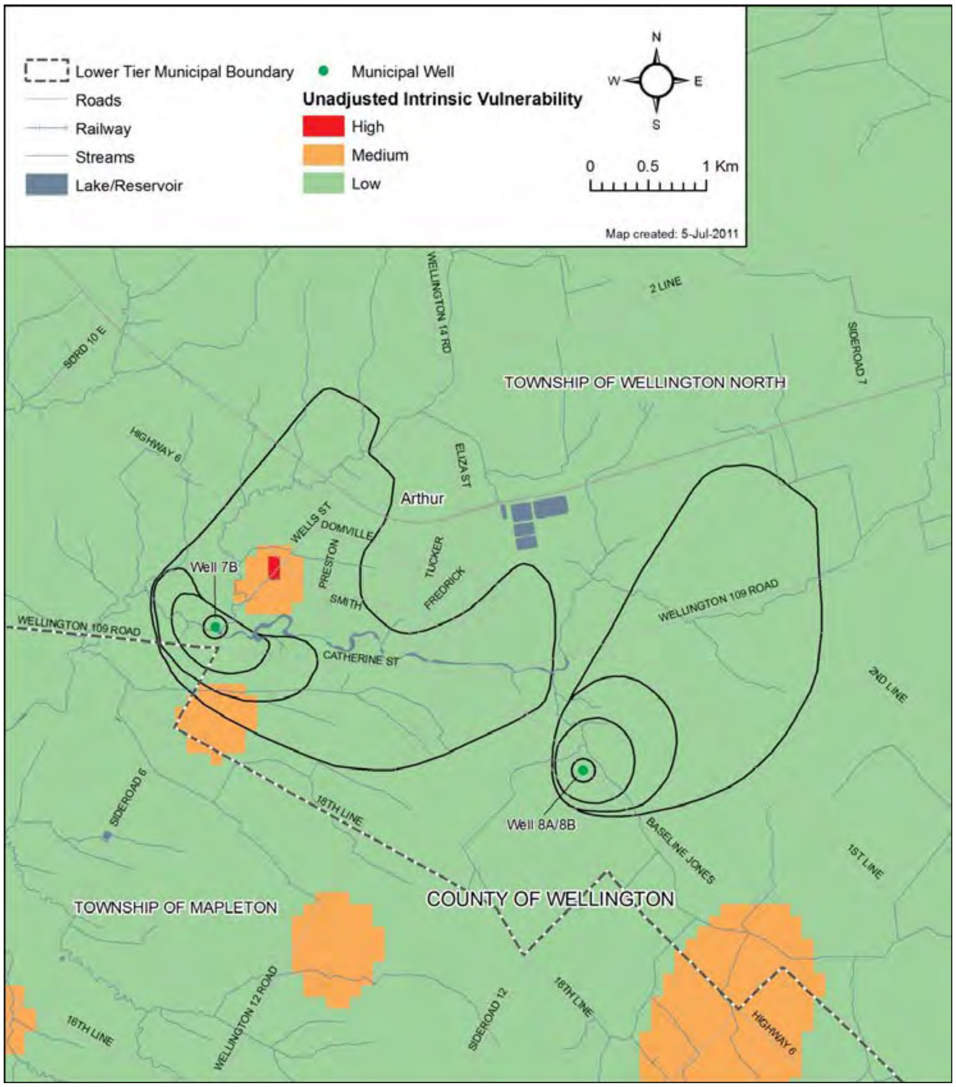
In addition to the spatial distribution and density of the pathways in each WHPA, the physical characteristics of the pathway was considered, where known or assumed, to determine if the constructed pathway extends to the water table or breaches protective layers (e.g., low permeability soils or bedrock strata) above the aquifer(s) of interest. Where a constructed pathway is not deep enough to penetrate the natural protective layers above the aquifer, an adjustment to the original score may not be necessary. Conversely, where the constructed pathway completely penetrates the overlying layers (e.g., an improperly abandoned or poorly constructed well) then an adjustment (increase) in the intrinsic vulnerability may be warranted on a local basis. To be conservative, it was assumed all identified pathways had the potential to breach the natural protective layers above the aquifer.

Since septic and sanitary sewer systems and infrastructure were only identified within the 2-year time-of-travel capture zone, only those areas within the WHPA-B protection zone with an initial vulnerability score of less than 10 were selected for a transport pathway score adjustment. The transport pathway areas of influence are shown on **Map 6-5** and the final vulnerability score is shown on **Map 6-6.**

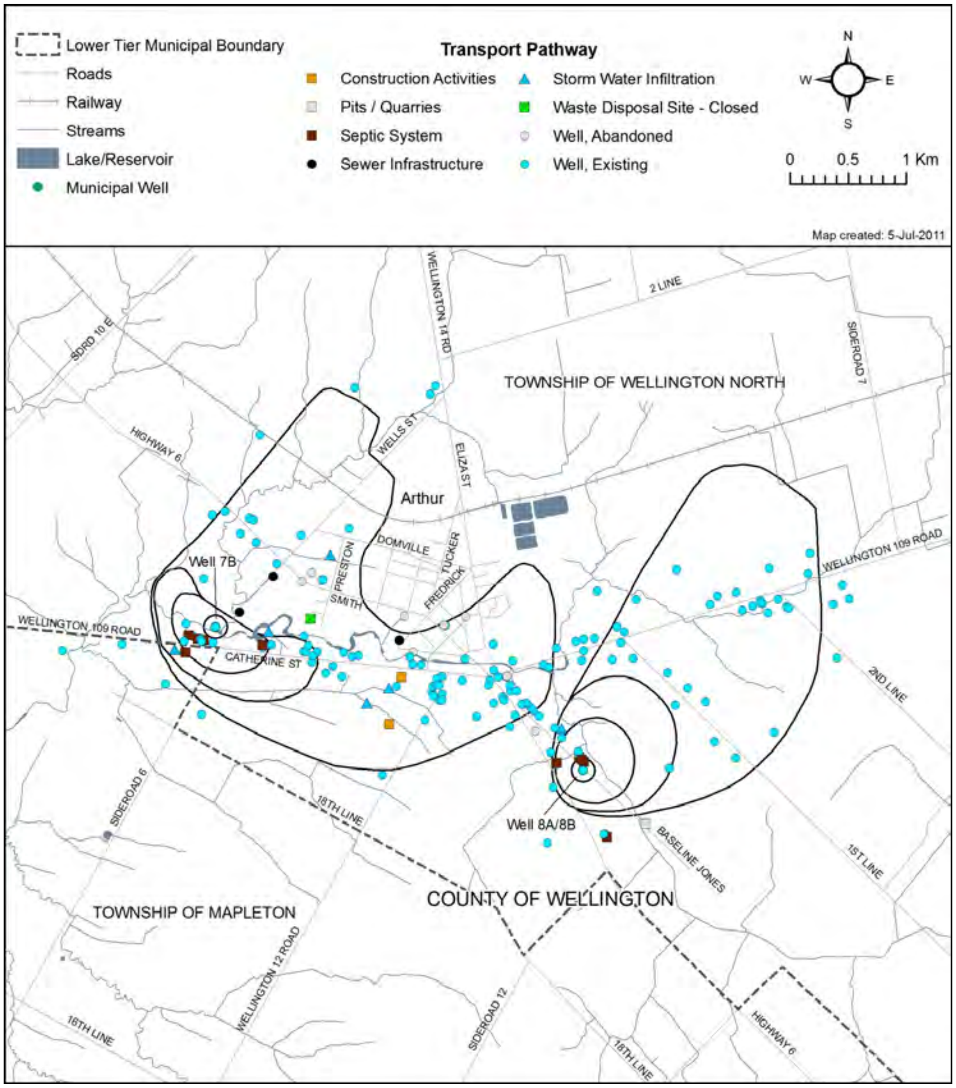
***Uncertainty in the Wellhead Protection Area Delineation and the Vulnerability Scoring for the Arthur Well Supply***

Data errors and data gaps are likely present in the information collected and thus the level of certainty is limited by the quality and completeness of the information available at the time the work was performed. Uncertainty associated with the regional aquifer vulnerability index mapping as part of the groundwater vulnerability analysis was determined to be high. Typically, the spatial accuracy and density of data points used to generate the mapping was low within the vulnerable areas included in this study. Since the vulnerability scoring is a fundamental segment brought forward to the threats evaluation, uncertainty must remain high for the number of significant threats identified.

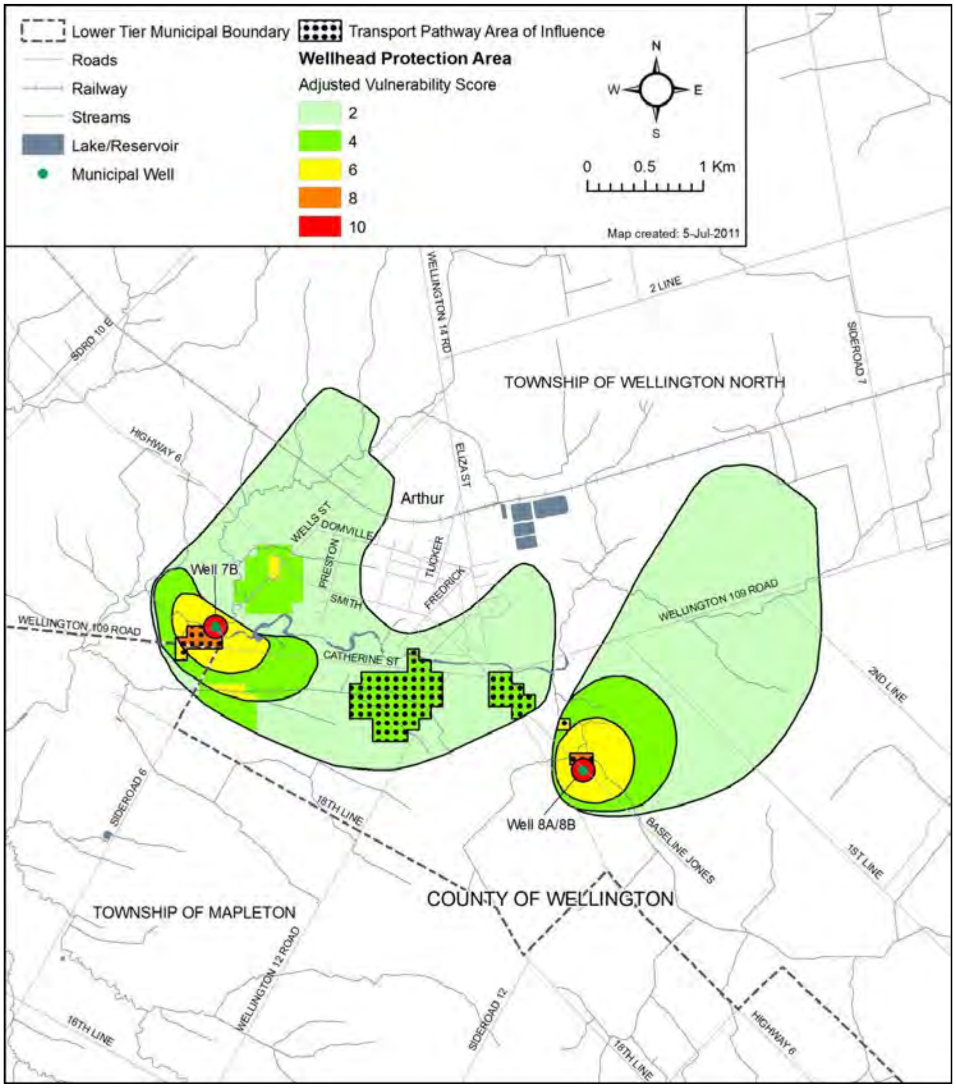
**Map 6-3 Arthur Well Supply Unadjusted Intrinsic Vulnerability**



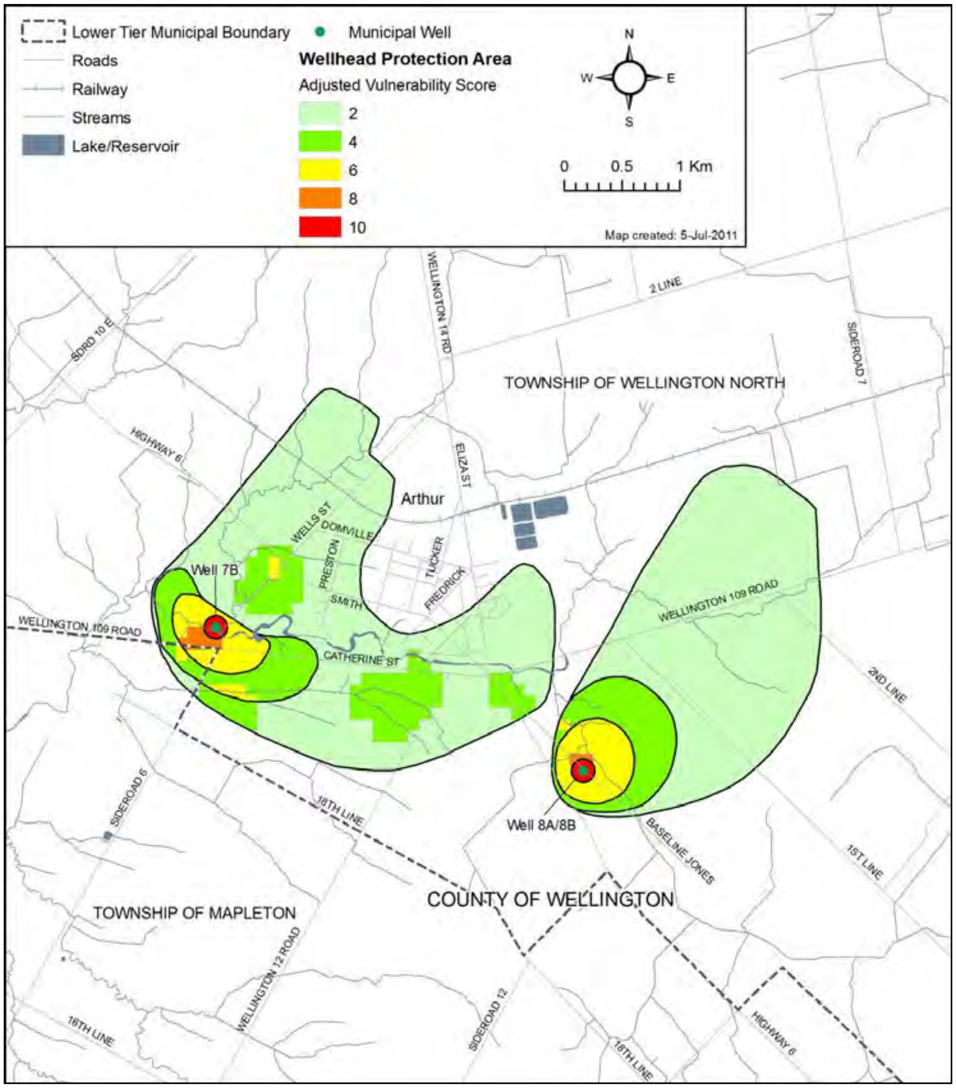
~~**Map 7-4: Arthur Well Supply Wellhead Protection Area Initial Vulnerability**~~
**Map 6-4: Arthur Well Supply Wellhead Protection Area Transport Pathways**



**Map 6-5: Arthur Well Supply Wellhead Protection Area Transport Pathways Areas of Influence**



**Map 6-6: Arthur Well Supply Wellhead Protection Area Final Vulnerability**



### *Managed Lands within the Arthur Wellhead Protection Areas*

Managed lands are lands that may receive agricultural source material (ASM), non-agricultural source material (NASM) or commercial fertilizer and can be divided into 2 categories of agricultural managed lands (AML) and non-agricultural managed lands (NAML). Agricultural managed lands include cropland, fallow and improved pasture that may receive ASM. Non-agricultural managed lands may include golf courses, sports fields, residential lawns and other built-up grassed areas or turf that may have commercial fertilizers applied.

Calculation of the percentage of managed lands was done in accordance with Technical Rule 16(9) (MOECCOE, 201709b) with details outlined in Chapter 3 of this Assessment Report. Mapping the percentage of managed lands area is not required where the vulnerability score for an area is less than the vulnerability score necessary for the activity to be considered a significant threat. Therefore, Tthe percentage of managed lands was only calculated where the vulnerability score in each Wellhead Protection Areas was 6 or greater. This criterion was used to determine the need to calculate managed lands surrounding the wells in the Arthur Well Supply as presented in **Table 7-4**.

**Table 7-4: Wellhead Protection Areas with Vulnerability Scores of 6 or Higher in the Arthur Well Supply**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Wellington | Arthur Well Supply | 7A/7B | Yes | Yes | No | Yes |
| | | 8A/8B | Yes | Yes | No | No |

*Methodology for Calculating Managed Land Percentage*

Each Wellhead Protection Area zone that required assessment for managed lands was selected and mapped using ArcGIS. The MPAC property layer with the associated farm code data table was overlaid over the Wellhead Protection Areas and all the properties that fell entirely or partially within the Wellhead Protection Area were selected for assessment. A union of these two layers was completed to determine the area of each parcel that only fell within the Wellhead Protection Area.

The GIS layers for wooded areas, wetlands (GRCA) and drainage (polygons determining spatial extent, not just linear location) were used to determine the extent of these land uses and were excluded from the combined MPAC parcel and Wellhead Protection Area layer.

Determining the non-agricultural managed lands utilized the MPAC description of the particular land use, but was also supplemented via air photo interpretation and an orthoimagery taken in 2006. Certain areas such as single residential unit parcels were analyzed for NAML area through air photo interpretation. For instance, by using a representative set of parcels within that MPAC category, areas that had potential as NAML (such as turf, lawns) were estimated with the area calculating tool. Further interpretation of the air photo were used to include or exclude parcels that were similar, then all these parcels were applied with the same percentage of managed land. Areas that had no managed lands included parcels with completely impervious cover or natural areas of scrubland or the like.

Utilizing attributes as described by the MPAC category and air photo interpretation, other areas were assessed to determine the percentage of NAML within the parcels in the Wellhead Protection Areas in the same method. These percentages of NAML were multiplied by the area to get the amount of NAML in each parcel. The sum of all the NAML areas for the parcels within the Wellhead Protection Area was divided by the total area of the Wellhead Protection Areas to get the percentage of NAML.

Farm codes were supplied in a separate table that was joined to the MPAC parcels to determine which parcels had the potential for application of ASM. Non-farm parcels were not coded ("Not Defined" in the Farm Operation code) and were assumed to not be agricultural in nature, unless the air photo was interpreted otherwise. AML includes cropland, improved pasture and fallow. The land area of these agricultural lands was summed then calculated as a percentage of the Wellhead Protection Area.

The area of NAML and the area of AML were summed then divided by the total area of the Wellhead Protection Area to get the percentage of managed lands.

The results of the calculations for managed lands are provided in **Table 6-3** and **Map6-7**, for the Arthur Wellhead Protection Areas.

**Table 6-3: Managed Lands Percentage in the Arthur Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Wellington North | Arthur | 7A/7B | 24.16% | 47.72% | N/Ao | 63.86% |
| | | 8A/8B | 79.39% | 96.11% | N/Ao | N/Ao |

**The coding of N/A indicates that the vulnerability score in this area is 4 or less, and this area has not been assessed.**

***Livestock Density within the Arthur Wellhead Protection Areas***

Technical Rule 16 also requires the mapping of livestock density. Livestock density is defined as the number of nutrient units over a given area, and is expressed by dividing the nutrient units by the number of acres in the agricultural managed land area or the livestock grazing area depending on the threat being assessed. Livestock density is used as a measure to determine the intensity of livestock animals and as such can be used as a measure of the potential for generating, storing and land applying agricultural source material. The method to calculate livestock density is detailed in Chapter 3 of this Assessment Report.

*Methodology for Determining Livestock Density*

As stated previously for the methodology on managed lands, the farm operation code table joined to the MPAC layer was used to determine what type of farming took place in each parcel. Often these categories were helpful for scoping of livestock housing, yet some were too generic (such as 'mixed farming') or erroneous and air photo interpretation was needed to determine what structures had the potential to house livestock.

The first screening of the air photo was to determine whether barns were present on a parcel that fell either partially or entirely within each Wellhead Protection Area. The barns on farms with codes not related to livestock (such as 'cash crops – feed and seed') were looked at but often quickly ruled out as livestock barns due to the farm code description.

Barns on farm parcels with codes related to livestock were looked at more carefully to determine what type of livestock could be housed and in which structures. Air photo interpretation with some knowledge of key identifying features of housing structures and land use practices allowed some confidence in selecting the correct structure as a livestock housing structure.

~~Once a livestock housing barn was selected, the type of livestock that was assumed to be housed in the barn was estimated with help from the farm code description and air photo interpretation. A polygon was drawn to cover the footprint of the structure to represent of the area of housing space for the livestock. The area of the barn was multiplied by the conversion factor for that livestock type, relating the area of the barn (in square metres) per Nutrient Unit, as supplied by OMAFRA in the Technical Memorandum issued by the Grand River Conservation Authority (GRCA) for Lake Erie Region Technical Studies (September 23, 2009) (GRCA, 2009a). This amount of nutrients is assumed to be applied to all the AML area on that farm unit evenly.~~

~~To verify the air photo interpretation, drive-by site visits were done to capture a photograph of the barn from the road-side.~~

~~Once all the livestock barns were found and the NU's calculated, the total NU applied to only the area within the Wellhead Protection Area is needed. Using area weighting, the livestock density (in NU/acre) of each farm parcel was applied to only the area within the Wellhead Protection Area and summed with all the other NU calculations on farm parcels in the Wellhead Protection Area.~~

~~The total NU generated by all the barns is divided by the total AML in the Wellhead Protection Area, as calculated in Step 5 of the Managed Lands Methodology, regardless of the type of farm (livestock or non-livestock). The livestock density in the Wellhead Protection Area is thus the sum of all NU applied within the Wellhead Protection Area divided by the total AML area (in acres).~~

The results of the calculations for livestock densities are provided in **Table 6-4** and **Map 6-8,** for the Arthur Wellhead Protection Areas.

**Table 6-4: Livestock Density (NU/acre) in the Arthur Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Wellington North | Arthur | 7A/7B | 0 | 0.13 | N/A | 0.95 |
| | | 8A/8B | 2.59 | 0.801 | N/A | N/A |

The coding of 0 indicates that there were no agricultural livestock barns to contribute nutrients and therefore the value for livestock density is 0. The coding of N/A indicates that the vulnerability score in this area is 4 or less, and this area has not been assessed.

***Assumptions While Assigning Non-Agricultural Managed Lands***
Some default values were used for estimating NAML based on the air photo interpretations and for ease of calculating. Roads generally had right-of-ways that were about 50% of the parcel size while the rest was the actual roadway, so most of these parcels were given NAML percentage of 50%. Parks or other open green-space that were interpreted as turf or grass were all assumed to have commercial fertilizers applied and thus defined as managed lands.

***Percent Impervious Surface Area within the Arthur Wellhead Protection Areas~~To calculate the percent impervious surface, information on land cover classification from the Southern Ontario Land Resource Information system (SOLRIS) was used. This provided land use information, including road and highway transportation routes, as continuous 15x15 metre grid cells across the entire Source Protection Area. All the cells that represent highways and other impervious surfaces used for vehicular traffic were re-coded with a cell value of 1 and all other land cover classifications were given a value of 0, to identify impervious surface areas.~~***

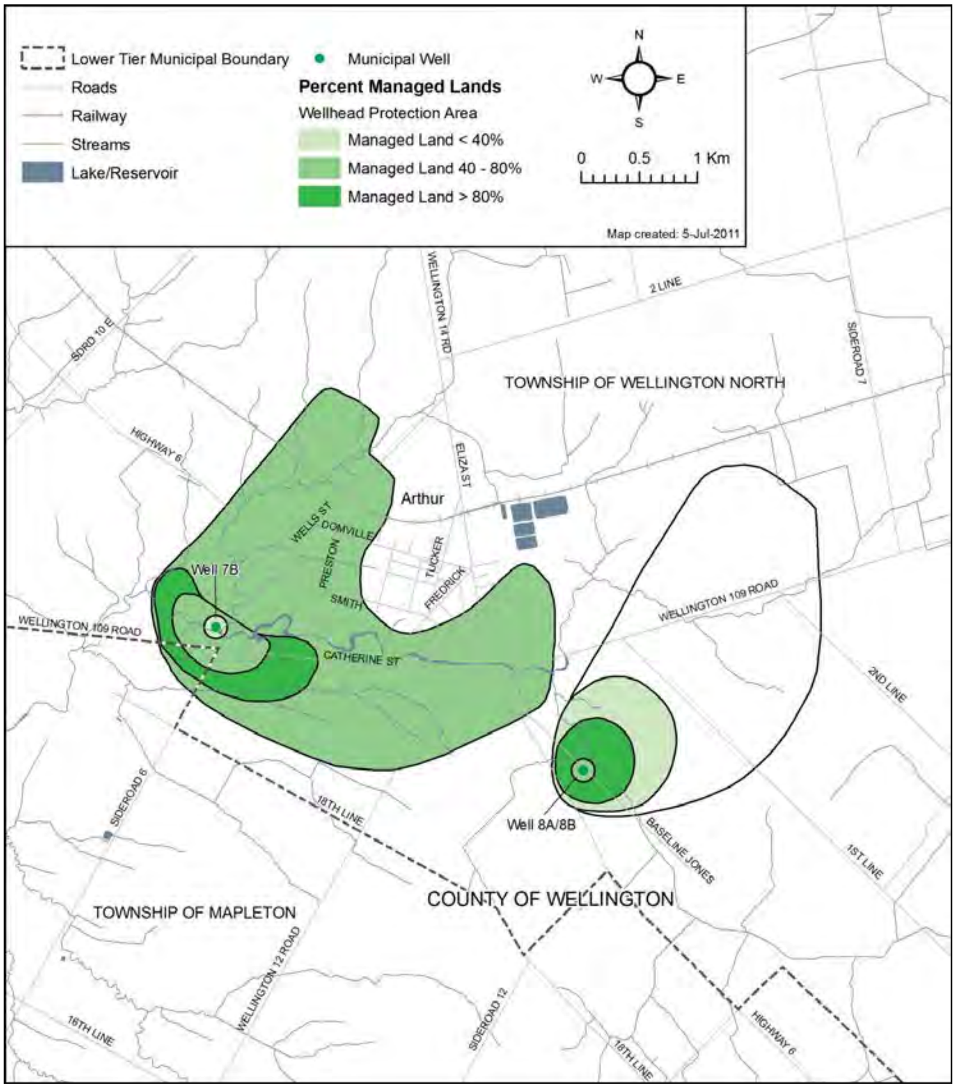
***Then, a focal sum moving window average was applied using the Spatial Analyst module of the ArcGIS software. For each 15x15 metre cell, the total number of neighbouring grid cells coded as impervious, within a 1x1 kilometre search area, was calculated. This total was then converted into the percentage of impervious surface by land area, using the area of each cell (225 sq. m) and the area of the moving window (1 sq. km). This provides a 1x1 kilometre moving window calculation of percent impervious surface, represented in 15x15 metre spatial increments. This dataset was calculated for the entire Source Protection Area, but was clipped to show those results only in the Wellhead Protection Areas and Intake Protection Zones. The analysis is more representative of road density and is better than the method described in the Technical Rules. As per Technical Rule 15.1, the Director has confirmed his agreement with the departure. The Director's letter of confirmation can be found in*** *Appendix B.*

Percent impervious surface area for the Arthur WHPAs was calculated using the average moving window method, which is described further in Chapter 3 of this Assessment Report. **Table 6-5** and **Map 6-9** provide a summary of percent imperviousness within each of the Arthur Wellhead Protection Areas.

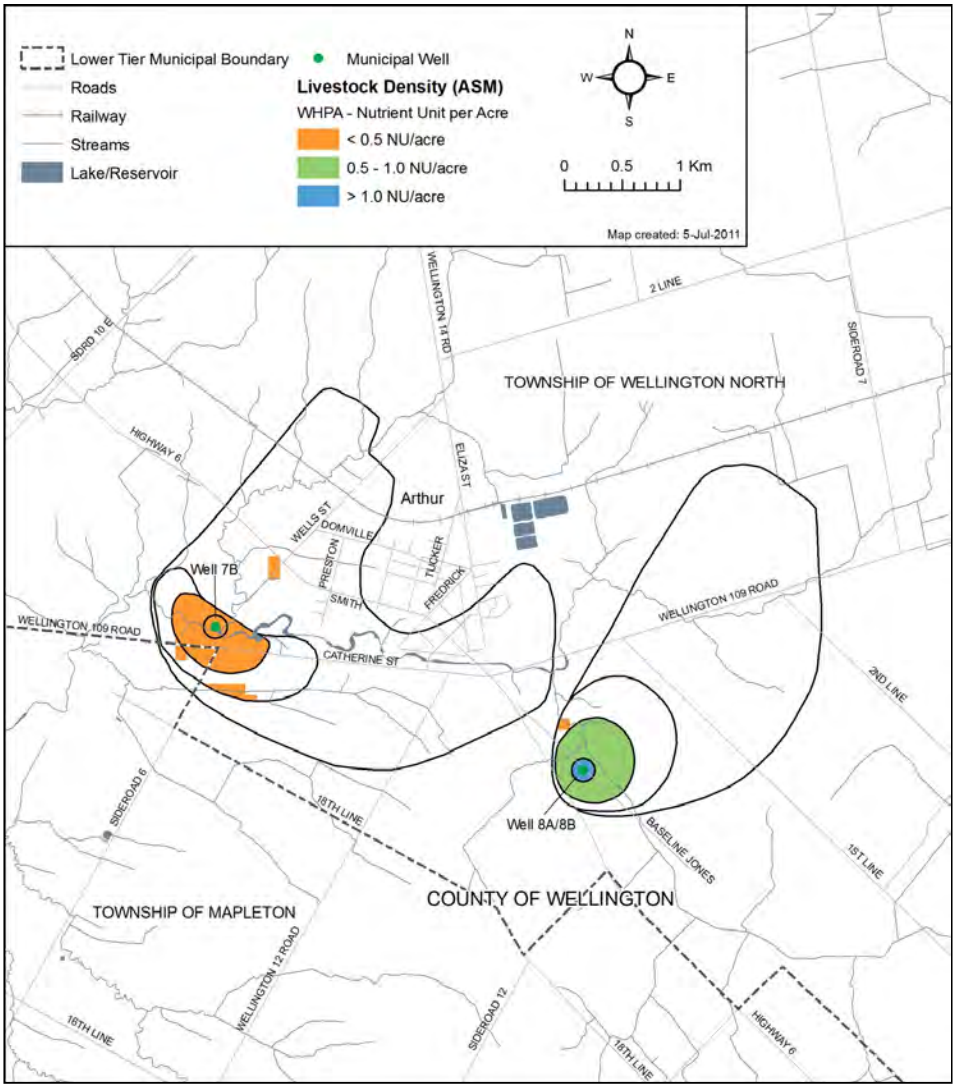
**Table 6-5: Percent Impervious Surface Area in the Arthur Wellhead Protection Areas**

| Arthur Well ID | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|
| 7B | 0% | 7.77% | 3.23% | 21.24% |
| 8B | 0% | 1.16% | 1.64% | 2.4% |

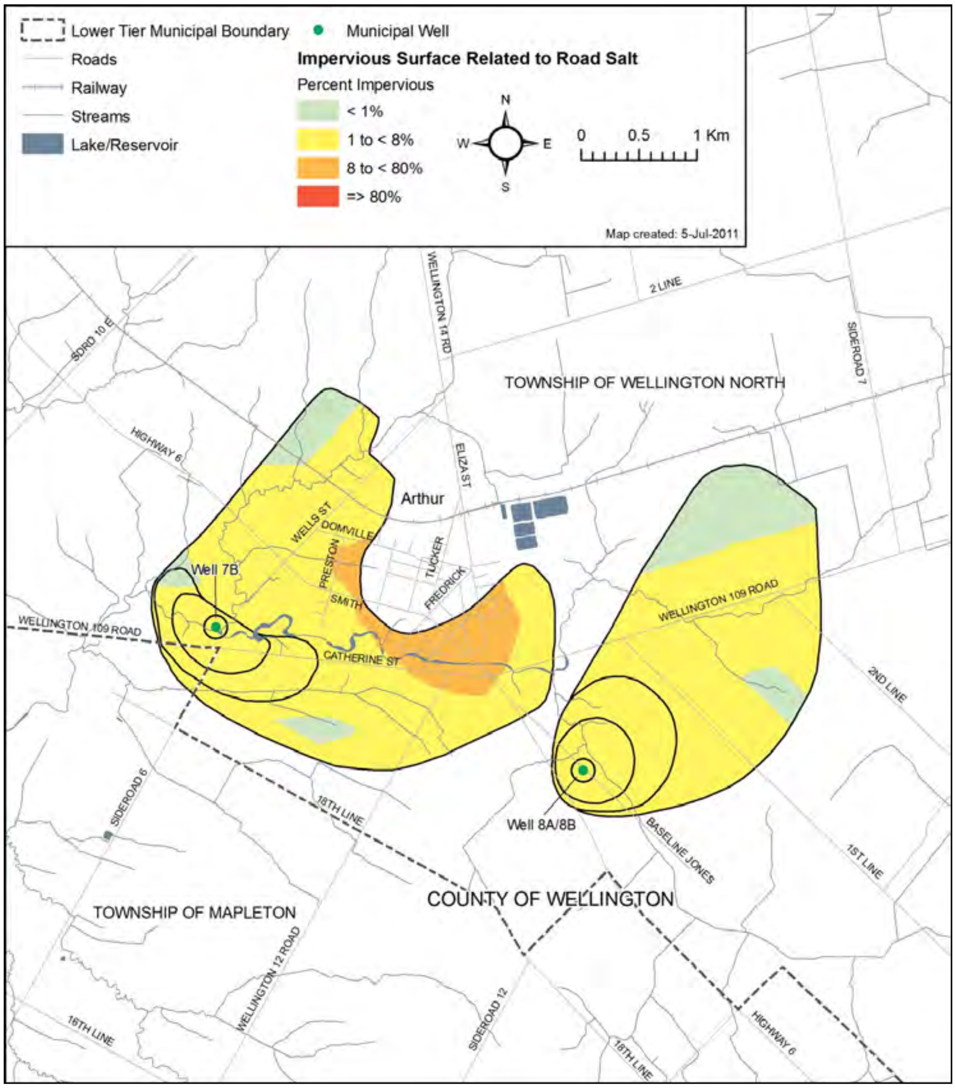
**Map6-7 : Arthur Well Supply Percent Managed Lands**



**Map 6-8: Arthur Well Supply Livestock Density**



**Map 6-9: Arthur Well Supply Percent of Impervious Surfaces**



### 6.1.3 Drinking Water Threats Assessment

The Ontario *Clean Water Act*, 2006, defines a Drinking Water Threat as "an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat." A Prescribed Drinking Water Threats table in Chapter 3 of this Assessment Report lists all possible drinking water threats.

***Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Arthur Well Supply***

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. The information above can be used with the vulnerability scores shown in **Map 6-6** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

**Table 6-6** provides a summary of the threat levels possible in the Arthur Well Supply for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), and Pathogens. A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map** 6-6.

**Table 6-6: Identification of Drinking Water Quality Threats in the Arthur Wellhead Protection Areas**

| Threat Type | Vulnerable Area | Vulnerability Score | Threat Classification Level | | |
|---|---|---|---|---|---|
| | | | Significant 80+ | Moderate 60 to <80 | Low >40 to <60 |
| Chemicals | WHPA-A | 10 | ✔ | ✔ | ✔ |
| | WHPA-B | 8 | ✔ | ✔ | ✔ |
| | WHPA-B/C/D | 6 | | ✔ | ✔ |
| | WHPA-C/D | 2 & 4 | | | |
| Handling / Storage of DNAPLs | WHPA-A/B/C | Any Score | ✔ | | |
| | WHPA-D | 6 | | ✔ | ✔ |
| | WHPA-D | 2 & 4 | | | |
| Pathogens | WHPA-A | 10 | ✔ | ✔ | |
| | WHPA-B | 8 | | ✔ | ✔ |
| | WHPA-B | 6 | | | ✔ |

### 6.1.4 Conditions Evaluation

Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the CWA Technical Rules (2009b), lists the following two criteria for groundwater sources:

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.

- The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.

The above listed criteria were used to evaluate potentially contaminated sites within the Arthur WHPAs to determine if such a Condition was present at a given site.

***Conditions Evaluation for the Arthur Well Supply***
There is no indication of existing groundwater conditions resulting from past activities or spills that constitute a drinking water threat (as defined under Part XI.3 Rule 126 of the Assessment Report Technical Rules).

Ecolog records from the Occurrence Reporting Information System (1988-2002) were reviewed to identify reported spills and occurrences within each Wellhead Protection Area that have the potential to contaminant groundwater. Fuel spills were identified in Arthur. These spills may have resulted in surface water or soil contamination, but none were reported to have contaminated groundwater.

### 6.1.5 Drinking Water Quality Issues Evaluation

The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)). Elevated concentrations of selected parameters that are naturally occurring or where effective treatment is in place are not considered drinking water Issues.

Once a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the Issue within an Issue Contributing Area and manage these threats appropriately. If at this time the Issue Contributing Area can not be identified or the Issue can not be linked to threats then a work plan must be provided.

If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are significant drinking water threats, regardless of the vulnerability.

***Data Sources for the Drinking Water Quality Issues Evaluation***
Drinking water quality data for each municipal well and surface water intake was collected from governmental sources, including:

- Engineer Reports
- Operator Statements
- The Drinking Water Information Systems Database (DWIS)
- Annual Reporting to the ~~MOE~~ MECP (web-based)
- The Assessment Report's Watershed Characterization Report

***Drinking Water Quality Issues Evaluation for the Arthur Well Supply***

Parameters that are possible Issues are listed in **Table** 6-7**.** The table lists the parameter or pathogen of concern, and municipal well at which the exceedance(s) occurred, frequency of occurrence, potential source of contamination, and source of information.

**Table 6-7: Summary of Possible Water Quality Issues**

| Municipal Well | Parameter/ Pathogen | Contaminant | Potential Contaminant Source | Reference | Comments |
|---|---|---|---|---|---|
| Arthur 7A and 7B | Iron | Chemical | Naturally Occurring | Annual Reporting; BM Ross, 2001 | Commonly exceeds ODWQS Technical Support Document Table 4. |
| Arthur 7A and 7B | Fluoride | Chemical | Naturally Occurring | Annual Reporting; BM Ross, 2001 | Infrequently exceeds ODWQS Schedule 2. |
| Arthur 7A | Water Colour | Chemical | Naturally Occurring | Annual Reporting; BM Ross, 2001 | Commonly exceeds ODWQS Technical Support Document Table 4. |
| Arthur 7A and 7B | Total Dissolved Solids | Chemical | Naturally Occurring | Annual Reporting; BM Ross, 2001 | Occasionally exceeds ODWQS Technical Support Document Table 4. |
| Arthur 7B | Manganese | Chemical | Naturally Occurring | Annual Reporting; BM Ross, 2001 | Infrequently exceeds ODWQS Technical Support Document Table 4. |

There is currently no evidence to suggest that the presence of any of these parameters would lead to a deterioration of the Arthur Well Supply drinking water quality, nor is there any evidence to suggest a trend of increasing concentrations. In addition, the parameters of concern are all naturally occurring. No Issues have been identified under Rule 114 of the Technical Rules (~~MOE~~MOECC, 2017~~09b~~).

***Summary of Water Quality Issues Evaluation for the Arthur Well Supply***

A total of four parameters listed in **Table 6-7** (iron, water colour, total dissolved solids, and manganese) were identified to commonly or occasionally exceed the drinking water quality standards of the Technical Support Document for Ontario Drinking Water Standards, Objectives, and Guidelines, and one parameter (fluoride) that was found to infrequently exceed the limits listed under Schedule 2 of the Ontario Drinking Water Quality Standards (CRA, 2009). It was noted, however, that the identified Issues for the Arthur Well Supply are naturally occurring, therefore, no Issues are reported for the Arthur Well Supply.

***Limitations and Uncertainty for the Drinking Water Quality Issues Evaluation for the Arthur Well Supply***

Data collected for the Issues Evaluation was limited in quantity and in temporal continuity. Raw water quality results ranged from 2 to 18 years in age, depending on the source. Recent analytical data typically included only raw water analysis for pathogens. Analytical data for metals, chemical and physical parameters were typically after treatment, resulting in the possibility for false negatives. Also, since large temporal gaps existed in the data, it was difficult to define increasing trends.

### 6.1.6 Enumeration of Significant Drinking Water Quality Threats

The Technical Rules require an estimation of the number of locations at which an Activity is a significant drinking water threat and the number of locations at which a Condition resulting from past activity is a significant drinking water threat.

The enumeration of land use activities that may be associated with prescribed drinking water threats was based on a review of multiple data sources, including public records, data provided through questionnaires completed by municipal officials, previous contaminant/historical land use information, and data collected during windshield surveys. No site specific information was collected; therefore. As more site specific information becomes available during the source protection planning process, the presence of drinking water threats and their current level of management can be confirmed.

Drinking water threats as defined in the Ontario Clean Water Act (2006) were identified within the Arthur Wellhead Protection Areas through an enumeration of land use activities that may be associated with Prescribed Drinking Water Threats (Ontario Regulation 287/07).

The main objective of the assessment was to identify significant threats. A significant threat to a source of drinking water has a high likelihood of rendering a current or future drinking water source impaired, unusable or unsustainable, combined with a potential route for the contaminant to enter the source water.

***Methodology for Enumerating Significant Drinking Water Quality Threats***

Land use inventories were developed for each vulnerable area to associate activities with prescribed drinking water quality threats and generate a list of threats that are or have the potential to adversely affect the quality of drinking water. Existing and historical land uses were identified for each land parcel within (or intersecting) each Wellhead Protection Area and logged into a geospatial drinking water threat source database based on unique parcel identifiers (PINS).

A series of field walks and windshield surveys within the vulnerable areas was undertaken to identify existing land use activities. Residential, commercial, industrial, municipal, and other land uses were identified, cataloged and mapped within each Wellhead Protection Area. Other sources of information included government databases, assessment information, aerial photography, and general knowledge of the study area through Municipal representatives. EcoLog Environmental Risk Information Services Ltd. (ERIS) was used to conduct a search of available federal, provincial and private databases within each Wellhead Protection Area. Searchable databases which returned records are listed below.

- Aggregate Inventory
- Certificates of Approval
- Environmental Registry
- ERIS Historical Searches
- Fuel Storage Tank
- Occurrence Reporting Information System
- Ontario Regulation 347 Waste Generators Summary
- Ontario Regulation 347 Waste Receivers Summary
- Pesticide Register
- Private and Retail Fuel Storage Tanks

- Scott's Manufacturing Directory
- Water Well Information System

Land use categories were adapted from the Municipal Property Assessment Corporation (MPAC) property codes

A North American Industrial Classification System (NAICS) code was assigned to each land use activity identified within each parcel. In many instances, the land use activities identified through the available database searches, in the field, or through air photo interpretation differed from the MPAC property code classification. Professional judgment was used to assign an appropriate NAICS code. Where more than one land use activity was identified within a property, the appropriate NAICS codes were assigned.

The land uses identified within each parcel were used to determine if the associated activity (or activities) represents a potential significant threat to a drinking water source for which a policy in the source protection plan would be required to reduce or eliminate the threat.

The key data sources used to identify threats within the Arthur Wellhead Protection Areas included the following: Windshield surveys; government databases; assessment information; aerial photography; discussions with municipal representatives; EcoLog Environmental Risk Information Services Ltd. Search; and Municipal Property Assessment Corporation (MPAC) property codes.

***Significant Drinking Water Quality Threats in the Arthur Wellhead Protection Areas***

**Table 6-8** summarizes the total number of significant pathogen, chemical, and DNAPL threats identified within each vulnerable area.

**Table 6-8: Significant Drinking Water Quality Threats in the Arthur Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 1 | WHPA-A |
| 2 | Sewage System or Sewage Works- ~~Septic System~~Onsite Sewage Systems | 2 | WHPA-A |
| 3 | Application of Agricultural Source Material to Land | 3 | WHPA-A |
| 8 | Application of Commercial Fertilizer | 2 | WHPA-A |
| 10 | Application of Pesticide to Land | 3 | WHPA-A |
| 16 | Handling and Storage of DNAPLs | 2 | WHPA-A, WHPA-C |
| 17 | Handling and Storage of Organic Solvents | 1 | WHPA-A |
| **Total Number of Properties** | | | **6** |
| **Total Number of Activities** | | | **14** |

**Table 6-8: Significant Drinking Water Quality Threats in the Arthur Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

***Limitations and Uncertainty for the Enumeration of Significant Drinking Water Supply Threats for the Arthur Well Supply***

Certainty in the threats evaluation is limited by the completeness and accuracy of the land use information and knowledge of the circumstances associated with the parcel-based activities identified across the study area. Any revisions to the vulnerability scoring and/or to the list of activities/Conditions and their circumstances would effectively impact the threats evaluation, altering the number of significant threats identified within the vulnerable areas included in the study. As the threats evaluation was a desktop exercise, verification would be needed to confirm the threats listed above.

Limitations include the general completeness of the databases used, currency of the data, accuracy of the data, and the generic nature of the threat ranking.

The following assumptions were made during the threat evaluation:

- ASM and NASM assumed based on land use activities, qualities estimated;
- Application of pesticides assumed based on land use activity;
- The presence of a on-Site septic system could lead to the discharge of a pathogen in the ground or surface water; and
- Storage of pesticides was based on the presence of farm buildings. The circumstances were unknown, therefore the quantities were assumed.

## 6.2 Township of Mapleton

Two municipal groundwater supply wells are located within the Township of Mapleton within the Grand River Source Protection Area: Drayton and Moorefield.

### 6.2.1 Drayton Well Supply

The Village of Drayton Well Supply system provides water for the Village of Drayton which has a population of approximately 1,550 persons (Statistics Canada, 2002). The area serviced is shown in **Map 6-10**. The system consists of two production wells located in a pumphouse off of Wood Street.

The Drayton production wells are both 250 mm diameter wells located approximately 6.1 m apart and in the context of this report they were modelled as a single source. Well 1 was drilled to a depth of 66.29 m in 1967 and Well 2 was drilled to a depth of 67.05 m in 1984. The two municipal wells were completed as open holes in the upper portion of the dolostone bedrock aquifer which is overlain by about 58 m of fine-grained overburden (Burnside, 2001c).

The Drayton Well Supply system operates according to Permit to Take Water (PTTW) No. 85-P-2004. According to the permit, the rate from the Drayton wells is not to exceed 2.73 $m^3$/min and the daily amount is not to exceed 3,927 $m^3$/day. As required by the Permit to Take Water conditions, two domestic wells referred to as the Thomson Well and the Flinkert Well are monitored for water levels (Burnside, 2009a).

### 6.2.2 Moorefield Well Supply

The Moorefield Well Supply system services the small hamlet of Moorefield located at Wellington Road 10 and Concession 8 with a population of approximately 550 residents. The water supply system includes two production wells which are located at the Public Works property on Wellington Road 10. The serviced area is shown on **Map 6-10.**

Moorefield Well 1 was originally installed in 1996 and was drilled to a total depth of 91.5 m. Moorefield Well 2 was installed in 2002 as a backup well. Due to similarity in construction and separation distance these wells were also modelled as a single source in the context of this report. Water in the wells comes from an extremely permeable portion of the dolomite bedrock aquifer at a depth of 82 m. The aquifer responds as a confined aquifer with little to no leakage. Overburden sediments consist of primarily fine grained silt and clay till (Burnside, 2002a).

The Moorefield Well Supply system operates according to Permit to Take Water No. 4651-6JTS55 which provides that the pumping rate from each well is not to exceed 910 L/min and the daily amount from each well is not to exceed 1,310 $m^3$/day (Burnside, 2009b). As part of the PTTW, a monitoring program has been established and results are reported annually to the MECP~~OE~~. Two monitoring wells known as the Yard Well and Lounabury Well are included in this program.

**Map 6-10: Township of Mapleton Serviced Areas**

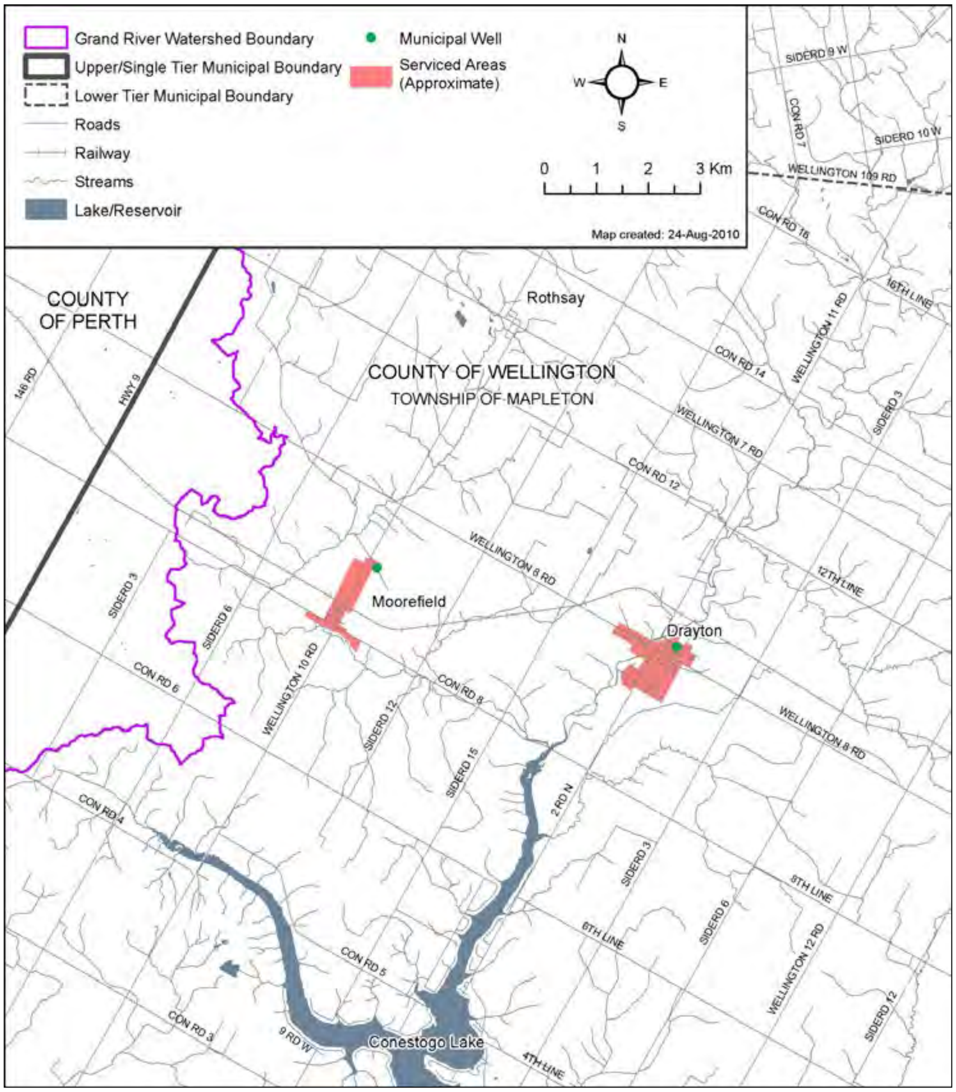


**Table 6-9, Table 6-10 and Table 6-11** summarize the municipal groundwater systems and pumping rates for both the Drayton and Moorefield Well Supply systems within the Township of Mapleton.

**Table 6-9: Municipal Production Wells in the Township of Mapleton**

| Well | Depth (m) | Open Interval | PTTW Number | Permitted Pumping Rate |
|---|---|---|---|---|
| Drayton PW1 | 66.3 | 62.2 m to 66.3 m | 85-P-2004 | 273 L/min |
| Drayton PW2 | 67.05 | 61.6 m to 67.05 m | | |
| Moorefield PW1 | 91.5 | 76.2 m to 91.5 m | 4651-6JTS55 | 910 L/min |
| Moorefield PW2 | 91.5 | 73.1 m to 91.5 m | | |

**Table 6-10: Municipal Residential Drinking Water System Information for the Township of Mapleton in the Grand River Source Protection Area (Drayton and Moorefield Well Supply Systems)**

| DWS Number | DWS Name | Operating Authority | GW or SW | System Classification[1] | Number of Users Served[2] |
|---|---|---|---|---|---|
| 220004064 | Drayton Well Supply | OCWA | GW | Large Municipal Residential System | 1,550 |
| 260069732 | Moorefiled Well Supply | OCWA | GW | Large Municipal Residential System | 550 |

[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*
[2] Drayton and Moorefield 2009 Annual Reports (O.Reg 170/03)

**Table 6-11: Annual and Monthly Average Pumping Rates for Mapleton Municipal Residential Drinking Water Systems in the Grand River Region**

| Well or Intake | Annual Avg. Taking[1] ($m^3/d$) | Monthly Average Taking[1] ($m^3/d$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Drayton PW1 | 453.03 | 438.66 | 458.44 | 461.38 | 418.93 | 445.36 | 506.08 | 472.20 | 392.85 | 508.09 | 455.33 | 444.18 | 434.88 |
| Drayton PW2 | 8.54 | 0.83 | 0.79 | 3.01 | 2.21 | 30.23 | 1.08 | 2.23 | 42.8 | 0.78 | 16.23 | 1.11 | 1.25 |
| Moorefield PW1 | 60.98 | 71.63 | 71.39 | 63.81 | 63.84 | 63.84 | 61.96 | 60.39 | 54.64 | 56.42 | 54.91 | 52.84 | 56.04 |
| Moorefield PW2 | 54.54 | 76.49 | 66.46 | 69.26 | 64.17 | 64.50 | 65.62 | 61.96 | 57.72 | 63.23 | 58.99 | 60.38 | 65.75 |

[1] source: Township of Mapleton 2009 annual summary report

### 6.2.3 Vulnerability Analysis

***Delineation of Wellhead Protection Areas***

Wellhead Protection Areas associated with the municipal water supply represents the areas within the aquifer that contribute groundwater to the well over a specific time period. Four Wellhead Protection Areas are specified, one a proximity zone and the others time-related capture zones:

- WHPA-A 100m radius from wellhead
- WHPA-B 2-year Time-of-Travel (TOT) capture zone
- WHPA-C 5-year TOT capture zone
- WHPA-D 25-year TOT capture zone

***Modelling Approach for the Drayton and Moorefield Well Supply Systems***

The Township of Mapleton delineated Wellhead Protection Areas as part of their previous groundwater management study (Golder, 2006a). The Wellhead Protection Areas were delineated using a regional scale MODFLOW model for the Township of Mapleton and the southern half of Wellington-North. The model was constructed and calibrated with available hydrogeological data and hydrogeological mapping products as described in the Groundwater Protection Study report (Golder, 2006a). The pumping rates used in developing the capture zones were based on a forecast of anticipated future groundwater use and are provided in **Table 6-12**.

**Table 6-12: Pumping Rates Used for Wellhead Protection Area Delineation of Drayton and Moorefield Well Supply Systems**

| Supply Wells | Pumping Rate Used |
|---|---|
| Drayton PW1/2 | 1,208 $m^3$ / day |
| Moorefield | 225 $m^3$ / day |

To develop Time of Travel capture zones, groundwater particles were released at the pumping wells in the models and tracked backwards towards their source of origin (recharge). At each well location, particles were released in all hydrostratigraphic units “open” to the wellbore. The time-related pathlines that are subsequently generated by the model from this analysis are then overlain and a single Time of Travel capture zone drawn around the “family” of pathlines generated at each well. To check the capture areas generated from the backward tracking analysis (and in some cases to refine the Time of Travel outline produced) a series of forward particle tracking simulations were completed. The resulting capture zone from this process represents the two-dimensional (2-D) projection of the particle outlines to ground surface. The models infer that the groundwater flow systems are equivalent porous media at the scale of the time-related capture zones under consideration. While groundwater flow in bedrock aquifers occurs primarily in the fractures, the use of an equivalent porous medium approach can still provide a reasonable approximation of the time of travel related capture zones of a bedrock supply well provided the scale of observation is much greater than the scale of individual fractures, and consideration is given to the selection of a reasonable “effective” porosity. The effective porosity assumed for the travel time calculations was 5% (Golder, 2006a).

***Delineation of the Drayton and Moorefield Wellhead Protection Areas***

The locations and orientations of the Drayton and Moorefield Wellhead Protection Areas are shown in **Map 6-11** and **Map 6-12,** respectively.

The Drayton capture zones extend in a north-east direction from the well up gradient of regional groundwater flow in the bedrock. The WHPA-D zone extends approximately 6 km from the well and the total Wellhead Protection Area covers an area of 1,082 ha. The Moorefield capture zones also extend in a north-east direction. The Wellhead Protection Area is 4 km long and approximately 900 m wide with a total area of 236 ha.

**Delineation of WHPA-E and WHPA-F for the Drayton and Moorefiled Wellhead Protection Areas**

~~The Technical Rules (MOE, 2009b) require that all wells that are identified as GUDI (groundwater under the direct influence of surface water) delineate an additional protection zone that is representative of its surface water vulnerability, known as a WHPA-E. GUDI wells are identified in accordance with subsection 2 (2) of O. Reg. 170/03 (Drinking Water Systems) of the Safe Drinking Water Act, 2002.~~

None of the wells in this study have been identified as GUDI, therefore delineation of a WHPA-E was not required. The Technical Rules also require that a WHPA-F be delineated for a well when the wells Wellhead Protection Area contains a WHPA-E and a drinking water Issue is identified that originates outside of the areas WHPA-A through WHPA-E. Since a WHPA-E was not required for any of the wells, the delineation of a WHPA-F was also not required.

***Uncertainty of the Delineation of the Drayton and Moorefield Wellhead Protection Areas***

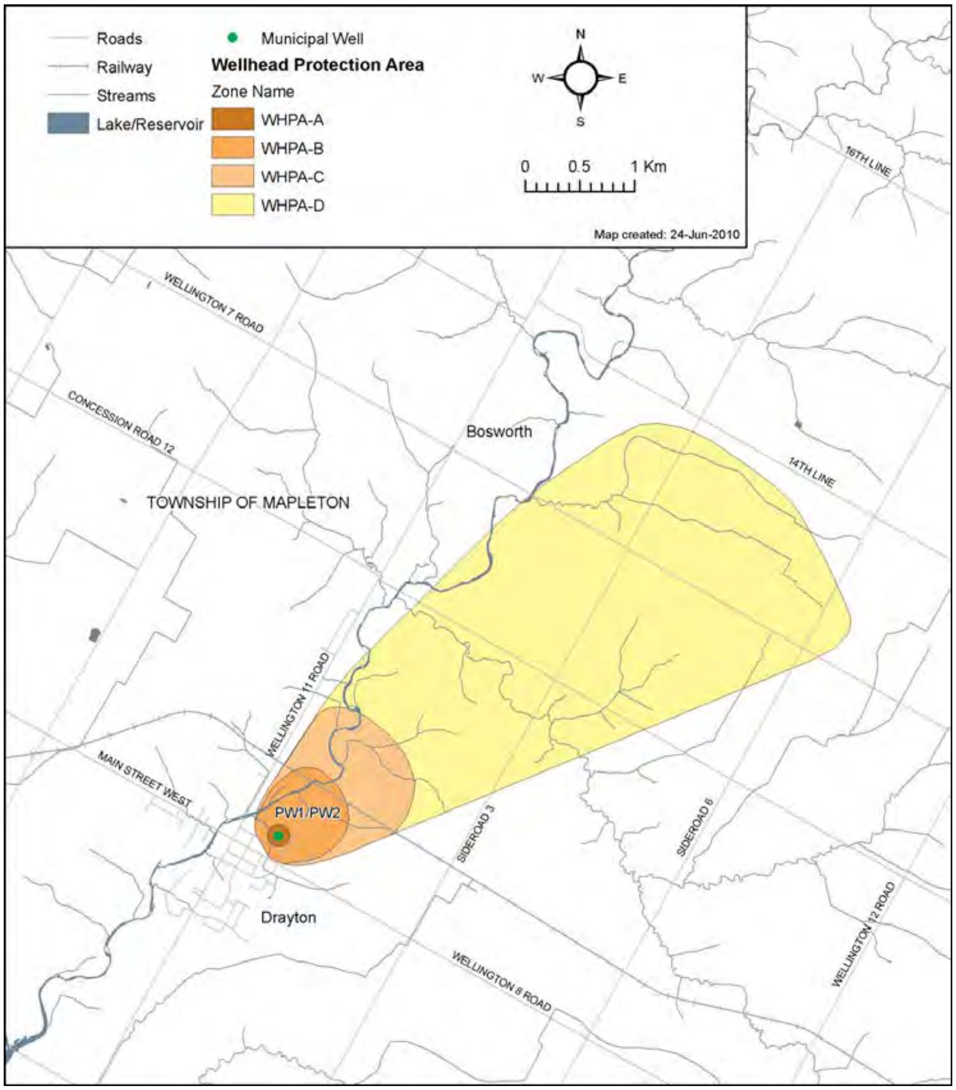
The delineation of the Wellhead Protection Areas was completed by Golder in the Wellington County Groundwater Protection Study, 2006 through the use of a MODFLOW groundwater model. The model was completed based on a number of simplifying assumptions that incorporate some level of uncertainty that is dependent on the nature, spatial distribution and density of available data.

The groundwater model was calibrated to represent steady state conditions in the aquifer using static water levels from 1,323 points. The NRMS error for the calibration is reported as being 4.5% which is considered to be within the acceptable limits of less than 10% for numerical models (Golder, 2006a). Model boundary conditions included river boundaries, constant head boundaries and pumping well boundaries.

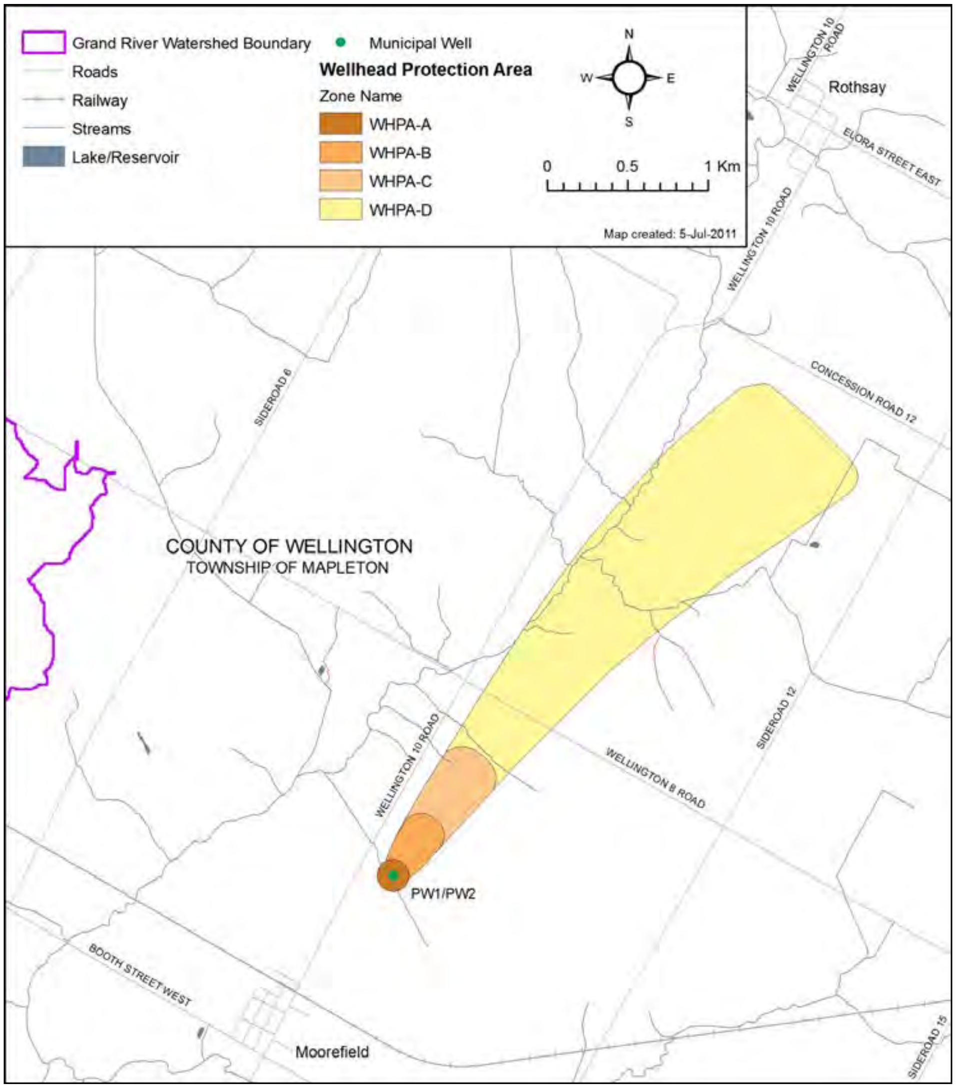
Uncertainties within the model are associated with limitations in the availability of subsurface information and can be related to projected variability in the aquifer properties (e.g. hydraulic conductivity; porosity) or uncertainties with the conceptual model (e.g. groundwater-surface water interactions; location of flow boundaries; recharge rates; continuity in aquitards; direction of regional groundwater flow). To account for some of these uncertainties Golder has applied a factor of safety to the Wellhead Protection Areas. The factor of safety has been applied to two components of the Wellhead Protection Areas; the width and length of the capture zones were increased by 20% to account for uncertainty in the hydraulic characteristics of the aquifer system and the orientation of the capture zone was adjusted by 5 degrees (plus and minus) along its centre line to account for some uncertainty in the regional flow direction by increasing the width of the capture zones at increasing distances from the pumping well. This reflects the concept that the available data is typically concentrated around the pumping well and that the uncertainty in the hydrogeological understanding increases at increasing distances from the supply wells (Golder, 2006a).

Based on the calibration results of the model and the safety factor applied to the Wellhead Protection Areas the uncertainty of the delineations can be considered low.

**Map 6-11: Drayton Well Supply Wellhead Protection Area**



**Map 6-12: Moorefield Well Supply Wellhead Protection Area**



### *Vulnerability Scoring in Wellhead Protection Areas*

The completion of aquifer vulnerability scoring is outlined under Part VII, subsection VII.3 of the Technical Rules (MOE, 2009b). Mapping for this study was completed in three stages: i) development of aquifer vulnerability mapping ii) update of vulnerability due to transport pathways and iii) assignment of vulnerability scores.

Aquifer vulnerability mapping was completed by the GRCA using the Surface to Aquifer Advection Time (SAAT) approach. The SAAT approach estimates the average time required by a water particle to travel from a point at the ground surface to the aquifer of concern. The SAAT is approximated by using the vertical component of the advective velocity integrated over the vertical distance and the average porosity. The travel times generated are categorized into groups being <5 years, 5 to 25 years and > 25 years.

The GRCA retained Earthfx to complete the vulnerability mapping using the SAAT method for most of the Grand River watershed (Earthfx, 2008). The regional mapping was reviewed on a local scale in the vicinity of the water supply wells. The vulnerability mapping was refined based on the following considerations: bedrock outcrops, surficial geology, overburden thickness, SAAT point values and hydrogeological interpretations. There were no adjustments made to the Drayton and Moorefield SAAT ratings (Golder, 2010a). The SAAT travel times were grouped to create ratings which were then used to construct an aquifer vulnerability map of the study area. Time of Travel values less than 5 years are rated as High Vulnerability. Values between 5 and 25 years are Medium vulnerability. Any value greater than 25 years is classified as having a Low Vulnerability. The various vulnerability ratings based on the travel times is shown in **Table 7-16**. The instrinsic vulnerability for Drayton and Moorefield are shown on **Map 6-13 and Map 6-15.**

**Table 7-16: SAAT Vulnerability Ratings**

| Time of Travel (years) | Vulnerability Rating |
|---|---|
| <5 | High |
| 5 to 25 | Medium |
| >25 | Low |

A vulnerability score is assigned to each vulnerable area according to the groundwater's susceptibility to becoming contaminated and that contamination reaching a well (Technical Rules, MOE, 2009b). Within Wellhead Protection Areas, the vulnerability score is determined based on overlaying the aquifer vulnerability classification (high, medium, low) with the defined Wellhead Protection Areas. The vulnerability scoring was completed in accordance with Rule 82 of the Technical Rules. Vulnerability scores range from 10 for areas with the highest vulnerability to 2 for areas with low vulnerability. Scores were assigned as per Table 2(a) in Part VII of the Technical Rules (MOE, 2009b). A summary of the process used to define vulnerability scores is outlined in Chapter 3.the **Table 7-17.**

**Table 7-17: Wellhead Protection Area Vulnerability Scores - SAAT**

| | SAAT Times | | |
|---|---|---|---|
| **Time of Travel Zone (WHPA)** | **0 to 5 years (High)** | **5 to 25 Years (Medium)** | **>25 Years (Low)** |
| WHPA-A (100m) | 10 | 10 | 10 |
| WHPA-B (2 year TOT) | 10 | 8 | 6 |
| WHPA-C (5 year TOT) | 8 | 6 | 2 |
| WHPA-D (25 year TOT) | 6 | 4 | 2 |

Aquifer vulnerability mapping for Drayton and Moorefield is provided on **Map 6-14 and Map 6-16** respectively. In both WHPAs, the vulnerability score for WHPA-A is 10, WHPA-B is 6, and WHPA-C and WHPA-D is 2. The mapping illustrates that the study area is rated as having a low vulnerability. This is a reflection of the fine-grained till overburden located in the area ranging from 60 to 70 m in thickness providing protection from contaminants reaching the municipal aquifer.

**Uncertainty in the Vulnerability Scoring for the Drayton and Moorefiled Well Supply Systems**

Vulnerability assessment was completed by Earthfx on behalf of the GRCA in 2008 and was based on the SAAT. The SAAT calculation was based on a number of empirical formulae provided in past guidance documents from the MECP~~OE~~. Detailed descriptions of the methodology and associated assumptions for these calculations are included in the report entitled *Aquifer Vulnerability mapping for Norfolk, Brant Counties, Catfish Creek and Kettle Creek watershed* (Earthfx, 2008).

The calculation of SAAT is made up of two components; the unsaturated zone advection time (UZAT) and the water table to aquifer advection time (WAAT). In the Earthfx study both components were computed based on simplifying assumptions included in MECP~~OE~~ provided formulae. It was noted that the UZAT was computed based on estimates for groundwater recharge derived from a GAWSER model. Also values for specific yield of soils were obtained from existing literature. The results of the UZAT analysis showed a high degree of variance which may be attributed to variance in the input GAWSER model. The results of the analysis indicate that there is a 95.5 % certainty that the UZAT time calculated is within +/-42 years of the actual time at any well. This indicates that the variability of the UZAT value (margin of error) is greater than the divisions of the vulnerability range i.e. the vulnerability could vary across the entire range of classifications from low to medium or high based on its margin of error. The potential for this high variation indicates that the uncertainty related to this component is high.

UZAT was computed at various water well points across the study area. There was considerable effort made within the study to improve the quality of the locational and lithologic data provided by each data point. In this regard only wells with a location accuracy of less than 100 m were used as part of the study. It can be interpreted that the computations performed represented values that were correct locationally across the study area.

The second component of the SAAT vulnerability, WAAT, was computed based on a formula provided by the MECP~~OE~~ and was applied in areas where the target aquifer was known to be confined or where no aquifer material was recognized. The calculation assumes that flow within this zone can be approximated by the Darcy law for groundwater flow. The results of a statistical analysis indicate a high variance in the computed values which points to a high variance and high degree of uncertainty in the underlying data. The computation is known to be dependent on estimates of hydraulic properties, and interpolation of potentiometric surfaces which are based on sparse and unreliable data. The resulting product can be regarded as being an amalgamation of all the primary data uncertainties. Based on the uncertainty associated with the input data it is concluded that the WAAT calculation can be regarded as having a high uncertainty.

Finally the SAAT is derived by combining the previously discussed components of UZAT and WAAT. It is noted that the UZAT was computed using a GAWSER model to estimate recharge. The GAWSER model is known to be built on certain simplifying assumptions that have not been expounded in the background report from Earthfx. In light of this no level of uncertainty can be attached to the results of this model. Using the results of the UZAT and WAAT calculations as outlined in the Earthfx report it is concluded that the level of uncertainty associated with the computation of SAAT is high. While the corrections applied to well locations resulted in locationally correct analyses, the underlying uncertainty in the computations themselves results in an overall ranking of high uncertainty for the process.

Earthfx performed a comparative analysis of vulnerability methods using Intrinsic Susceptibility Index (ISI) to compare with the values for SAAT. It was indicated that the SAAT ranking compared favourably to the ISI in the high vulnerability areas with more significant deviations in the medium and low ranked areas. The statistical analysis performed on the ISI however indicated that there was also a high uncertainty in these values.

The delineation of the Wellhead Protection Areas and the scoring of the vulnerable areas for the Township of Mapleton were completed using the most up to date models and information available for the area. Although there is some uncertainty involved the groundwater model, the amount of data available, the processing of this data to use only the highest quality data, and the use of conservative assumptions to account for uncertainty was sufficient to conclude that the uncertainty of the Wellhead Protection Areas delineations for the Drayton and Moorefield Well Supply systems is low.

The evaluation of the vulnerability indicated that due to variability in the underlying data the resulting uncertainty of vulnerability is considered to be high. This is despite the efforts to improve the spatial accuracy of some of the data points and also despite up to date approaches. It will be important to revisit the assumptions made as part of the assessment to try and develop methods to reduce the uncertainty associated with these values.

***Identification of Transport Pathways and Vulnerability Adjustment***

Rules 39 to 41 of the Technical Rules (~~MOE, 2009b~~MOECC, 2017) allows for an increase in vulnerability rating of an aquifer due to the presence of transport pathways that may increase the vulnerability of the aquifer by providing a conduit for contaminants to bypass the natural protection of the aquifer.

~~Transport pathways are developed where natural or man-made features in the aquifer provide a path along which contaminants can migrate to the regional aquifer. The presence of the transport pathways should be accounted for in the vulnerability assessment and these pathways may include private water wells, unused water wells, abandoned water wells, construction of underground services, subsurface excavations, pits and quarries. The vulnerability of an area may be increased from low, to medium or high and from medium, to high based on the presence of transport pathways.~~

~~The Technical Rules indicate that the following factors should be considered when evaluating whether the vulnerability of an area is increased:~~

~~Hydrogeological conditions;~~

~~Type and design of any transport pathways;~~

~~The cumulative impact of any transport pathways; and~~

~~The extent of any assumptions used in the assessment of the vulnerability of the groundwater~~

***Transport Pathways in the Drayton and Moorefield Wellhead Protection Areas***

A review of water well records from the ~~MOE~~ MECP water well database and a field survey were conducted to identify wells within the Wellhead Protection Areas. The wells were then ranked based on their risk to the supply aquifer. The survey resulted in the identification of 32 water wells within the Drayton Wellhead Protection Areas and classified 18 of the wells as high risk wells.

Five water wells were identified in the Moorefield Wellhead Protection Areas and three were classified as high risk wells and had their locations field verified.

Septic systems are considered transport pathways as they can provide a conduit for contaminants to travel through the ground to the water table. Septic systems are generally built in the upper few metres of the sub-surface and consist of a tank and drainage tiles which distribute effluent allowing it to infiltrate back into the ground. In the case of thin confining layers or in unconfined aquifer conditions, these shallow penetrating systems may present a significant conduit for contaminants to the aquifer of concern. Both Drayton and Moorefield have municipal sewage collection systems, however septic systems may still be present that were used before servicing was available. In ground individual septic systems are assumed present at all rural residences outside of the serviced areas. The municipal aquifer for the Drayton and Moorefield water supply wells is a confined aquifer that are overlain by greater than 20 m of fine grained sediments. In this study individual septic systems are not considered to constitute a transport pathway due to their relatively shallow depth of penetration.

Utilities that are constructed in the sub-surface are potential transport pathways as the disturbed soil surrounding them can provide a pathway for contaminants to enter into the aquifer below. Utilities that may act as transport pathways include storm-water trunk sewers and sanitary infrastructure. The depth of excavation for the construction of utilities will determine the risk that the wells pose on the municipal supply aquifer. Since the aquifers used by the municipal supply wells are generally protected by an upper aquitard, the risk for transport pathways to be created due to utilities is low.

Surface water features can be considered transport pathways as they can create a short cut to the aquifer for contaminants, especially when the features are man-made such as man-made ponds, dugouts and aggregate extraction ponds. Based on the hydrogeology of the areas, the aquifer utilized by the municipal wells is protected by a thick aquitard, thus most constructed surface water features should have little to no connectivity with the regional aquifer.

Aggregate operations are defined as activities that involve the extraction of material from the surface and in the current study include both pits and quarries. Pits and quarries present a transport pathway as their creation serves to remove a potential layer or layers of protection from the regional aquifer. In some cases, these excavations may extend to below groundwater table in which case the pit or quarry is a direct conduit to the aquifer that the municipal source may be a part of.

As part of the current study aggregate operations have been mapped based on existing databases and the review of aerial photography and satellite imagery along with a windshield survey of the Wellhead Protection Areas. There were no aggregate operations located within the Wellhead Protection Areas.

#### Uncertainty of Transport Pathways within the Drayton and Moorefield Wellhead Protection Areas

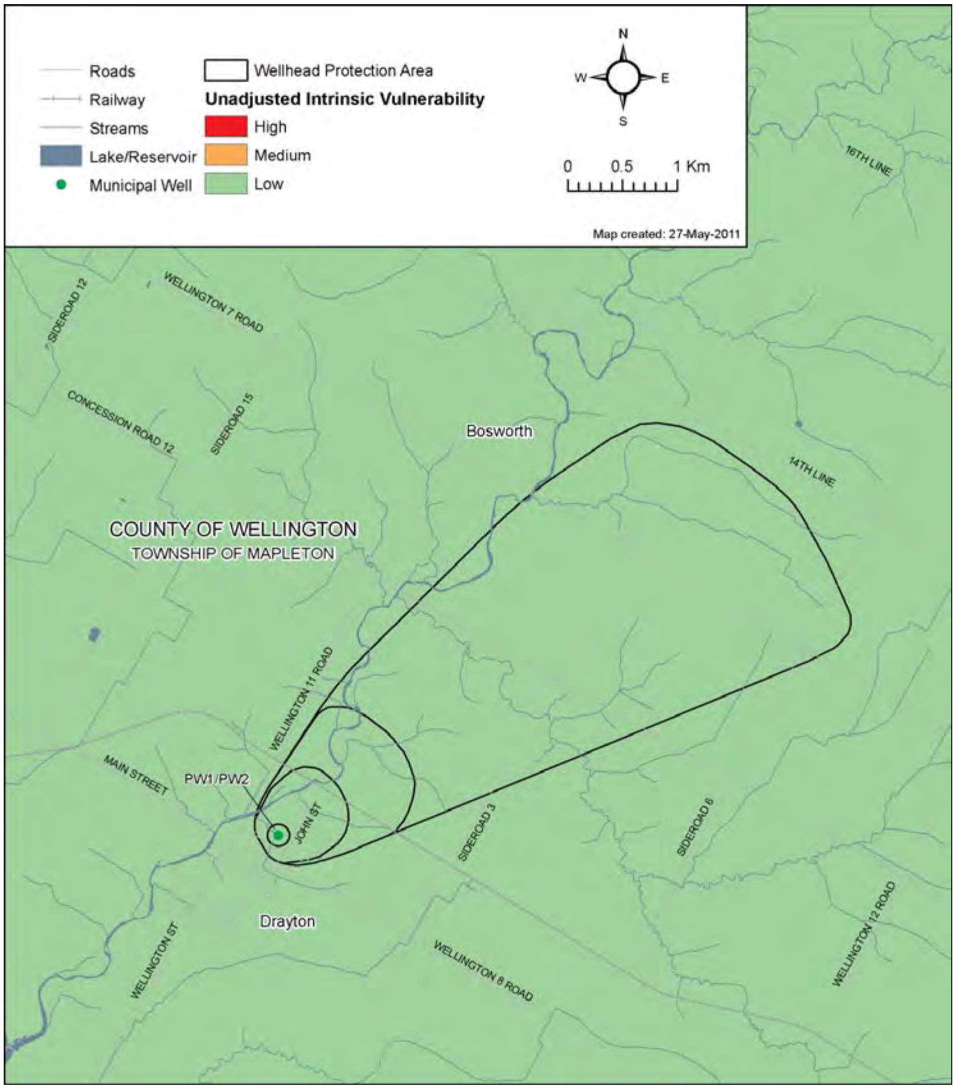
In the Drayton and Moorefield Wellhead Protection Areas the aquifer vulnerability was modified to consider increases in vulnerability due to transport pathways. In this area only well locations were considered to increase the vulnerability of an area. To decrease the uncertainty in the location and risk of the wells mapped, a field verification survey was completed. This survey sought to verify the location of wells included in the various Wellhead Protection Areas and also evaluate the visual condition of these wells. The information gathered during the field verification exercise was used to update the project database, and formed the basis for the determination of the adjustment of vulnerability. When a well was not located in the field, the risk was assigned based on information provided in the MECP~~OE~~ well records.

***Adjusted Vulnerability Scoring for the Drayton and Moorefield Wellhead Protection Areas***

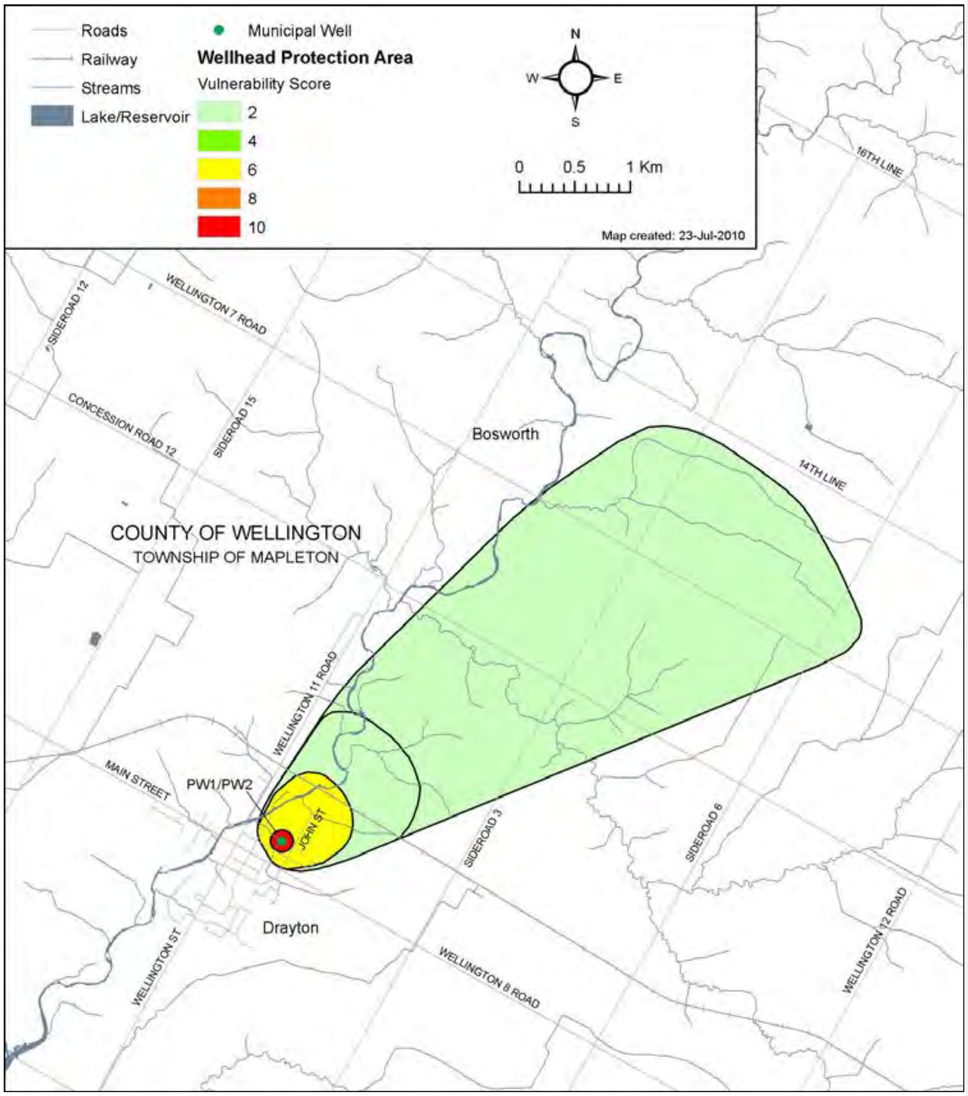
The increase in vulnerability as a result of transport pathways is generally limited to one rank (low to medium or medium to high) except in extreme cases where the constructed pathway is considered to increase the vulnerability of the aquifer from low to high. These cases may occur at pits or quarries that completely breach any low permeability layers overlying a deeper aquifer. To account for the presence of high risk wells as potential transport pathways, increases in vulnerability may be applied in areas with a high density of high risk wells.

For this evaluation a visual survey of high risk well locations was undertaken. Since there were no areas within the current study that had a significant concentration of high risk wells, no increases in vulnerability were made.

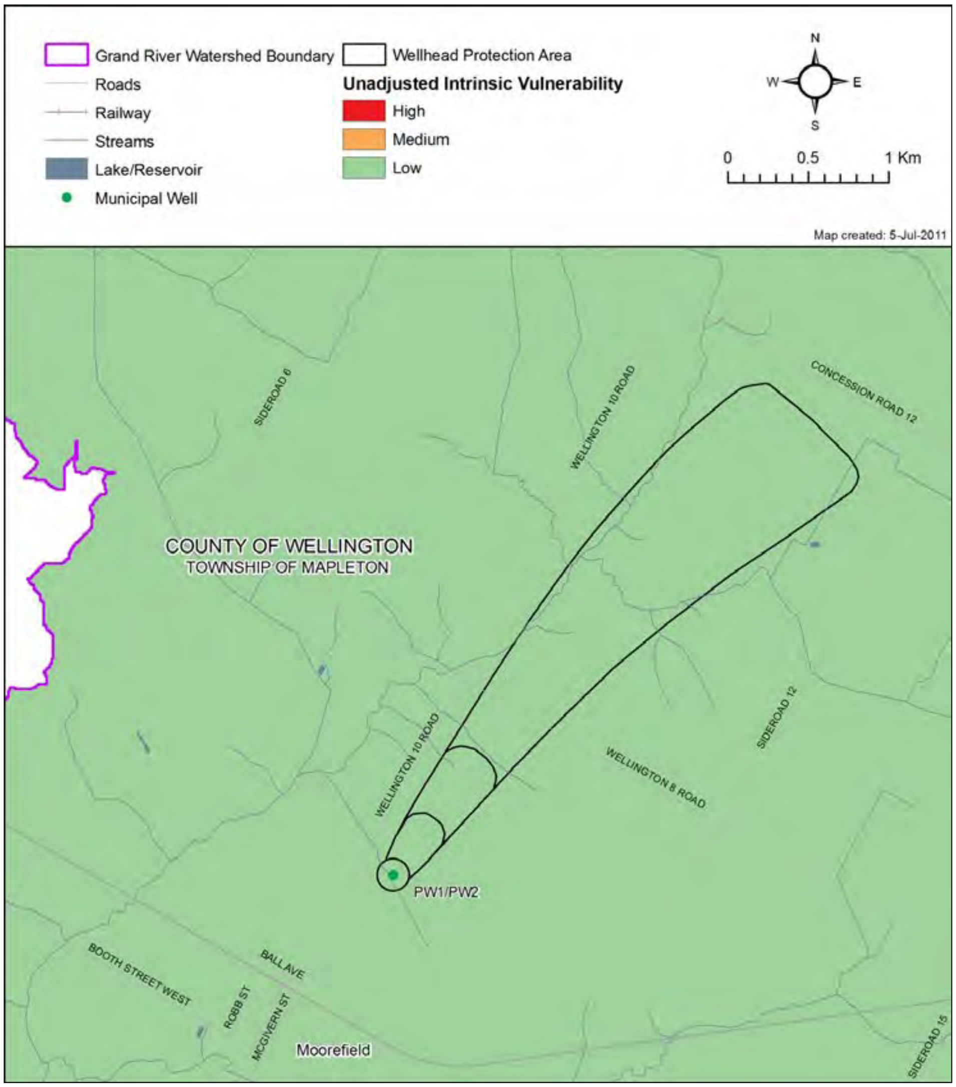
**Map 6-13 Drayton Well Supply Unadjusted Intrinsic Vulnerability**



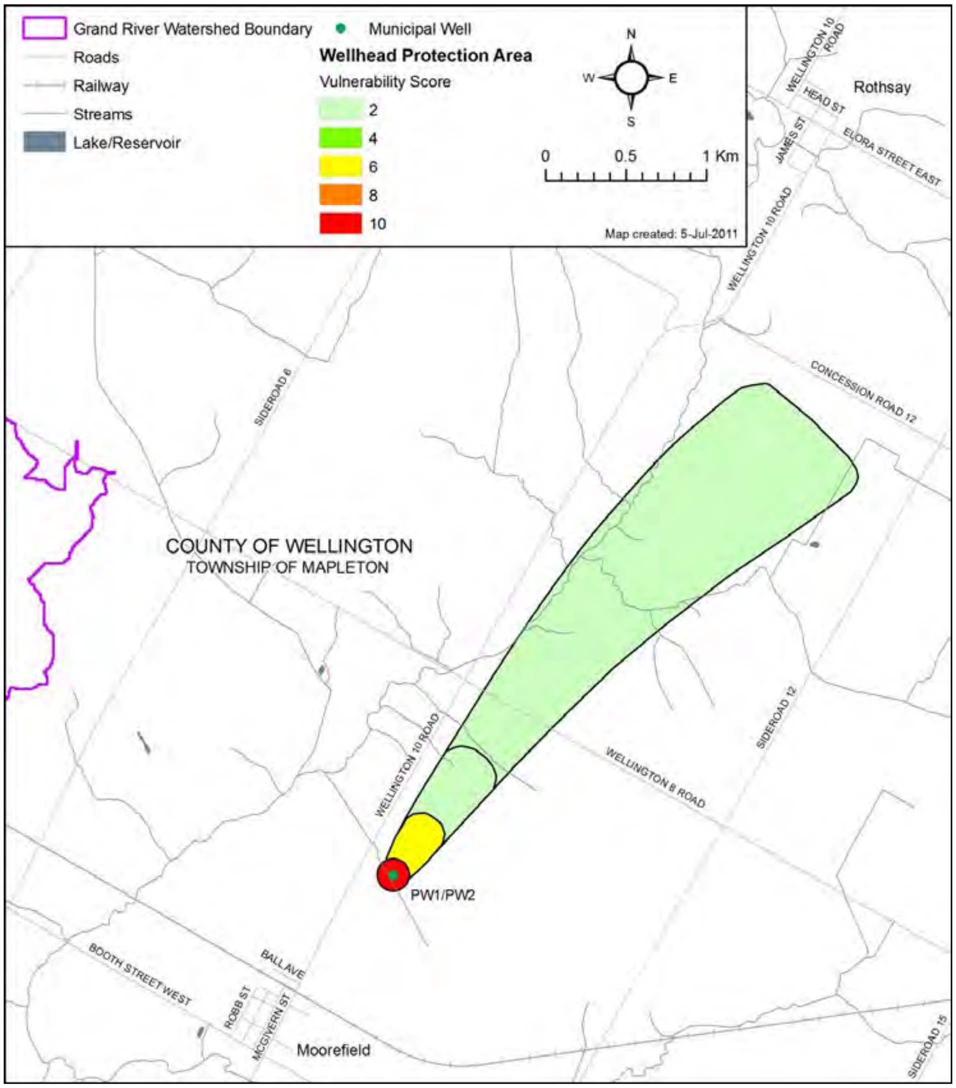
**Map 6-14: Drayton Well Supply Wellhead Protection Area Final Vulnerability**



**Map 6-15 Moorefield Well Supply Unadjusted Intrinsic Vulnerability**



**Map 6-16: Moorefield Well Supply Wellhead Protection Area Final Vulnerability**



***Managed Lands within the Drayton and Moorefield Wellhead Protection Areas***

Managed land is defined as any land to which there may be the application of agricultural source material (ASM), commercial fertilizer, or non-agricultural source material (NASM). Managed land includes the following crop land, fallow land, improved pasture, golf courses, sports fields and lawns. ~~Managed land can be broken down into two subsets; agricultural and non-agricultural managed land. Agricultural managed land includes cropland, fallow and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses (turf), sports fields, lawns (turf) and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer). The storage, handling and application of pesticides, fertilizers and agricultural source material associated with managed land and agricultural activities can result in surface water runoff and potential pathogen and chemical contamination.~~

~~To measure the impacts from these activities on water supplies a methodology was developed by the GRCA in association with the MOE for the evaluation of percentage of managed land within each vulnerable area. The methodology is described in detail in a technical bulletin issued by the MOE in December 2009 and titled "Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source material, Non-Agricultural Source Material and Commercial Fertilizers."~~

~~Under the methodology the percentage of managed land is computed based on the land area associated with that vulnerable area or area within the vulnerable area. The percentage of agricultural managed lands are also evaluated separately from the overall managed land percentages. The overall percentage of managed land is used to categorize the landscape for further analysis of threats through the MOE provided Tables of Drinking Water Threats. For areas where the managed lands total accounts for less than 40% of the vulnerable area, the area is considered to have a low potential for nutrient application to cause contamination of drinking water sources. If the managed lands total accounts for 40% to 80% of the vulnerable area then the area is considered to have a moderate potential for nutrient application to cause contamination of drinking water sources. If the managed land total accounts for over 80% of the vulnerable area then the area is considered to have a high potential for nutrient application to cause contamination of drinking water sources.~~

Calculation of the percentage of managed lands was done in accordance with Technical Rule 16(9) (~~MOE, 2009b~~MOECC, 2017) with details outlined in Chapter 3. ~~Mapping the percentage of managed lands area is not required where the vulnerability score for an area is less than the vulnerability score necessary for the activity to be considered a significant threat. Therefore, the percentage of managed lands was only calculated where the vulnerability score in each Wellhead Protection Areas was 6 or greater.~~

The results of the calculations for managed lands are provided in **Table 6-13**, **Map 6-17** and **Map 6-18** for the Drayton and Moorefield Wellhead Protection Areas. A coding of N/A indicates that the vulnerability score in this area is 4 or less, and this area has not been assessed.

**Table 6-13: Managed Lands Percentage in the Drayton and Moorefield Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Mapleton | Drayton | PW1/ PW2 | 48.04% | 76.34% | N/A | N/A |
| | Moorefield | PW1/ PW2 | 44.82% | 98.04% | N/A | N/A |

***Livestock Density within the Drayton and Moorefield Wellhead Protection Areas***

Livestock density is used as a surrogate measure of the potential for generating, storing and land applying ASM as a source of nutrients in vulnerable areas. The livestock density is expressed as nutrient units per acre (NU/Acre) and is calculated based on the number of animals housed, or pastured on a farm unit that generate enough manure to fertilize an area of land. Detailed methods for livestock density calculations is outlined in Chapter 3.

~~Livestock density is combined with the results of the computations for percentage agricultural managed land for the purposes of determining the circumstances related to the application of nutrients and the associated threats as defined by the MOE's Table of Drinking Water Threats.~~

~~For the current study, both livestock density and the managed land calculations were completed by the GRCA. The methodology used was consistent with the methodology provided in the MOE publication "Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source material, Non-Agricultural". The resulting analyses and the interpreted data was incorporated into the project database and utilized for the subsequent evaluations of threat raking.~~The results of the calculations for livestock densities are provided in **Table 6-14, Map 6-19,** and **Map 6-20**, for the Drayton and Moorefiled Wellhead Protection Areas.

**Table 6-14: Livestock Density (NU/acre) in the Drayton and Moorefield Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Mapleton | Drayton | PW1/ PW2 | 0 | 0.80 | N/A | N/A |
| | Moorefield | PW1/ PW2 | 0 | 0 | N/A | N/A |

The coding of 0 indicates that there were no agricultural livestock barns to contribute nutrients and therefore the value for livestock density is 0. The coding of N/A indicates that the vulnerability score in this area is 4 or less, and this area has not been assessed.

***Percent Impervious Surface Area in Wellhead Protection Areas***

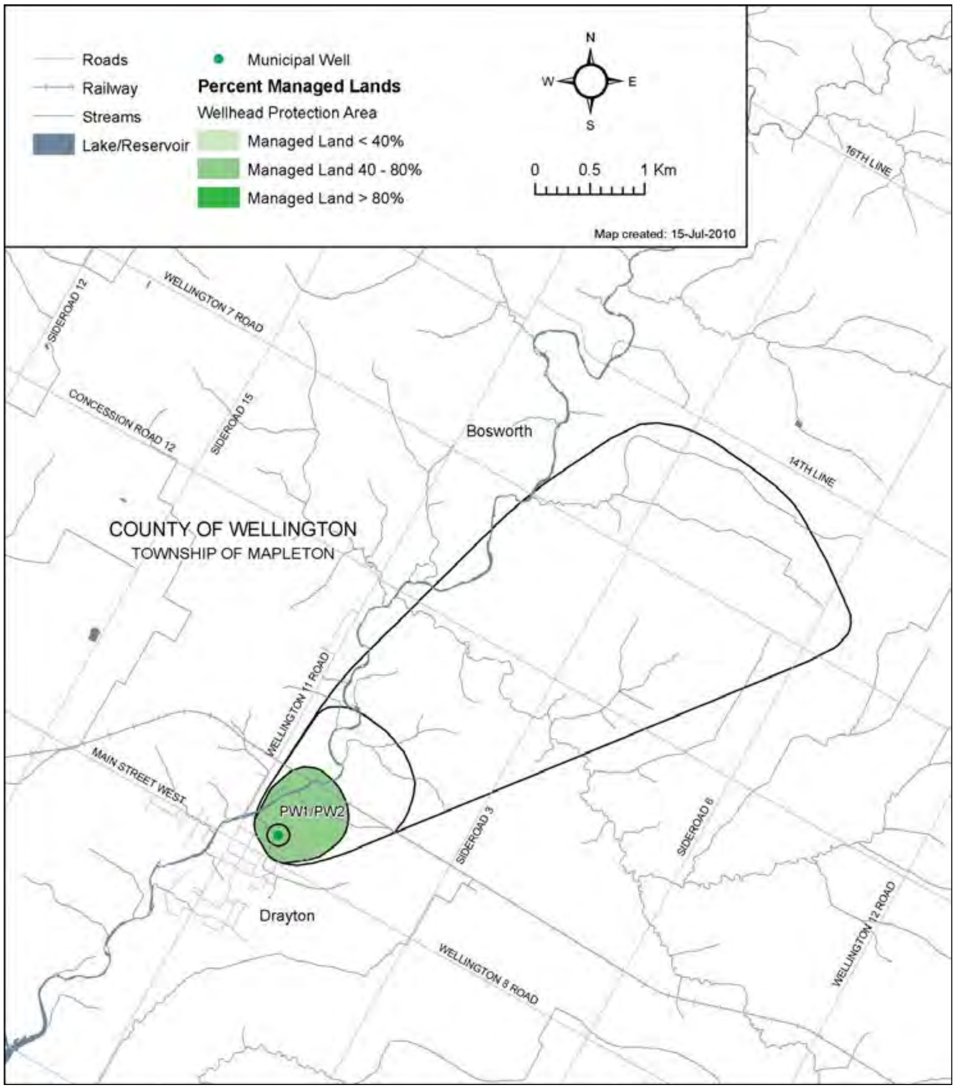
Road salt used during winter road maintenance is regarded as a threat. Generally road salt application rates depend on the amount of traffic a road receives and weather conditions.

To calculate the percent impervious surface, information on land cover classification from the Southern Ontario Land Resource Information system (SOLRIS) was used. This provided land use information, including road and highway transportation routes, as continuous 15x15 metre grid cells across the entire Source Protection Area. All the cells that represent highways and other impervious surfaces used for vehicular traffic were re-coded with a cell value of 1 and all other land cover classifications were given a value of 0, to identify impervious surface areas.

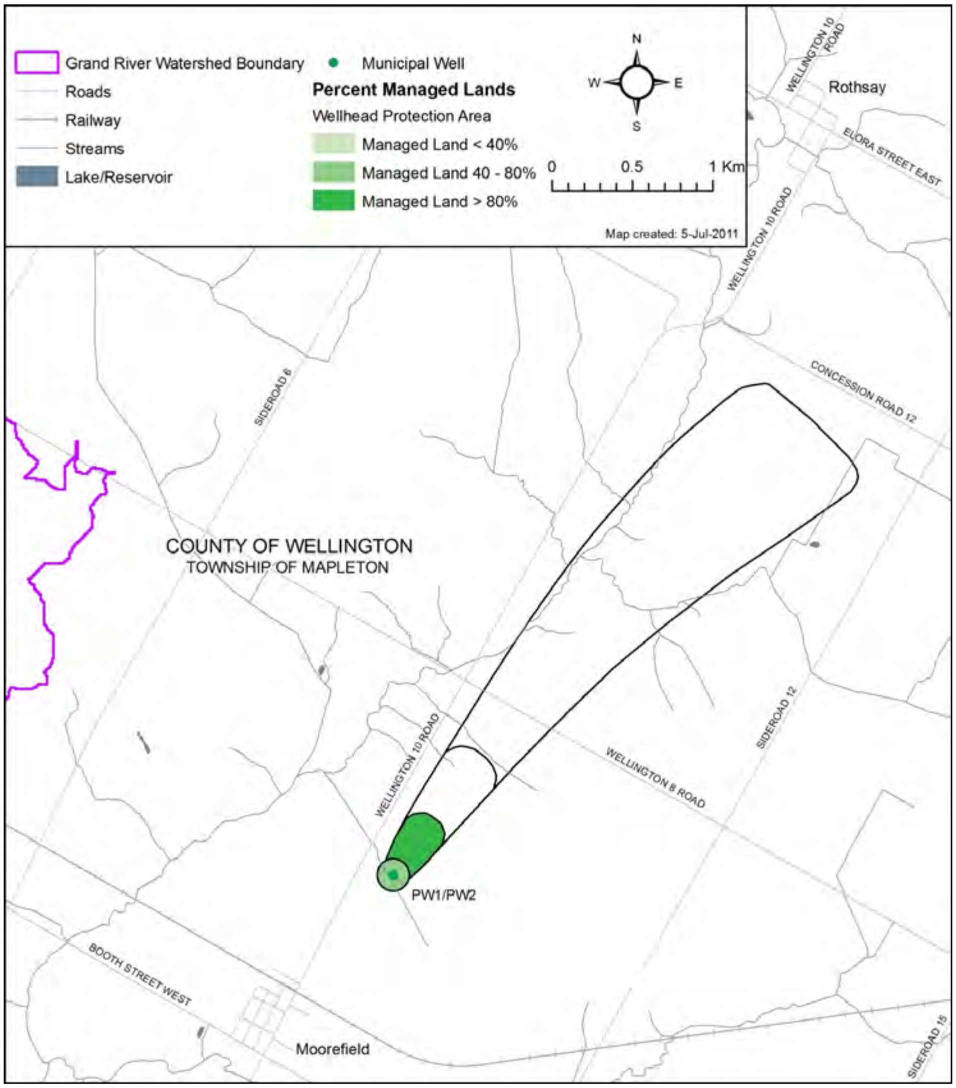
Then, a focal sum moving window average was applied using the Spatial Analyst module of the ArcGIS software. For each 15x15 metre cell, the total number of neighbouring grid cells coded as impervious, within a 1x1 kilometre search area, was calculated. This total was then converted into the percentage of impervious surface by land area, using the area of each cell (225 sq. m) and the area of the moving window (1 sq. km). This provides a 1x1 kilometre moving window calculation of percent impervious surface, represented in 15x15 metre spatial increments. This dataset was calculated for the entire Source Protection Area, but was clipped to show those results only in the Wellhead Protection Areas and Intake Protection Zones. The analysis is more representative of road density and is better than the method described in the Technical Rules. As per Technical Rule 15.1, the Director has confirmed his agreement with the departure. The Director's letter of confirmation can be found in **Appendix B.**

The percentage of impervious surfaces is an indicator for the potential for impacts due to road salting. In areas with high levels of impervious surfaces (roads) there is an increased likelihood that road salts will be applied (**Map 6-21** and **Map 6-22).**

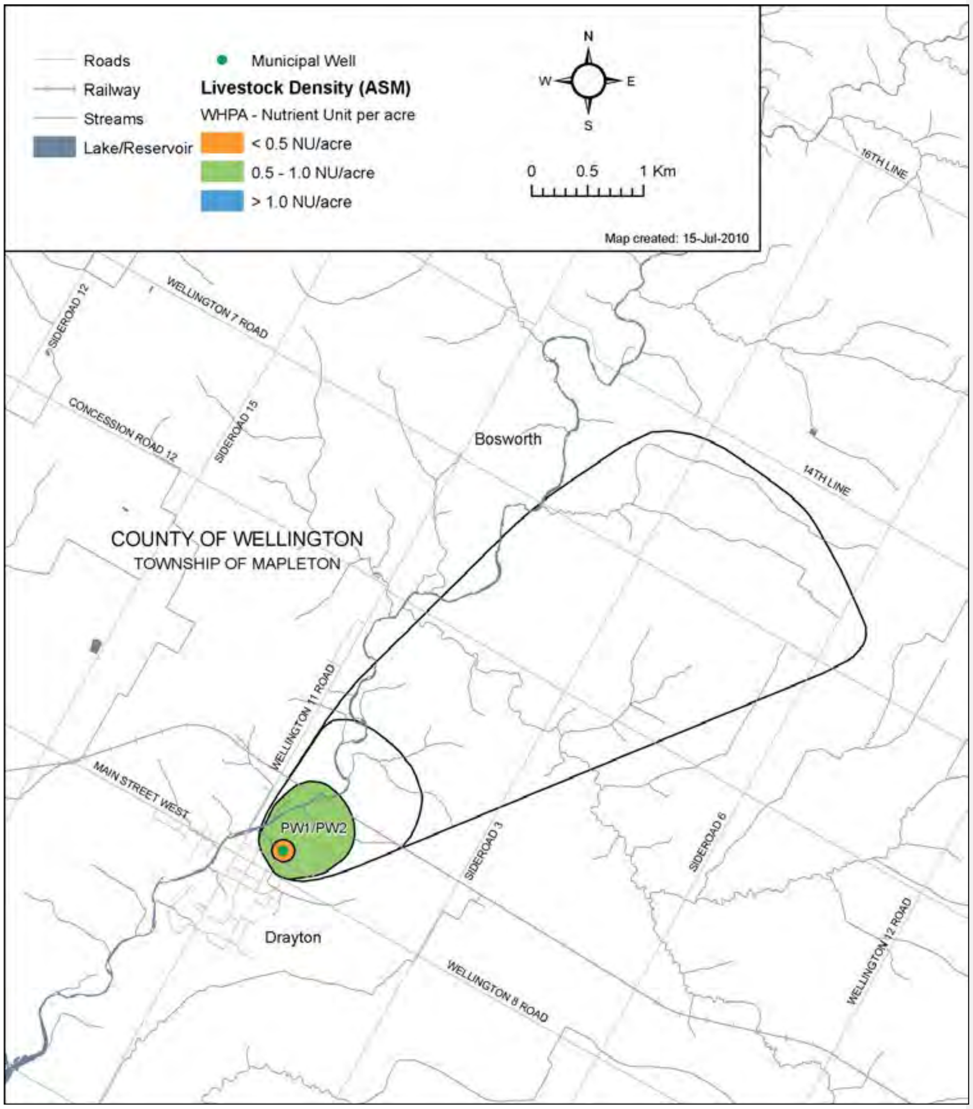
**Map 6-17: Drayton Well Supply Percent Managed Lands**



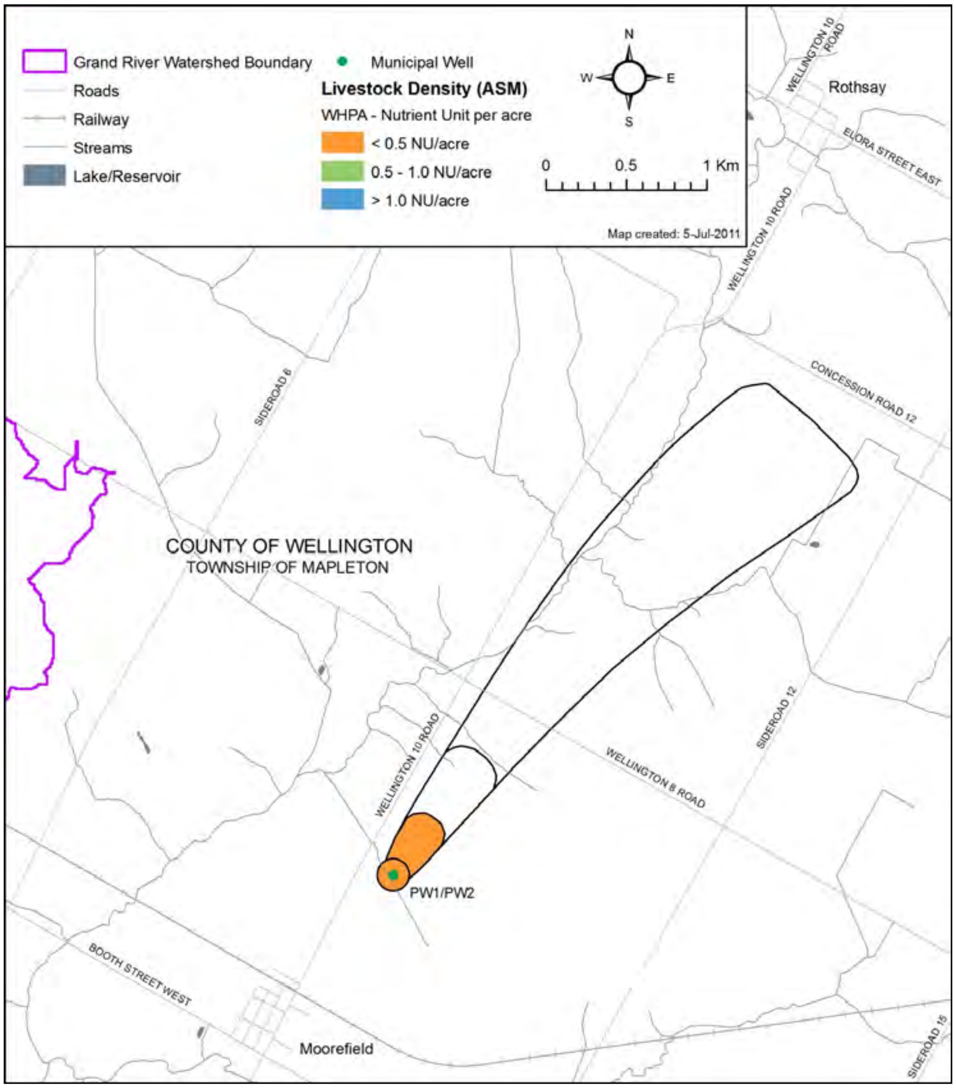
**Map 6-18: Moorefield Well Supply Percent Manged Lands**



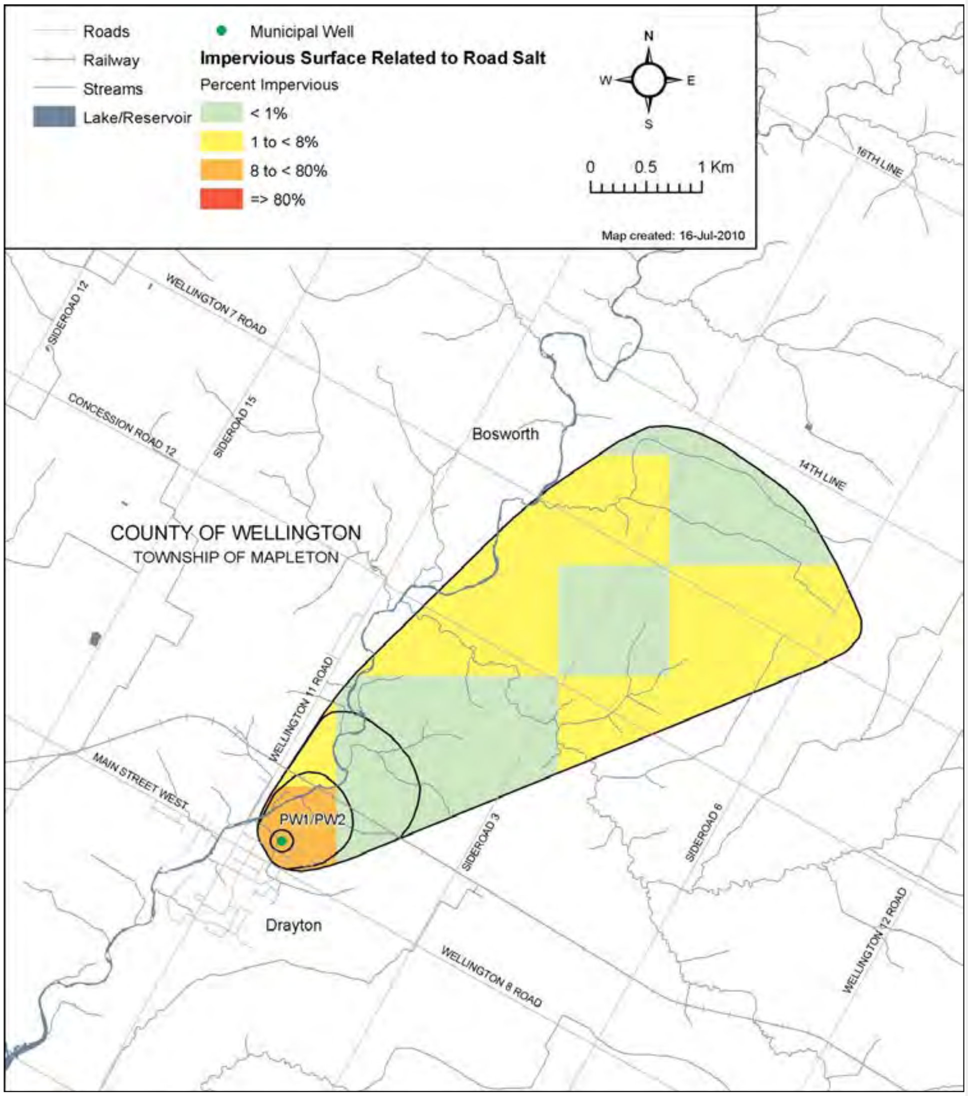
**Map 6-19: Drayton Well Supply Livestock Density**



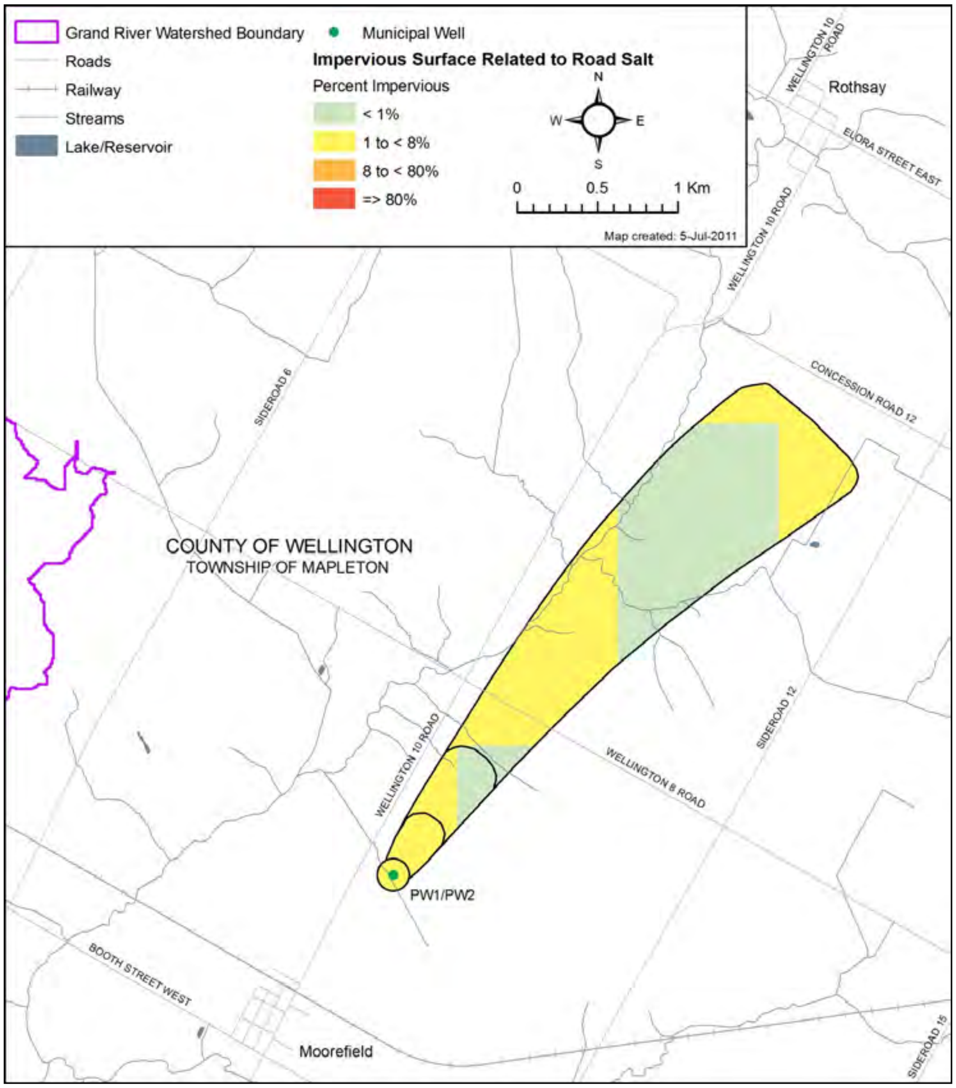
**Map 6-20: Moorefield Well Supply Livestock Density**



**Map 6-21: Drayton Well Supply Percent of Impervious Surfaces**



**Map 6-22: Moorefield Well Supply Percent of Impervious Surfaces**



### 6.2.4 Drinking Water Threats Assessment

The Ontario Clean Water Act, 2006, defines a Drinking Water Threat as "an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat." A Prescribed Drinking Water Threats table in Chapter 3 lists all possible drinking water threats.

**Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Drayton and Moorefield Well Supply**

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. The information above can be used with the vulnerability scores shown in **Map 6-14 and Map 6-16** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

**Table** 6-15 provides a summary of the threat levels possible in the Drayton and Moorefield Well Supplies for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), and Pathogens. A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map 6-14 and Map 6-16**.

**Table 6-15: Identification of Drinking Water Quality Threats in the Drayton and Moorefield Wellhead Protection Areas**

| Threat Type | Vulnerable Area | Vulnerability Score | Threat Classification Level | | |
|---|---|---|---|---|---|
| | | | Significant 80+ | Moderate 60 to <80 | Low >40 to <60 |
| Chemicals | WHPA-A | 10 | ✔ | ✔ | ✔ |
| | WHPA-B | 6 | | ✔ | ✔ |
| | WHPA-C/D | 2 | | | |
| Handling / Storage of DNAPLs | WHPA-A/B/C | Any Score | ✔ | | |
| | WHPA-D | 2 | | | |
| Pathogens | WHPA-A | 10 | ✔ | ✔ | |
| | WHPA-B | 6 | | | ✔ |

### 6.2.5 Conditions Evaluation

Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the Technical Rules (MOECC, 2017~~09~~), lists the following two criteria for groundwater sources:

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.

- The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.

The above listed criteria were used to evaluate potentially contaminated sites within the Drayton and Moorefield WHPAs to determine if such a Condition was present at a given site.

***Conditions Evaluation for the Drayton and Moorefield Well Supply Systems***
A review of available data regarding potential contamination included databases from the Ecolog ERIS results such as Record of Site Condition, MECP~~OE~~ Spills Database and Occurrence Reporting Information System.

There were no conditions identified in the Drayton and Moorefield Wellhead Protection Areas.

### 6.2.6 Drinking Water Quality Issues Evaluation

The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)). Elevated concentrations of selected parameters that are naturally occurring or where effective treatment is in place are not considered drinking water Issues.

Once a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the Issue within an Issue Contributing Area and manage these threats appropriately. If at this time the Issue Contributing Area can not be identified or the Issue can not be linked to threats then a work plan must be provided to assess the possible link.

If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are as significant drinking water threats, regardless of the vulnerability.

***Methodology for the Drinking Water Quality Issues Evaluation***
As part of the Issues evaluation, a review of the available water quality data to assess whether any contaminants are impacting or have the potential to impact or interfere with the Township of Mapleton drinking water sources. This included the following steps:

- Collection of water quality data.
- Comparison of water quality data to the ODWQS to see if any parameters were in exceedance.
- Concentrations of parameters of consideration over time were plotted to evaluate if there were any increasing trends.

***Data Sources for the Drinking Water Quality Issues Evaluation***
All available water quality data for the Drayton and Moorefield water supply wells was collected and reviewed. This included hydrogeological studies, engineering reports and MECP~~OE~~ Annual reports for the water supply systems.

***Drinking Water Issues Evaluation for the Drayton Well Supply***

The following parameters were identified as parameters of consideration: hardness, iron, and organic nitrogen.

A hardness concentration of 226 mg/L was recorded at the Drayton wells in 2001 which exceeds the Operational Guideline (OG) of the ODWQS which ranges from 80-100 mg/L (MOE, 2006b). This level is typical of drinking water obtained from a dolostone bedrock source and is naturally occurring. Hardness in water is an aesthetic objective and is typically handled using household water softeners; hardness therefore should not interfere with the use of water from these sources.

A sample from the Drayton well collected in 2001 had an iron concentration of 0.374 mg/L. This exceeds the ODWQS guideline of 0.3 mg/L. Iron is an aesthetic objective, which means that it may impair the taste, smell or colour of the water or interfere with good water quality control practices. Elevated levels of iron are typical for bedrock aquifers. Since iron is an aesthetic objective and naturally occurring it is not considered a water quality Issue under Technical Rule 114.

Organic nitrogen has an operational guideline of 0.15 mg/L in drinking water. High levels may be caused by septic tank or sewage effluent contamination, which is often associated with odour and chlorine-worsened taste problems. Organic nitrogen compounds that contain amine groups can react with chlorine to severely reduce its disinfection power. An organic nitrogen concentration of 0.53 mg/L was measured in a 2001 sample from the Drayton well which exceeds the OG. This exceedance in organic nitrogen was identified in 2001 and was from a single sample. An exceedance has not been identified in any more recent sampling.

Water quality samples are collected routinely by OCWA (Ontario Clean Water Agency) licensed operators at the Drayton water systems. Data collected between July 2006 and December 2008 was reviewed as part of this study. Analysis completed were bacteriological analyses for *E. coli* and total coliforms for raw water, and nitrate and nitrate on treated water. The treatment process does not include nitrate reduction therefore the results should be reflective of raw water quality. No Issues with total coliforms or *E. coli* bacteria have been documented.

***Summary of Water Quality Issues Evaluation for the Drayton Well Supply***

Upon review of available current drinking water quality data there are no Issues under Technical Rule 114 for the Drayton Well Supply. Iron and hardness have elevated concentrations, however are naturally occurring and therefore do not reflect a deterioration of water quality. Neither of the above parameters is currently interfering or anticipated to interfere with the use of the groundwater as a source of drinking water.

***Drinking Water Quality Issues Evaluation for the Moorefield Well Supply***

The following parameters were identified as parameters of consideration: hardness, iron, and organic nitrogen.

Organic nitrogen has an operational guideline of 0.15 mg/L in drinking water. High levels may be caused by septic tank or sewage effluent contamination, which is often associated with odour and chlorine-worsened taste problems. Organic nitrogen compounds that contain amine groups can react with chlorine to severely reduce its disinfection power. The Moorefield Well also had an exceedance of organic nitrogen in 1995, however a sample collected in 2002 did not exceed the ODWQS (Burnside, 2002a). There are no other dates for which organic nitrogen was sampled for in the data reviewed making it difficult to know if it was only a single occurrence.

Water quality samples are collected routinely by OCWA (Ontario Clean Water Agency) licensed operators at the Moorefield water system. Data collected between July 2006 and December 2008 was reviewed as part of this study. Analysis completed were bacteriological analyses for *E. coli* and total coliforms for raw water, and nitrate and nitrate on treated water. The treatment process does not include nitrate reduction therefore, the results should be reflective of raw water quality. No Issues with Total Coliforms or E. coli bacteria have been documented.

***Summary of Water Quality Issues Evaluation for the Moorefield Well Supply***
Upon review of available current drinking water quality data there are no Issues under Technical Rule 114 for the Moorefield Well Supply. Iron and hardness have elevated concentrations, however are naturally occurring and, therefore, do not reflect a deterioration of water quality as per Rule 114 of the Technical Rules (~~MOE, 2009b~~MOECC, 2017).

**Limitations and Uncertainty for the Drinking Water Quality Issues Evaluation for the Drayton and Moorefield Well Supply Systems**

The water quality data reviewed includes data from 1995 to 2008. This is a limited time span making it difficult to identify trends, especially when not all parameters were sampled during each year. It is also noted that there is no monitoring well water quality data available. Monitoring wells are only monitored for water levels as part of PTTW requirements.

### 6.2.7 Enumeration of Significant Drinking Water Quality Threats

~~The Technical Rules (MOE, 2009b) require an estimation of the number of locations at which an Activity is a significant drinking water threat and the number of locations at which a Condition resulting from past activity is a significant drinking water threat.~~

The threats enumeration was compiled using the data from various sources that were reviewed as part of this study. Following the preliminary research, field assessments were used to verify and complete the threats inventory process. As a conservative measure no effort to include the impact of management techniques that may be employed at any threat location was considered. It can therefore be concluded that the level of uncertainty associated with this enumeration is high. A re-evaluation of the prioritized threats is required if the level of uncertainty associated with the current results is to be reduced.

***Data Sources for the Enumeration of Significant Drinking Water Quality Threats***
The threats inventory was compiled using the data and information sources outlined below. All threats were recorded in a database provided by the MECP~~OE~~.

EcoLog Environmental Risk Information Services Ltd. (EcoLog ERIS) is a national database service, which provides specific environmental and real estate information for locations across Canada. A review of all available provincial, federal and private environmental databases was requested for the areas within a radius around the wells that included the outer edge of the WHPA-D. As a result, the search included data to the west of the Wellhead Protection Areas. The search included the following databases:

Federal Government Source Databases

- National PCB Inventory 1988-June 2004
- National Pollutant Release Inventory 1994-2004
- Environmental Issues Inventory System 1992-2001
- Federal Convictions 1988-January 2002

- Contaminated Sites on Federal Land June 2000-2005
- Environmental Effects Monitoring 1992-2004
- Fisheries & Oceans Fuel Tanks 1964-September 2003
- Indian & Northern Affairs Fuel Tanks 1950-August 2003
- National Analysis of Trends in Emergencies System (NATES) 1974-1994
- National Defense & Canadian Forces Fuel Tanks Up to May 2001 National Defense & Canadian Forces Spills March 1999-February 2005
- National Defense & Canadian Forces Waste Disposal Sites 2001,2003
- National Environmental Emergencies System (NEES) 1974-2003
- Parks Canada Fuel Storage Tanks 1920-January 2005
- Transport Canada Fuel Storage Tanks 1970-May 2003

Provincial Government Source Databases

- Certificates of Approval 1985-September 2002
- Ontario Regulation 347 Waste Generators Summary 1986-2004
- Ontario Regulation 347 Waste Receivers Summary 1986-2004
- Private Fuel Storage Tanks 1989-1996
- Ontario Inventory of PCB Storage Sites 1987-April 2003
- Compliance and Convictions 1989-2002
- Waste Disposal Sites – MOE CA Inventory 1970-September 2002
- Waste Disposal Sites – MOE 1991
- Historical Approval Inventory Up to October 1990
- Occurrence Reporting Information System 1988-2002
- Pesticide Register 1988-August 2003
- Wastewater Discharger Registration Database 1990-1998
- Coal Gasification Plants 1987, 1988
- Non-Compliance Reports 1992(water only), 1994-2003
- Ministry Orders 1995-1996
- Aggregate Inventory Up to May 2005
- Abandoned Aggregate Inventory Up to September 2002
- Abandoned Mines Inventory System 1800-2005
- Record of Site Condition 1997-September 2001
- Ontario Oil and Gas Wells (1999-Oct 2004; 1800-May 2004 available for 14 select counties)
- Drill Holes 1886-2005
- Mineral Occurrences 1846-October 2004
- Environmental Registry 1994-July 2003

Private Sources Databases

- Retail Fuel Storage Tanks 1989-June 2005
- Canadian Pulp and Paper 1999, 2002, 2004, 2005
- Andersen's Waste Disposal Sites 1930-2004
- Scott's Manufacturing Directory 1992-2005
- Chemical Register 1992,1999-June 2005
- Canadian Mine Locations 1998-2005
- Oil and Gas Wells October 2001-2005

- Automobile Wrecking & Supplies 2001-June 2005
- Anderson's Storage Tanks 1915-1953
- ERIS Historical Searches, March 1999-2005

Items identified within the Drayton Wellhead Protection Area include one landfill site, the Drayton Water Supply System and two registered waste generators. The Occurrence Reporting Information System documented a sewage spill due to a force main break, however the location was not given (EcoLog ERIS, 2006a).

No items were identified by the search within the Moorefield Well Wellhead Protection Area (EcoLog ERIS, 2006b).

Municipal Parcel Assessment Codes

Data from the Municipal Property Assessment Corporation (MPAC) was obtained from the GRCA. This data classifies parcels by land use and is generally used by Municipalities for tax purposes. For this reason it is a fairly up to date and a reliable source of information to identify land uses on a parcel basis. The data obtained was used for land use classification where other data was not available and for servicing information such as whether the parcel has water or sanitary services. The MPAC data was also useful in identifying agricultural land types.

Aerial Photo Interpretation

Historical aerial photographs (1978 and 2000) were obtained from the University of Waterloo Map and Design Library and reviewed to identify land use changes and potential high-risk activities such as waste disposal sites within the Wellhead Protection Areas. Current aerial photography of the Wellhead Protection Areas was obtained from the GRCA Watershed Ortho-imagery (2006).

Site Reconnaissance and Inspection

A drive-by roadside inspection of the Wellhead Protection Areas was completed in 2006 to verify and compliment the dataset compiled during the records review portion of the assessment. The inspection consisted of a fence line/roadside documentation of the properties and their land uses included in the Wellhead Protection Area.

Sanitary Sewers

Drayton and Moorefield are serviced with sanitary sewers. The wastewater for Drayton and Moorefield is conveyed via sanitary sewers to storage lagoons at the Drayton Wastewater Pollution Control Plant southwest of Drayton. The plant is approved to handle 750 $m^3$/day of wastewater (MOE, 2008a). The sewers and their connections that transport the wastewater are considered threats as there is the potential for leaks to occur.

According the to the Certificate of Approval (4150-7JDP55), sanitary sewers within the Drayton Wellhead Protection Area are located on John Street, Wood Street, Robin Drive, Elm Street and Main Street (MOE, 2008a). There are no sanitary sewers within the Moorefield Wellhead Protection Area. The sewage pumping station and lagoons are located outside of both of the Wellhead Protection Areas.

Septic Systems

Within the Wellhead Protection Areas, septic systems are assumed to be used at all rural homes and buildings outside of the serviced areas. Septic systems that are not properly maintained can contribute to pathogen and chemical contamination in ground water. To identify properties with septic systems MPAC data was used to identify properties that had a building on it and were not municipally serviced. These parcels were assumed to have a septic system.

***Significant Drinking Water Quality Threats in the Drayton Wellhead Protection Areas***

The lands within the Drayton Wellhead Protection Areas are used dominantly for agricultural activities with some residential and municipal uses on the north edge of the town of Drayton. Within WHPA-B there is residential housing, a large municipal park and fairgrounds, a church, the Municipal works yard, a school bus yard, an auto body shop, a manufacturer of fabricated metal products and a commercial business. The municipal works yard contained two underground storage tanks, one unmarked above ground storage tank and a large empty storage dome for sand.

The remainder of the Wellhead Protection Area consisted of agricultural and natural lands. Several livestock operations for chickens, swine and beef were observed during the inspection. Sizes of farms ranged from small barns to large intensive livestock operations. Cash crops such as soy, corn and grains were commonly planted on the fields in the zone. Rural residential properties were observed within WHPA-D. It is assumed that these homes have septic systems and water wells. Some private above-ground storage tanks (ASTs) for propane or other heating fuel were observed at these homes. No quarries or gravel pits were noted within the Wellhead Protection Area during the site inspection. The Bosworth landfill is located within the WHPA-D but is no longer in operation.

~~As per the Technical Rules (MOE, 2009b), the enumeration of significant threats is required for the completion of the Assessment Report.~~ **Table 6-16** summarizes the significant drinking water quality threats identified in the Drayton Wellhead Protection Areas in Drayton.

**Table 6-16: Significant Drinking Water Threats in the Drayton Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 4 | WHPA-A |
| 2 | Sewage System or Sewage Works- ~~Septic~~ Onsite Sewage Systems | 1 | WHPA-A |
| | Sewage System or Sewage Works- Sanitary Sewers and related pipes | 1 | WHPA-A |
| 15 | Handling and Storage of Fuel | 1 | WHPA-A |
| 16 | Handling and Storage of Dense Non-Aqueous Phase Liquids | 7 | WHPA-A<br>WHPA-B |
| 17 | Handling and Storage of Organic Solvents | 4 | WHPA-A |
| **Total Number of Activities** | | **18** | |
| **Total Number of Properties** | | **7** | |

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| **Table 6-16: Significant Drinking Water Threats in the Drayton Wellhead Protection Areas** | | | |

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

***Significant Drinking Water Quality Threats in the Moorefield Wellhead Protection Areas***

A drinking water quality threat is defined as a chemical or pathogen contaminant that poses a potential risk to the drinking water sources (MOE, 2006a). Threats are considered to be of two main types; threats related to current land use practices (activities) and threats related to pre-existing circumstances (conditions). Both of these threat types are described in the following sections.

Significant threats to the Moorefield groundwater supply were assessed through the development of a desktop land use inventory.

A site inspection of the Moorefield Wellhead Protection Areas confirmed that the majority of land use is agricultural. The Moorefield Water Supply wells are located within the Town of Moorefield municipal lot, which also contains municipal office buildings, a fire department building, a maintenance garage and a salt storage building. Surrounding the wells is land used for cash crops such as hay, soy and corn. Within the Wellhead Protection Areas, there are a total of five residential and/or farm properties.

~~As per the Technical Rules (MOE, 2009b), the enumeration of significant threats is required for the completion of the Assessment Report.~~ **Table 6-17** summarizes the significant threats identified in the Moorefield Wellhead Protection Areas in the Township of Mapleton.

**Table 6-17: Significant Drinking Water Threats in the Moorefield Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 1 | WHPA-A |
| 2 | Sewage System or Sewage Works- Sanitary Sewers and related pipes | 1 | WHPA-A |
| 3 | Application of Agricultural Source Material to Land | 2 | WHPA-A |
| 10 | Application of Pesticides to Land | 2 | WHPA-A |
| 15 | Handling and Storage of Fuel | 1 | WHPA-A |
| 16 | Handling and Storage of DNAPLs | 1 | WHPA-A |
| 17 | Handling and Storage of Organic Solvents | 1 | WHPA-A |
| **Total Number of Activities** | | **9** | |

**Table 6-17: Significant Drinking Water Threats in the Moorefield Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| **Total Number of Properties** | | **3** | |

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

**Limitations and Uncertainty for the Enumeration of Significant Drinking Water Supply Threats for the Drayton and Moorefield Well Supply Systems**

In this study a number of databases were used to create the threats inventory database. All databases have an error associated with them, whether it applies to the spatial or attribute information. The accuracy of the databases used depends on the source, the age of the information and the scale at which the spatial information was recorded. In this study, to decrease some of the error in the database information a field reconnaissance was completed to confirm the data when possible.

The determination of land use activities used a series of assumptions which have an uncertainty associated to them. For this enumeration, it was assumed that any possible threats associated with an activity were present and that all potential chemicals were present. The circumstances and quantity for each threat were assigned based on available knowledge such as typical storage practices, typical chemical quantities and typical waste disposal practices for that particular land use activity.

Based on the uncertainty involved in the assumptions and data used, the uncertainty for threats enumeration has been classified as high, but this level of uncertainty is expected in desk top study. With regards to the location of the threats, however, there is low uncertainty as most locations were field verified.

## 6.3 Township of Centre Wellington

### 6.3.1 Centre Wellington Well Supply

Two municipal groundwater systems are located within the Township of Centre Wellington: the Village of Elora and the Town of Fergus. Both Elora and Fergus obtain their water supply from municipal wells located within the village and town but the systems are connected. The serviced area is shown on **Map 6-23.** Together the two water systems are referred to as the Centre Wellington Well Supply, as presented in **Table 6-18**. The number of residents using municipal water is estimated to be 20,600 ~~, 12,893 in Fergus and 5,202 in Elora~~. The Township of Centre Wellington owns and operates the water supply system.

**Table 6-18: Municipal Residential Drinking Water System Information for the Township of Centre Wellington in the Grand River Source Protection Area (Centre Wellington Well Supply)**

| DWS Number | DWS Name | Operating Authority | GW or SW | System Classification[1] | Number of Users served[2] |
|---|---|---|---|---|---|
| 220000086 | Centre Wellington Well Supply | Township of Centre Wellington | GW | Large Municipal Residential | ~~18,095~~20,600 |

[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*
[2] Centre Wellington Well Supply ~~2008~~ 2018 Annual System Reports (O.Reg 170/03)

#### Elora Well Supply

The water supply system for Elora consists of three bedrock wells referred to as E1, E3 and E4 (**Table 6-19**). Well E2 is no longer used due to water quality issues (iron) and potential interference with other municipal wells. As such, E2 has been decommissioned in accordance with Ontario Regulation 903.

**Table 6-19: Municipal Production Wells in the Elora Well Supply**

| Well | Well Field | Depth of Well (m) | Depth of Casing (m) | Purpose | Status |
|---|---|---|---|---|---|
| E1 | Elora | 130 | 19.8 | Production | In Regular Use |
| ~~E2~~ | ~~Elora~~ | ~~N/A~~ | ~~N/A~~ | ~~Production~~ | ~~Decommissioned~~ |
| E3 | Elora | 122 | 29.2 | Production | In Regular Use |
| E4 | Elora | 128 | 25 | Production | In Regular Use |

The water takings allowed for each well is governed by Permit to Take Water No. 2823-7QEH3C. A summary of the permitted taking and ~~the average takings over the period 2006 – 2008~~ the rates used to delineate Elora WHPAs are summarized in **Table 6-20**.

**Table 6-20: Municipal Production Wells Pumping in the Elora Well Supply**

| Well | Permit to Take Water (L/day) | Rate Used to Delineate WHPA (L/day) |
|---|---|---|
| E1 | 1,740,960 | 1,50~~12~~0,000 |
| E3 | 1,963,000 | 900~~81~~,000 |
| E4 | 1,227,000 | 1,200~~27~~,000 |

~~Only well E1 pumps close to the permitted capacity. Pumping rates at E3 are restricted due to potential interference effects on nearby private wells.~~

~~There is a monitoring well (61 m deep with casing to 26 m) near E4 used for monitoring purposes.~~

***Fergus Well Supply***

The water supply system for Fergus consists of six bedrock wells referred to as F1, F2, F4, F5, F6 and F7 (**Table 6-21**). Well F3 is no longer used due to potential interference with other municipal wells and reduced capacity. As such, F3 has been decommissioned in accordance with Ontario Regulation 903.

**Table 6-21: Municipal Production Wells in the Fergus Well Supply**

| Well | Well Field | Depth of Well (m) | Depth of Casing (m) | Purpose | Status |
|---|---|---|---|---|---|
| F1 | Fergus | 79.6 | 19.9 | Production | In Regular Use |
| F2 | Fergus | 76.5 | 3.6 | Production | Well Not in Use |
| ~~F3~~ | ~~Fergus~~ | ~~N/A~~ | ~~N/A~~ | ~~Production~~ | ~~Decommissioned~~ |
| F4 | Fergus | 129.5 | 80.5 | Production | In Regular Use |
| F5 | Fergus | 124.4 | 31.1 | Production | In Regular Use |
| F6 | Fergus | 122.5 | 33.4 | Production | In Regular Use |
| F7 | Fergus | 138.7 | 47.2 | Production | In Regular Use |

Well F2 in Fergus has been identified as GUDI (Groundwater Under the Direct Influence of surface water) and there is a potential for surface water from the Grand River to migrate to the well. It should be noted that Well F2 has not been used for municipal supply since June 2003 as a result of water quality concerns associated with the GUDI status of the well and limited pumping rates imposed on this well due to interference with nearby private wells (Stantec, 2010).

The water taking allowed for each well is governed by Permit to Take Water No. 2823-7QEH3C. A summary of the permitted taking and the rates used to delineate Fergus WHPAs ~~the average takings over the period 2006 – 2008~~ are summarized in **Table 6-22**.

**Table 6-22: Municipal Production Wells Pumping in the Fergus Well Supply**

| Well | Permit to Take Water (L/day) | Rate Used to Delineate Wellhead Protection Area (L/day) |
|---|---|---|
| F1 | 1,832,947 | ~~974,000~~1,300,000 |
| F2 | 490,140 | ~~630~~400,000 |
| F4 | 1,963,911 | 1,~~113~~200,000 |
| F5 | 1,963,872 | ~~736,000~~1,000,000 |
| F6 | 1,963,872 | ~~870,000~~1,300,000 |
| F7 | 1,962,000 | ~~1,961,000~~1,600,000 |

~~Well F4 pumps close to the permitted capacity. Pumping rates at some of the other wells (F2) are restricted due to potential interference effects on nearby private wells, water quality deterioration in some wells (F2, F6) when pumped at higher rates and incapability of some wells (F5) to produce water at higher rates.~~

~~There is a sentry well (29 m deep with casing to 2 m) near F1 that is used for monitoring purposes.~~

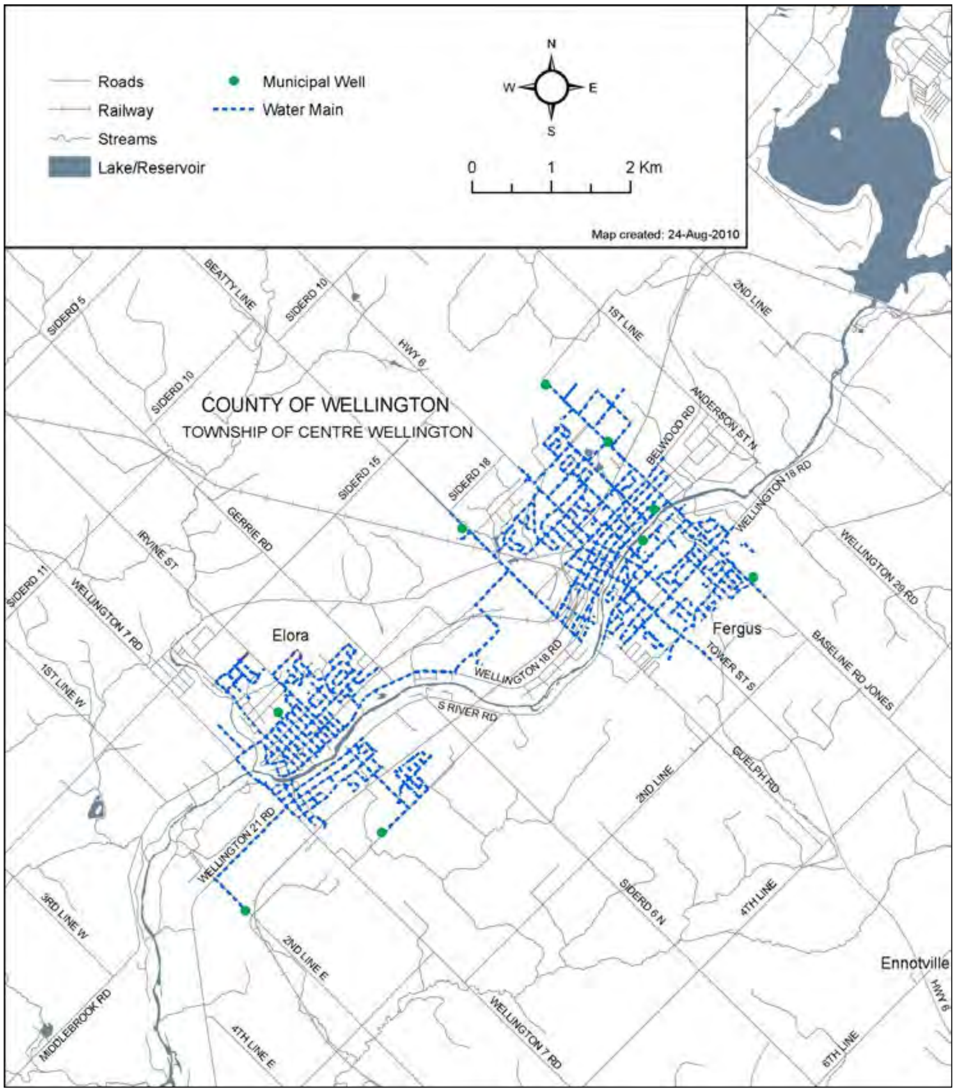
**Table 6-23** summarizes the average annual and monthly pumping rates for all wells in the Centre Wellington Well Supply.

**Table 6-23: Annual and Monthly Average Pumping Rates for Centre Wellington Well Supply**

| Well or Intake | Annual ~~Avg.~~ Taking[1] (m³~~/d~~) | Monthly Total~~Average~~ Taking[1] (m³~~/d~~) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| **Elora Well System** | | | | | | | | | | | | | |
| E1 | 316,707~~1092~~ | 33,828~~1404~~ | 32,236~~1452~~ | 27,459~~1043~~ | 20,506~~1205~~ | 24,730~~1333~~ | ~~1~~22,942~~170~~ | 25,802~~1495~~ | 30,920~~1447~~ | 26,544~~1269~~ | 23,278~~661~~ | 23,096~~66~~ | ~~562~~25,366 |
| E3 | 264,474~~219~~ | 22,198~~160~~ | 26,743~~312~~ | ~~109~~24,926 | 21,064~~177~~ | 20,888~~228~~ | 21,442~~237~~ | 24,732~~83~~ | 22,859~~220~~ | 21,929~~134~~ | 19,285~~237~~ | 20,413~~476~~ | 17,995~~255~~ |
| E4 | 92,092~~291~~ | 8,916~~79~~ | 99~~51~~ | 7,333~~361~~ | 7,670~~189~~ | 11,490~~35~~ | 13,313~~206~~ | 10,957~~77~~ | 7,220~~12~~ | 6,798~~217~~ | 7,360~~629~~ | 2,984~~942~~ | 7,953~~697~~ |
| **Fergus Well System** | | | | | | | | | | | | | |
| F1 | 266,322~~672~~ | 18,694~~769~~ | 20,757~~411~~ | 24,769~~514~~ | 27,160~~482~~ | 33,234~~533~~ | 32,371~~398~~ | 26,925~~590~~ | 17,703~~811~~ | 17,318~~798~~ | 16,198~~952~~ | 13,754~~857~~ | 17,439~~949~~ |
| F4 | 373,135~~1407~~ | 27,601~~1455~~ | 25,944~~1452~~ | 27,219~~1305~~ | 19,652~~1434~~ | 20,615~~1404~~ | 26,522~~1436~~ | 34,055~~1435~~ | 35,520~~1432~~ | 39,203~~1396~~ | 40,491~~1479~~ | 38,014~~1281~~ | 38,300~~1375~~ |
| F5 | 135,800~~402~~ | 10,044~~401~~ | 7,280~~447~~ | 5,571~~442~~ | 11,481~~493~~ | 11,134~~411~~ | 15,598~~411~~ | 18,165~~233~~ | 14,998~~258~~ | 13,720~~384~~ | 9,956~~351~~ | 5,390~~585~~ | 12,464~~408~~ |
| F6 | 188,777~~383~~ | 28,193~~361~~ | 18,668~~314~~ | 18,487~~386~~ | 8,143~~366~~ | 8,014~~385~~ | 19,689~~387~~ | 10,881~~274~~ | 21,615~~363~~ | 11,271~~483~~ | 10,406~~393~~ | 17,780~~384~~ | 15,629~~505~~ |
| F7 | 224,916~~328~~ | 16,323~~217~~ | 14,547~~569~~ | 17,617~~541~~ | 21,600~~523~~ | 24,899~~527~~ | 15,650~~618~~ | 25,740~~593~~ | 20,913~~130~~ | 25,272~~149~~ | 17,456~~79~~ | 17,420~~0~~ | 7,449~~0~~ |

[1] source: Centre Wellington annual summary reports, based on 2018~~08~~ monitoring data

**Map 6-23: Centre Wellington Well Supply Serviced Areas**



### 6.3.2 Vulnerability Analysis

***Delineation of Wellhead Protection Areas***

The delineation of Wellhead Protection Areas (WHPAs) represents the foundation of a municipal groundwater protection strategy. Wellhead Protection Areas associated with the municipal water supply represent the areas within the aquifer that contribute groundwater to the well over a specific time period. According to the *Clean Water Act, 2006* Technical Rules (November 2009), four Wellhead Protection Areas are required, one a proximity zone and the three others time-related capture zones:

- WHPA-A 100 m radius from wellhead
- WHPA-B 2-year Time of Travel (TOT) capture zone
- WHPA-C 5-year Time of Travel capture zone
- WHPA-D 25-year Time of Travel capture zone

In addition, two other capture zones may be added to a wellhead protection area when a well obtains groundwater that is under the direct influence of surface water (is a GUDI well).

- WHPA-E The time required for an operator to respond to a spill event (e.g. a 2-hour Time of Travel), in accordance with the rules of delineating an Intake Protection Zone-2.
- WHPA-F Encompasses any sources of Issues identified with the well if the source of the Issue is located outside of WHPAs A,B,C,D or E, in accordance with the rules of delineating an Intake Protection Zone-3.

***Modelling Approach for the Centre Wellington Well Supply***

The numerical modelling completed for this current study utilized the FEFLOW groundwater flow model developed for the Centre Wellington Tier 3 Assessment (Matrix 2018a). In the area of Centre Wellington, the Tier 3 model was calibrated to long-term average water levels, to a baseflow estimate at Irvine Creek, and to transient conditions observed during a shutdown/pumping test over a period of 6 weeks in 2012. The Tier 3 model is the most current tool available to delineate capture zones for Centre Wellington's municipal wells. The Tier 3 model version used incorporates estimated current pumping for non-municipal wells, existing land use, and long term average climate and groundwater recharge.

The capture zones and WHPAs delineated for this study are based on a Base Case scenario model and three alternative uncertainty scenarios developed as part of a sensitivity analysis.

*Base Case Scenario*

The calibrated Centre Wellington Tier 3 FEFLOW model is referred to as the Base Case scenario. The municipal pumping rates assigned for WHPA delineation are consistent with the wellfield capacity estimates being developed for the "Centre Wellington's Water Supply Master Plan" project (AECOM 2018). The final pumping rates applied in the Base Case model are provided in **Table 6-20** and **Table 6-22**. Effective porosity was assigned as 0.2 for the overburden, 0.03 for bedrock aquifers and 0.01 for bedrock aquitards. These values are consistent with those used for similar geologic units for the neighbouring City of Guelph and Township of Guelph/Eramosa Tier 3 Assessment (Matrix, 2017b).

*Sensitivity Scenarios*

A sensitivity analysis was completed to estimate the effects of model parameter uncertainty on the size and shape of the predicted capture zones. Some groundwater flow model input parameters have greater uncertainty than others. The sensitivity analysis involved adjusting the calibrated Base Case model parameters and evaluating the change in particle tracking results used to delineate the capture zones.

The first sensitivity scenario tested a decrease in the effective porosity of the bedrock production aquifer from 0.03 to 0.01. A reduction in porosity leads to greater velocities and longer pathlines and time-of-travel capture zones. Sensitivity Scenario 2 included the lower porosity of Scenario 1 and also included increasing the production bedrock aquifer conductivity values by a factor of 1.5. The magnitude of this increase was considered appropriate to maintain a reasonable calibration, and the value was based on insights gained when calibrating the Tier 3 model (Matrix 2018a). Sensitivity Scenario 3 also included the lower porosity of Scenario 1 and included decreasing the confining bedrock aquitard conductivity values by 20%. The magnitude of this decrease was considered appropriate to maintain a reasonable calibration, and the value was based on insights gained when calibrating the Tier 3 model (Matrix 2018a).

Virtual particles can be released in a groundwater flow model and tracked forward or backward in time through the subsurface for various time intervals. The computed pathlines travelled by these particles are projected to the ground surface and plotted on a plan view map. Time-of-travel capture zones are subsequently created by drawing polygons around the well and the particle pathlines for specific time intervals. As such, capture zones represent the land areas beneath, which water and contaminants located at and below ground surface may migrate toward a well within a specified period.

~~A groundwater flow model was developed to identify time of travel (TOT) capture zones for the municipal well fields as part of the County of Wellington Groundwater Protection Study (Golder, 2006). The model was constructed using the three dimensional model MODFLOW. The numerical model code, MODFLOW, is a well-documented and widely used numerical model that is based on the finite difference method for simulation of groundwater flow system.~~

~~The Wellington County Groundwater Protection Study Model was used to delineate the Wellhead Protection Areas for the Centre Wellington Well Supply based on the pumping rates described below.~~

~~The pumping rates used to determine the Wellhead Protection Area are based on the allocated quantity of water. The allocated quantity of water is the lesser of:~~

- ~~The maximum annual quantity of water that can lawfully be taken under the Permit to Take Water; or~~
- ~~The quantity of water that would have to be taken annually to meet committed demand of the system.~~

~~The pumping rates used in developing the Wellhead Protection Areas are based on a forecast of anticipated future groundwater use as determined in the Wellington County Groundwater Protection Study through discussions with Wellington County staff and Centre Wellington Water Works staff. The pumping rates give consideration to local population growth statistics as contained in the County of Wellington Official Plan; operational constraints within each system; and potential servicing of currently un-serviced areas.~~

~~It should be noted that Centre Wellington is currently undertaking a Master Water Supply Plan. When this plan is completed, the forecast pumping rates may need to be revised to reflect the future growth for the area and anticipated pumping.~~

~~To develop the time of travel capture zones, groundwater particles were released at the pumping wells in the model and backward tracked (using MODPATH) towards their source of recharge. At each well location, particles were released in all hydrostratigraphic units "open" to the wellbore. The time-related pathlines that are subsequently generated by the model from this analysis are then overlain and a single time of travel capture zone drawn around the "family" of pathlines generated at each well. To check the capture areas generated from the backward tracking analysis (and in some cases to refine the time of travel outline produced) a series of forward tracking simulations were also completed. The resulting capture zone from this process represents the two-dimensional projection of the particle outlines to ground surface. Note that the capture zone developed in this manner does not imply that a contaminant, spilled or released at surface, would reach the water supply well within the specified 2-year, 5-year or 25-year travel times. While in some cases the aquifer (and water table) may be near ground surface and so the travel time down to the water table may be relatively short, for confined and deeper aquifers (i.e., typical of those found in Elora and Fergus), the travel times from the point of contaminant release within the capture zone may be considerably longer and/or the contaminant may never reach the pumping well(s).~~

~~The use of the MODFLOW groundwater model infers that the groundwater flow systems within the Township of Centre Wellington can be simulated as an "equivalent porous media" at the scale of the time-related capture zones under consideration. Under this assumption, the rate of groundwater flow towards a pumping well occurs as a function of the hydraulic gradient, the hydraulic conductivity of the aquifer, and the effective porosity of the aquifer. The use of equivalent porous media models is standard practice for sand and gravel (overburden) aquifers. The equivalent porous medium assumption has also been commonly applied for sedimentary bedrock aquifers of the type found in the Township of Centre Wellington. While groundwater flow (and solute transport) in these aquifers occurs primarily in the fractures and solution cavities, the use of an equivalent porous medium can still provide a reasonable approximation of the time of travel related capture zones of a bedrock supply well (in particular for longer travel times) provided the scale of observation is much greater than the scale of individual fractures and solution cavities, and consideration is given to the selection of a reasonable "effective" porosity. The effective porosity of the bedrock aquifer was assumed to be 1% and 5% in developing the WHPAs with 1% being used in the less permeable bedrock zones. This is considered to be a reasonably conservative estimate of effective porosity to use for the time of travel calculations and is consistent with typical values used in these calculations for other groundwater studies completed for similar aquifers within the province.~~

~~The capture zones developed from the numerical modelling approach described above are considered to represent reasonable "theoretical" estimates based on the available data. However, it should be recognized that following this approach, there will not be a unique solution to the model calibration process and therefore, there is inherently some uncertainty associated with the (subsequent) capture zones forecast by the calibrated groundwater model. These uncertainties stem (in part) from limitations in the available subsurface information and can be related to variability in the aquifer properties (e.g., hydraulic conductivity; porosity) or uncertainties with the conceptual model (e.g., groundwater-surface water interactions; location of flow boundaries; recharge rates; continuity in aquitards; direction of regional groundwater flow).~~

To account for some of the uncertainty in the capture zones developed for the Township of Centre Wellington, a factor of safety is applied that effectively increases the spatial coverage of each time of travel related capture zone. The factor of safety is comprised of two components: in the first instance, using the pumping well as the reference point, the width and length of the capture zone is increased by 20% to account for some uncertainty in the hydraulic characteristics of the aquifer system supplying water to the well; secondly, and again using the pumping well as the reference point, the orientation of the capture zone is adjusted by 5 degrees (plus and minus) along its centreline which accounts for some uncertainty in the regional flow direction by increasing the width of the capture zone at increasing distances from the pumping well. The factor of safety approach to uncertainty described above is considered to provide a practical way to account for uncertainty in the scientific methods being used to generate the capture zones, and reflects the concept that the available data is typically concentrated around the pumping well and that the uncertainty in the hydrogeological understanding increases at increasing distances from the supply wells.

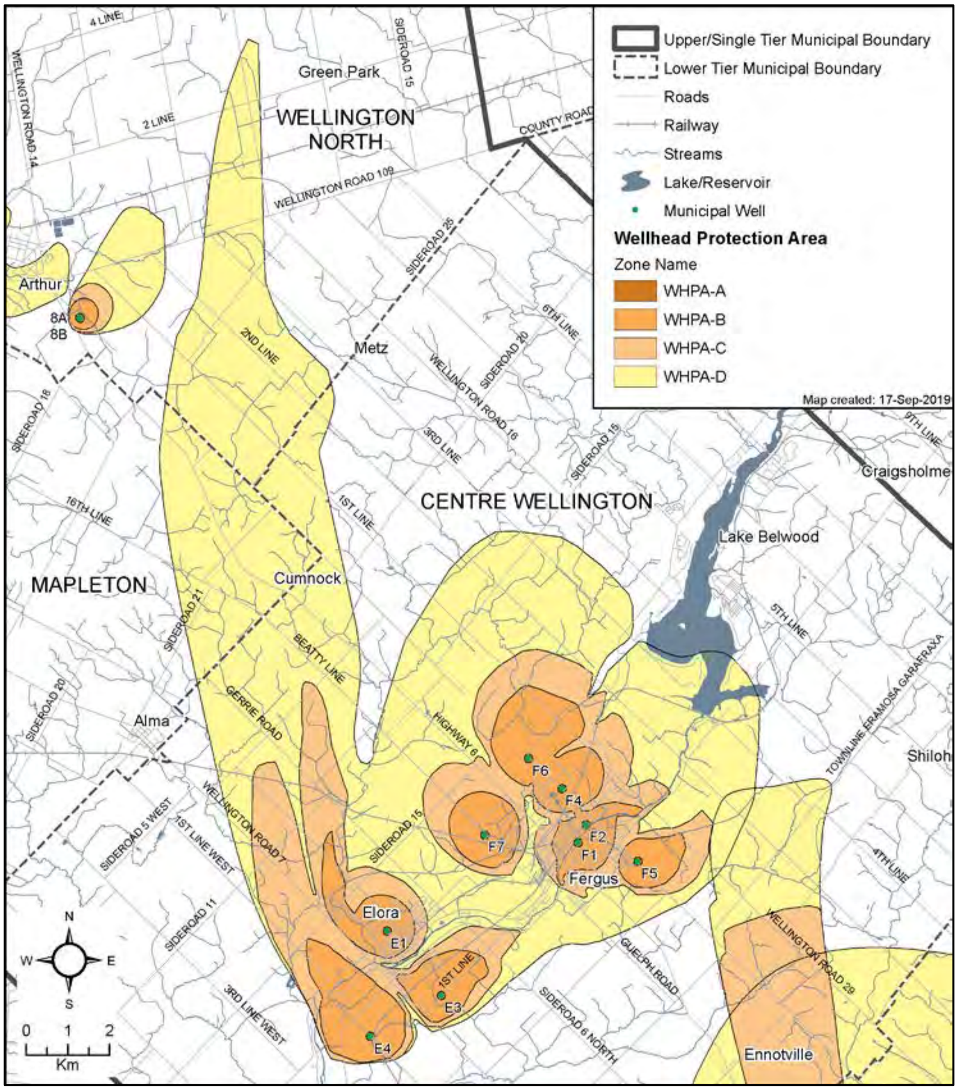
***Delineation of Centre Wellington Wellhead Protection Areas***

WHPA-A through WHPA-D were delineated for the nine Centre Wellington wells aAs seen in **Map 6-24**. , the 25-year capture zones for the Elora wells merge together and extend approximately 15 km to the north in the direction (upgradient) of regional groundwater flow in the bedrock. The 25-year capture zones for the wells south of the Grand River extend northward beneath the Grand River. The land use overlying much of the 25-year capture zones is rural agricultural, although the entire urban area of Elora also lies within the capture zones.

The Elora WHPAs are elongated and extend towards the north (e.g., Well E1) and portions of others (i.e., Well E3) extend to the east. The WHPA-D extends approximately 25 km upgradient to the north. The Fergus WHPAs are more radial compared to the Elora WHPAs, with the WHPA-D extending approximately 7 km to the northeast.

As seen in **Map 7-26** the 25-year capture zones for most of the Fergus wells merge together and extend approximately 16 km to the north in the direction (upgradient) of regional groundwater flow in the bedrock. The 25-year capture zone for Fergus Well 5, located south of the Grand River, extends eastward for approximately 5 km. The land use overlying much of the 25-year capture zones is rural agricultural, although most of the urban area of Fergus also lies within the capture zones. Due to the close proximity of the wells there is some overlap of the Elora and Fergus Wellhead Protection Areas.

**Map 6-24: Fergus and Elora Wells Wellhead Protection Areas**



**Map 6-25: Fergus Wells Wellhead Protection Areas**

***Delineation of WHPA-E for Centre Wellington – Fergus, Well F2***

Well F2 in Fergus has been identified as GUDI and becasue there is a potential for surface water from the Grand River to migrate to the well. Consequently, WHPA-E was delineated for this well. Well F2 is located near the Grand River in Fergus approximately 4.3 km downstream of the Shand Dam. The location of F2 relative to the Grand River is shown on **Map 6-25.**

The Assessment Report Technical Rules state that WHPA-E is to be delineated in accordance with the rules for delineating an IPZ-2, as though the intake for the system were located at the point of interaction between surface and groundwater (if known) or a point within the waterbody closest to the well. WHPA-E delineation for the F2 well in Fergus was based on a 2-hour time of travel under estimated high flow conditions and included appropriate setbacks on land, according to the Technical Rules. As the exact point of interaction between the Grand River and Well F2 is not known, WHPA-E was delineated from a point within the river adjacent to the well. A 2-hour response time, the minimum required by the Technical Rules, was deemed appropriate given the established protocol to quickly shut down the well in response to a spill and the fact that this supply well has not been used since June 2003.

The 2-hour time of travel in the Grand River upstream of the Well F2 was based on a statistical analysis of continuous flow monitoring data combined with dye tracer studies carried out at bankfull or near bankfull flow conditions. Continuous flow records for the Grand River were available from the Water Survey of Canada and Grand River Conservation Authority for the period from 1984 to 2009 and were used to calculate the 95$^{th}$ percentile of flow. Experience has shown that 95$^{th}$ percentile flow and bankfull conditions are not substantially different for natural watercourses. The 95$^{th}$ percentile flow was estimated to be 32 $m^3/s$.

A dye tracer study was carried out on April 28, 2009 at flows similar to the calculated 95$^{th}$ percentile flow and field observations indicated that water levels were at or near the top of bank (i.e. bankfull flow conditions). The results of the dye tracer study were used to calibrate a hydraulic model, which was used to scale up the time of travel to 95$^{th}$ percentile flow conditions. Under 95$^{th}$ percentile high flow conditions, it was estimated that the time of travel from the Shand Dam to Well F2 would be 100 minutes. This is 20 minutes less than the required 2 hour time of travel, therefore a semi-circular area within the reservoir upstream of the Dam was included in WHPA-E. The radius of the semi-circular area was conservatively estimated based on the minimum depth of water and the volume of water discharged from the reservoir at the 95$^{th}$ percentile flow for 20 minutes.

In accordance with the Technical Rules, WHPA-E also includes a setback on land to include the Conservation Authority Regulation Limit or 120 m, whichever is greater. Transport pathways were also included and accounted for in the delineation of WHPA-E. Several small tributaries, ditches and stormsewer outfalls that flow into the Grand River between Well F2 and the Shand Dam were identified. The WHPA-E was extended to incorporate portions of these pathways that may contribute water to the assumed intake point within a 2-hour time of travel as shown on **Map 6-25.** Detailed information on the areas draining to stormsewers was not available, therefore, it was conservatively assumed that all developed urban area draining toward the Grand River upstream of the assumed intake point was included in WHPA-E.

The technical study to delineate WHPA-E for Well F2 in Fergus is further described in the report *Wellhead Protection Area E Delineation and Vulnerability Scoring: Municipal Supply Well F2, Township of Centre Wellington* by Stantec Consulting Ltd. (2010).

### *Delineation of WHPA-F for Centre Wellington – Fergus, Well F2*

WHPA-F was not delineated for the F2 well in Fergus as there were no Issues identified for this well. It should be noted that Well F2 has not been used for municipal supply since June 2003 as a result of water quality concerns associated with the GUDI status of the well and limited pumping rates imposed on this well due to interference with nearby private wells.

### *Intrinsic Vulnerability Scoring in Wellhead Protection Areas*

Groundwater intrinsic vulnerability mapping for the Fergus and Elora wellfields was previously completed by EarthFX Inc. (2008) using the SAAT method. Golder (2010a) reviewed the vulnerability mapping and made adjustments based on hydrogeological knowledge at the WHPA scale. The intrinsic vulnerability was further refined in the Centre Wellington area by GRCA staff in May 2019. Smoothing (refinements) of the intrinsic vulnerability was done in areas where the existing vulnerability scoring was too complex to be implementable. This was done using the smooth line tool in ArcGIS (Polynomial Approximation with Exponential Kernel), with a 400m smoothing tolerance. Further manual adjustment was then made in a few minor areas to remove any tight loops created by the tool. The Elora and Fergus unadjusted and adjusted intrinsic vulnerability mapping is shown on **Map 6-26** and **Map 6-27**.

~~Following their delineation, the intrinsic vulnerability of the aquifer within each Wellhead Protection Area is assessed using one of the methods approved under the *Clean Water Act* Technical Rules. The resulting maps rank aquifer vulnerability as high, medium or low.~~

~~One method of assessing groundwater vulnerability is the surface to aquifer advection time (SAAT). The SAAT approach is described as "a direct estimate of the vertical travel time from the ground surface (or near ground surface) to the top of the aquifer (or top of the water table in and unconfined aquifer)". The intrinsic vulnerability derived from the SAAT method is expressed in units of time.~~

~~The SAAT time of travel has two components: 1) the unsaturated zone arrival time (UZAT); and 2) the water table to aquifer arrival time (WAAT). The UZAT is the time of travel from the surface to the water table and the WAAT is the time of travel from the water table to the aquifer of interest. The SAAT and UZAT are the same for unconfined aquifers. SAAT aquifer vulnerability mapping was completed for most of the Grand River Watershed as a separate project (Earthfx, 2008). A complete methodology is presented in the 2008 Earthfx report. This SAAT aquifer vulnerability mapping was used as the basis for the vulnerability scoring, although some Wellhead Protection Area scale adjustments to this mapping were made to account for local conditions in the Elora and Fergus Wellhead Protection Areas, as described later in this section.~~

~~The SAAT travel times were converted into aquifer vulnerability values based on Technical Rule IV.1 (38) as follows:~~

~~High Aquifer Vulnerability – SAAT less than 5 years;~~

~~Medium Aquifer Vulnerability – SAAT between 5 years and 25 years; and~~

~~Low Aquifer Vulnerability – SAAT greater than 25 years.~~

~~The watershed scale SAAT mapping was reviewed and adjusted at the Wellhead Protection Area scale through comparison of existing ISI mapping, surficial quaternary geology mapping (including bedrock outcrop locations) and cross sections throughout the Wellhead Protection Areas. The review and adjustments to the SAAT vulnerability mapping are further detailed in the draft technical memorandum Review and Refinement of the Grand River Conservation Authority's SAAT Vulnerability Mapping at the Wellhead Protection Area Scale (Golder, 2010b).~~

***Identification of Transport Pathways and Vulnerability Adjustment***

Following a review of the intrinsicinitial vulnerability scoring maps, an assessment of transport pathways was undertaken to determine whether adjustments to the vulnerability assessment were warranted. Technical Rules 39 – 41 address the general process of how transport pathways would increase vulnerability. Transport pathways for groundwater based drinking water systems include: wells (existing and abandonedcurrent, unused, or abandoned), pits and quarries, mines, construction activities or deep excavations, storm water infiltration, septic systems, and sanitary sewerburied municipal infrastructure.

The Technical Rules (MOECC, 2017) indicate that consideration should be given to the cumulative impact of any potential transport pathways; the impact of any discrete pathway should not be viewed in isolation. Therefore, following the assessment of risk for each feature, a density analysis was completed to determine where clusters of high risk pathways existed. A 50 m buffer was created around each of the high-risk pathways identified.

To evaluate the transport pathways, a review of water well records and previous pathway assessment (Blackport Hydrogeology Inc. and Triton Engineering Services, 2008) was conducted to identify transport pathways, but no on-site inspection of wells took place.

***Uncertainty of the Identification of Transport Pathways***

The transport pathway identification is a desktop analysis and involved only minor field verification or site visits to validate the information.

***Adjusted Vulnerability to Account for Transport Pathways***

At the completion of the transport pathways assessment, the Technical Rules allow investigators to modify the vulnerability scoring if there is a concern that the identified transport pathways within the Wellhead Protection Areas may increase the vulnerability of the aquifer beyond that represented by the intrinsic vulnerability. Modification of the vulnerability score is performed by increasing the vulnerability of the underlying aquifer vulnerability map from either a low to moderate value or moderate to high value. An initial aquifer vulnerability value of high cannot be increased.

***Adjusted Vulnerability Scoring for the Centre Wellington Wellhead Protection Areas***

Several data sources were reviewed to assess the relative risk of transport pathways to cross-cut natural protection over the municipal production aquifers in the Fergus and Elora WHPAs. Wells, buried municipal infrastructure, and septic systems were interpreted to warrant an update to vulnerability mapping. A total of 1,381 wells, 13.8 km of buried infrastructure, four lift stations, and 94 septic systems were identified as high-risk pathways. Where a high density of these pathways was identified, updates to the existing vulnerability mapping were recommended. These areas of transport pathway area of influence are identified on **Map 6-28.**

Following the adjustment of the vulnerability mapping based on the transport pathways assessment, vulnerability scoring was completed for Centre Wellington. The WHPAs for each well were overlain on the adjusted vulnerability mapping and scores were assigned.  Final vulnerability scoring for the Fergus and Elora wellfields is shown on **Map 6-29**.

There have been no confirmed private well pathways, and as such, no increases to vulnerability due to the presence of private wells have been included. As well, no adjustments to the vulnerability were made due to septic systems and buried utilities as they most likely do not act

as significant transport pathways due to their shallow nature in relation to the deeper municipal aquifer and do not breach the lower permeable sediments.
As no adjustments were made to the vulnerability scoring, the final vulnerability scoring maps were prepared to provide an indication of the relative vulnerability of the aquifer within the Wellhead Protection Areas. Due to the proximity of the wells, the WHPAs are shown together for all of Centre Wellintongton on **Map 7-29** and on a smaller scale for the urban areas of Elora and Fergus on **Map 7-31**.

***Vulnerability Uncertainty Assessment***

The uncertainty analysis factors considered in this assessment follow Part I.4, Rule 14 of the Technical Rules (MOECC, 2017) and are detailed in **Table 6-24**.

**Table 6-24: Uncertainty Analysis Factors and Ranking for WHPAs and Vulunerability Scores**

| Uncertainty Asssessment Factor | Uncertainty Designations | Description |
|---|---|---|
| 14(1) The distribution, variability, quality, and relevance of data used in the preparation of the assessment report | Low | Good coverage of Ontario Ministry of Environment, Conservation and Parks (MECP) water well record data surrounding the Study Area as well as high-quality data local to the well fields and regionally. Water levels from multiple periods. Averaging of multiple water levels at individual wells was completed to best reflect most recent conditions. |
| 14(2) The ability of the methods and models used to accurately reflect the flow processes in the hydrological system | Low | The groundwater flow model has been shown to reflect groundwater flow processes by representing water levels under long-term average and pumping conditions. |
| 14(3) The quality assurance and quality control procedures applied | Low | Each step of the model development process relied on data that had been collected and/or reviewed by professional engineers or geoscientists. The development of the model was fully documented (Matrix 2018a) and that document was reviewed by leading academics and industry professionals for the purposes of fulfilling the requirements of the Act. |
| 14(4) The extent and level of calibration and validation achieved for models used or calculations or general assessments completed | Low | The original Centre Wellington Tier Three model is a product of both steady-state and transient calibration efforts and the final parameters derived are both consistent with field observations and those that would be expected based on the conceptual model. |
| 14(5) The accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features | High | The groundwater vulnerability mapping is based on the SAAT methodology completed by EarthFX (2008) and Golder (2010a); however, the hydrogeologic conceptual model of the Study Area was reworked as part of the Centre Wellington Tier Three Assessment (Matrix 2017a). The vulnerability mapping was not refined to reflect the current conceptual model. Further, an assessment of the differences between the current conceptual model, and the one that the 2008 vulnerability mapping is based on, has not been completed to verify whether the groundwater vulnerability categories still effectively assess the relative vulnerability of the underlying hydrogeological features. |

| | | |
|---|---|---|
| | | |

Uncertainty in the delineation of the WHPAs was addressed through the simulation of multiple scenarios. The scenarios for WHPA delineation produced similarly shaped capture zones, which were all encompassed in the final WHPA delineation. Further, the reliability of the delineated WHPAs is supported by the reasonability of the calibrated model. The groundwater flow model is calibrated using model parameters that reflect hydraulic field tests and have values that are within expected ranges for the various hydrogeological units.

This results in a low uncertainty for the capture zone delineation. There is a low uncertainty rating associated with the time-of-travel delineation; however, there is a high uncertainty rating associated with the vulnerability mapping, which was not updated or reassessed using the current conceptual model (Matrix, 2017a). As a result, an uncertainty rating of high is assigned to the assessment of vulnerability of each WHPA. This high uncertainty is identified as a data gap and updates to the vulnerability mapping should be considered in the future.

***Vulnerability Scoring in WHPA-E***

Vulnerability analysis of WHPA-E includes consideration for both the area vulnerability and the source vulnerability as described in the Technical Rules. The two factors are multiplied to generate a vulnerability score for WHPA-E.

The area vulnerability factor for a WHPA-E is prescribed to be the same as IPZ 2, i.e. between 7 and 9. The source vulnerability factor for Well F2 has been assessed on the basis of Type C intake (i.e. assuming the well is hydraulically connected to an in-land river) and therefore was assumed to be in the range of 0.9 to 1.0.

The area vulnerability factor for Well F2 was assigned a value of 7 based on the following:

- Land area within WHPA-E is largely rural and undeveloped. While there is an area of low density residential, institutional and industrial development within WHPA-E, only 3 relatively small systems direct stormwater directly to the Grand River upstream of the well.
- There are only two minor road crossings of the Grand River within WHPA-E.
- Transport pathways that were identified for WHPA-E contribute relatively little flow compared to the Grand River.

These factors, taken together, suggest a low vulnerability of the source to contamination from spills, and, therefore, the lowest area vulnerability factor (7) was assigned to WHPA-E for Well F2.

According to the Technical Rules, the source vulnerability factor for a surface water intake takes into consideration the depth of the intake from the water surface, the distance from land and historical water quality concerns. For a WHPA-E, the first two factors do not apply as there is no particular relevance to a GUDI well that is likely drawing surface water from a distributed area, rather than a point and only a small portion of the water getting to the well originates from surface water.

There were no historical water quality concerns raised for Well F2 during the technical study. In addition, groundwater wells are known to be less vulnerable than surface water intakes to spills and other adverse conditions by virtue of the time delay between the surface water feature to the well, in-situ filtration through the soil and dilution of the surface water by groundwater from the rest of the well capture zone. For these reasons, the source vulnerability factor for Well F2 was assigned the lowest value, i.e. 0.9.

Combining the area and source vulnerability scores, the overall vulnerability score for the Well F2 WHPA-E is 6.3 (see **Table 6-25**).

**Table 6-25: Vulnerability score summary for the Centre Wellington Well F2 WHPA-E.**

| Location | Intake Protection Zone | Area Vulnerability Factor | Source Vulnerability Factor | Vulnerability Score |
|---|---|---|---|---|
| Well F2 | WHPA-E | 7 | 0.9 | 6.3 |

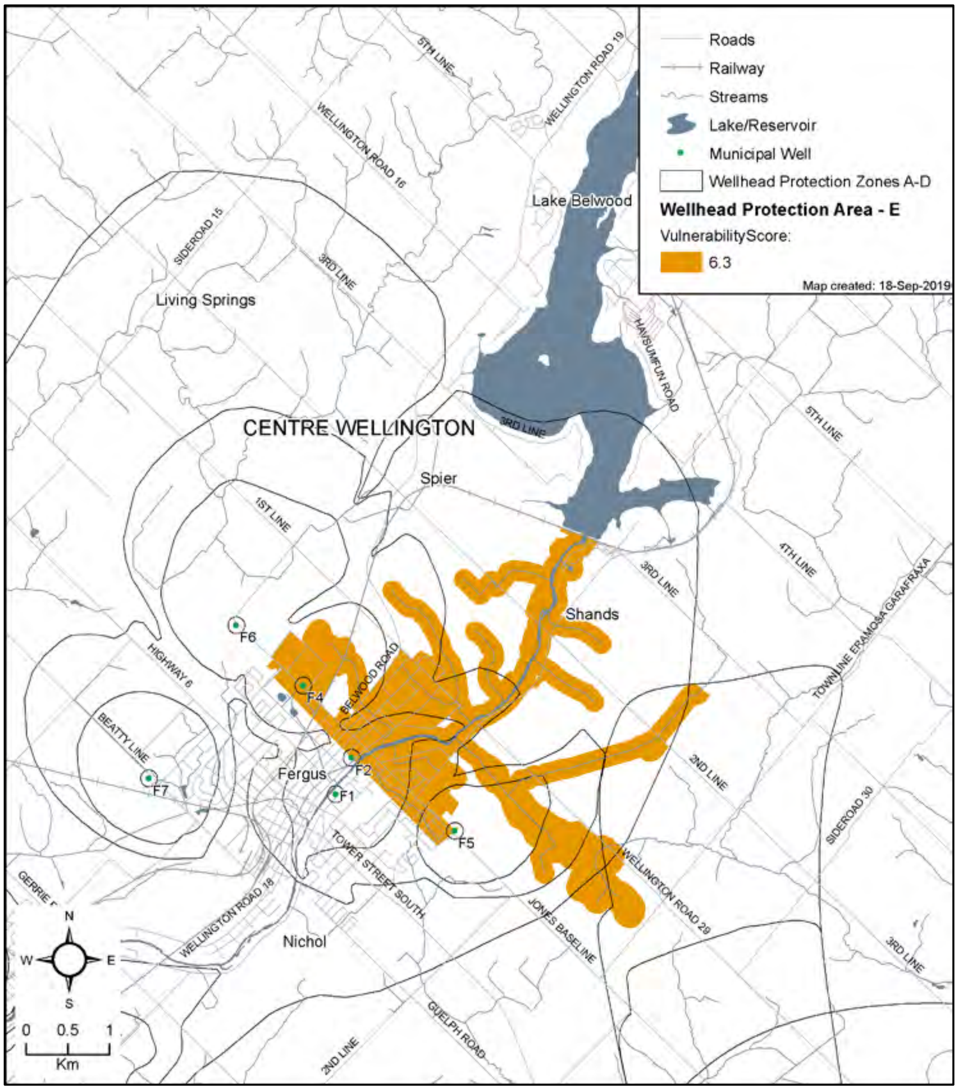
***Peer Review***

A peer review of the report *Township of Centre Wellington, Draft Source Protection Vulnerability, Issues and Threats Assessment Report* completed by Golder Associates, March 2010, was completed by Brian Luinstra of Luinstra Earth Sciences. The overall impressions of the report by the peer reviewer are as follows:

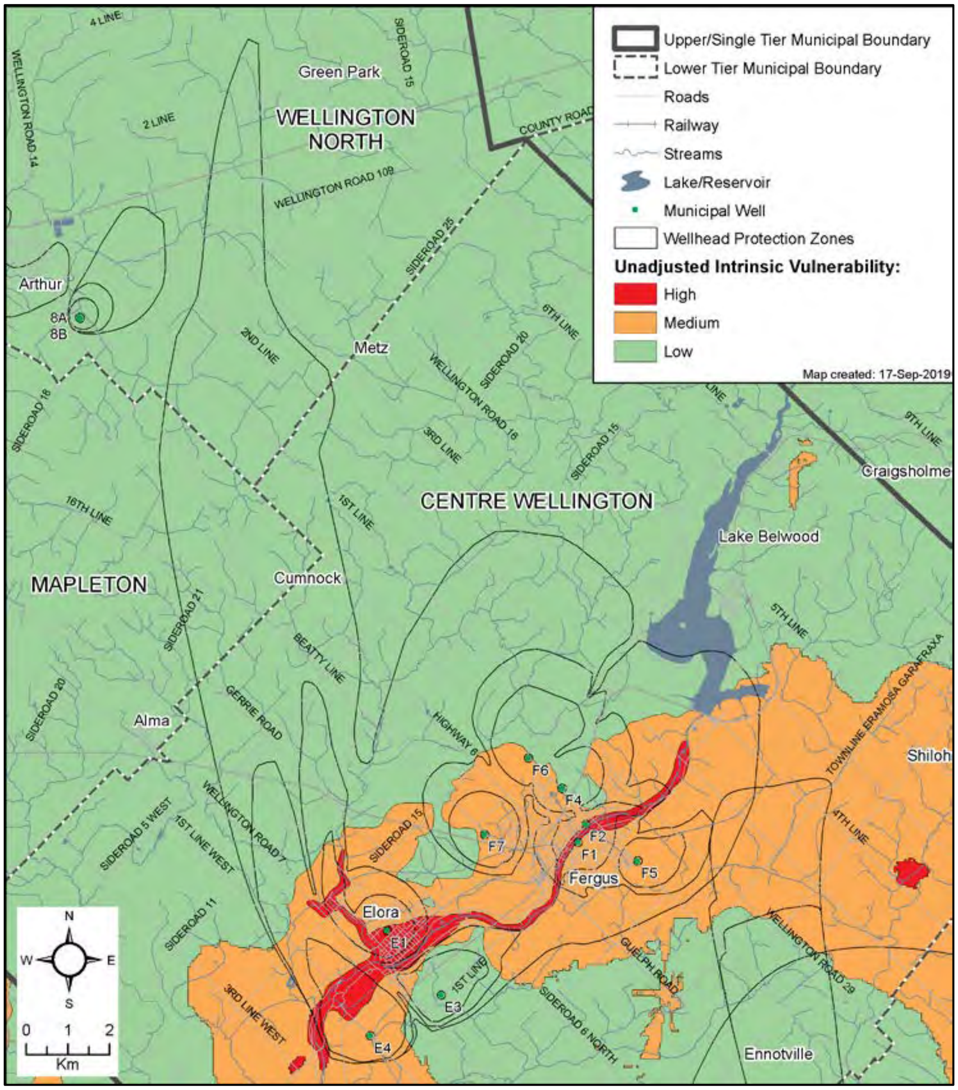
*"In the Peer Reviewer's professional opinion, the overall results appear reasonable and are consistent with the requirements outlined in the Ontario Ministry of Environment Technical Rules for completion of the Assessment Report under the Clean Water Act, 2006. The overall approach to the developing vulnerability scores, evaluating Issues and assessing threats are consistent with the Technical Rules.*

Responses to the peer review comments were incorporated into the final report. These responses to the peer review comments enhanced the overall defensibility or the report but did not impact the outcome of the Wellhead Protection Areas.

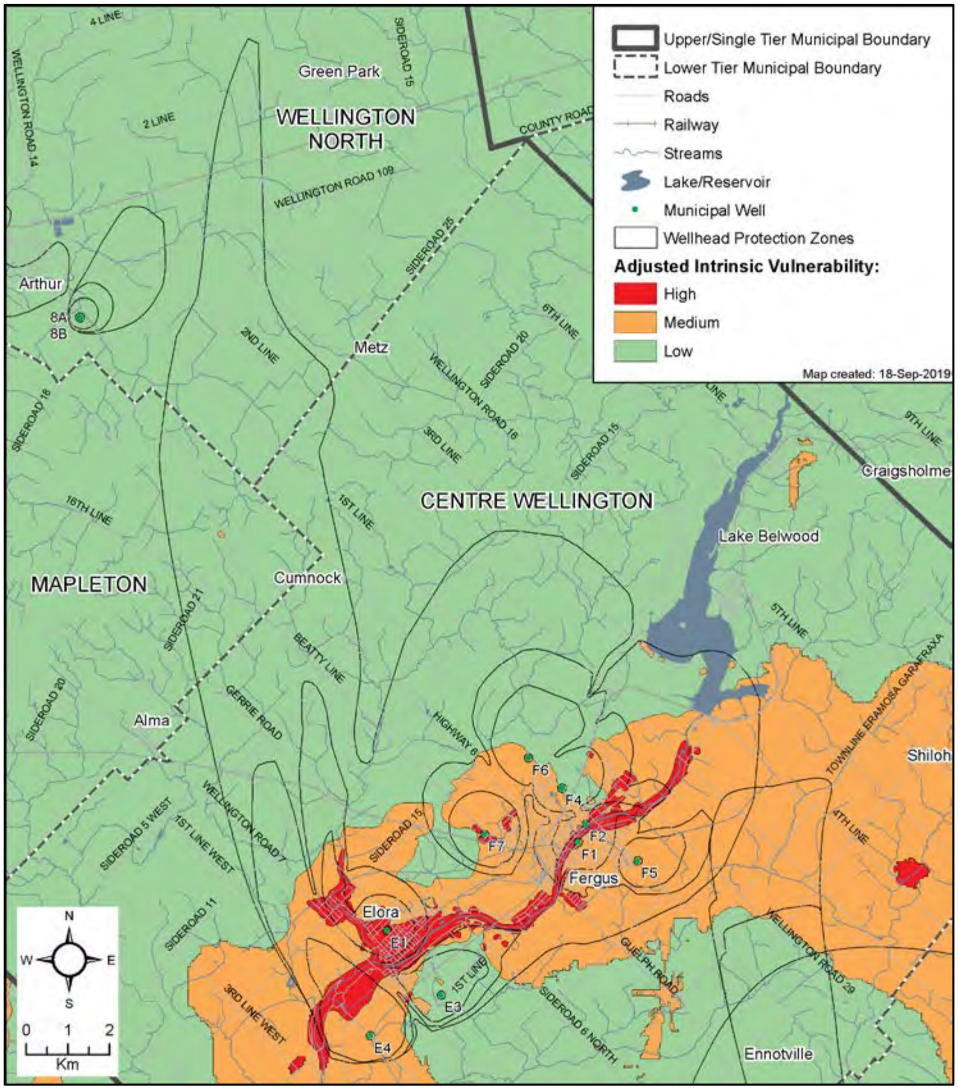
**Map 6-25: Centre Wellington Well Supply Wellhead Protection Area E Delineation (Fergus Well F2)**



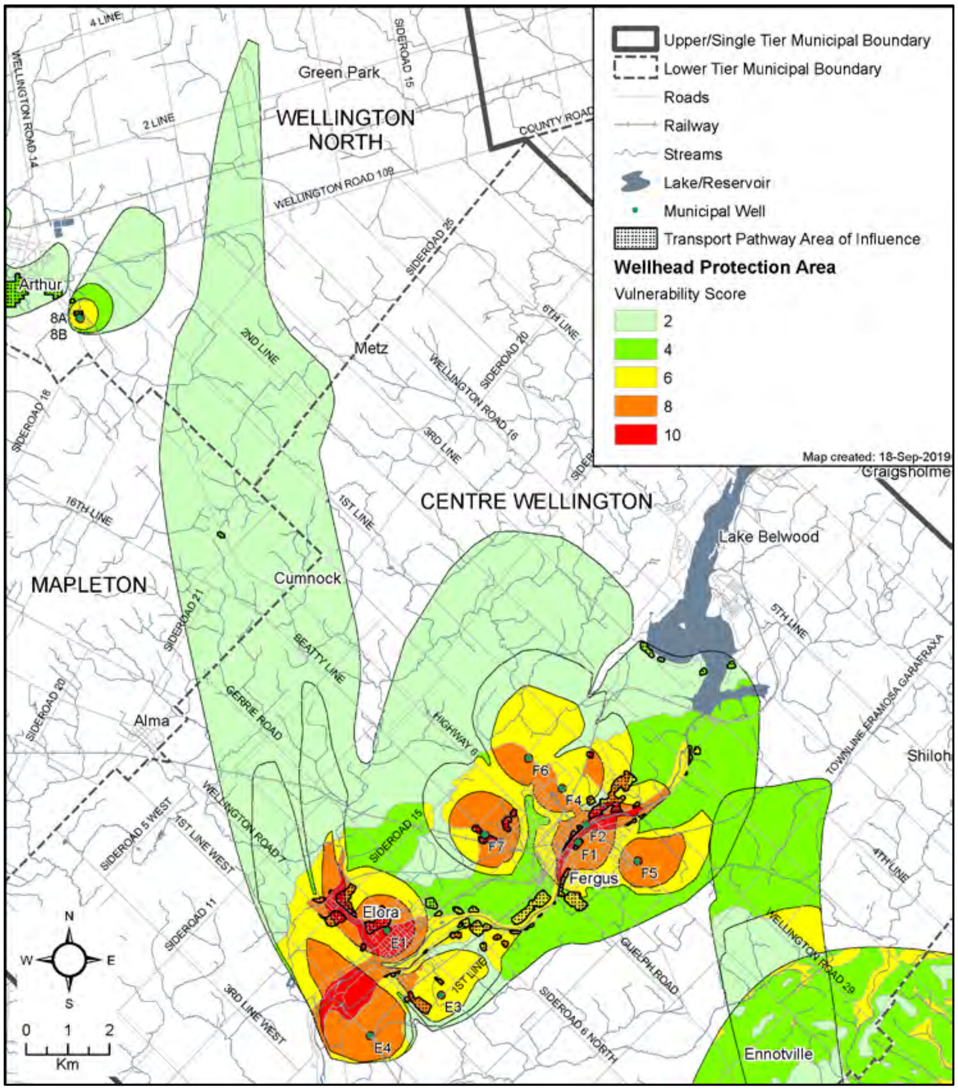
**Map 6-26 Centre Wellington Well Supply Unadjusted Intrinsic Vulnerability** ~~(Overview)~~



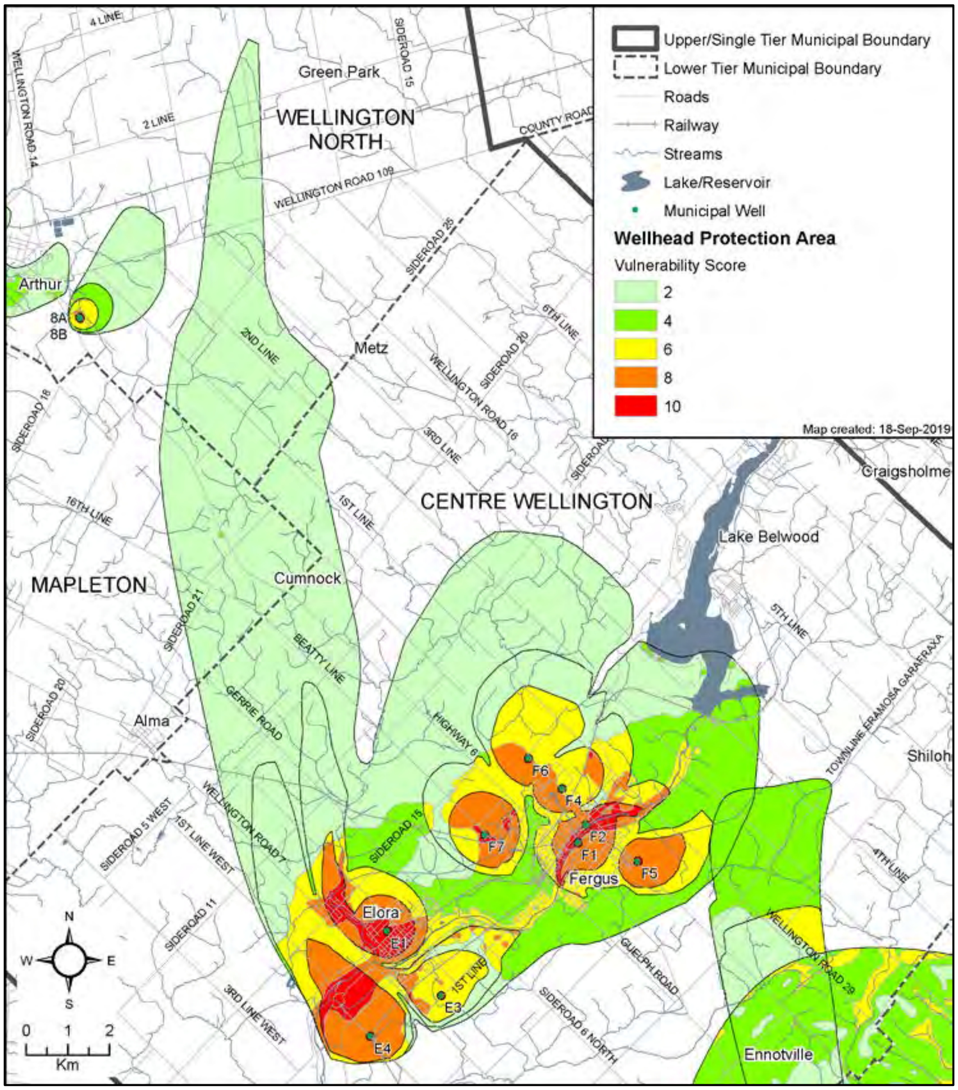
**Map 6-27: Centre Wellington Well Supply Wellhead Protection Area Adjusted Intrinsic Vulnerability** ~~(Overview)~~



**Map 6-28 Centre Wellington Transport Pathways Area of Influence**



**Map 6-29: Centre Wellington Wellhead Protection Area Final Vulnerability**



***WHPA-E Peer Review***

The vulnerability assessment of Fergus Well F2 was carried out by Stantec Ltd. on behalf of the Grand River Conservation Authority and Township of Centre Wellington. Some technical and peer review for the surface water vulnerability assessment was provided by GRCA during the study. External peer review was provided by Dr. Hugh Whitely, University of Guelph. Peer review comments were stated to be minor points for clarificatiUncertainty for the Wellhead Delineation and Vulnerability Scoring

An uncertainty assessment associated with the development of Wellhead Protection Areas and vulnerability mapping is required in order to assess the level of confidence in the results and determine the need for additional data collection and/or analysis as part of future assessments.

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. A groundwater model uses science and mathematics to draw together the available data into a mathematical or computer-based representation of the essential features of an existing hydrogeological system. The validity and accuracy of the model depends on the amount of data available relative to the degree of complexity of the geologic formations, the site geochemistry, the fate and transport of the dissolved compounds, and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of reality and the model described in this report is not an exception.

It should also be recognized that because the supply wells are completed in the bedrock aquifer, there is a fair amount of uncertainty over the times of travel and the effective area of capture. In a general sense, there would be greater uncertainty for bedrock systems than overburden systems due to the effect of the fractured rock and the assumptions with effective porosity.

For the Centre Wellington area, in addition to the regional studies that have been conducted, local hydrogeological studies have also been completed. Also, numerous water well records exist for private wells located within and around the Wellhead Protection Areas. After filtering out the lower quality water well records, the remaining water well records can provide information to fill in the gaps of the detailed studies. The Wellhead Protection Areas were delineated using a numerical model that had been calibrated reasonably well with the field data as described previously. In addition, a factor of safety was applied in delineating the Wellhead Protection Areas to help address in part the uncertainty in the hydraulic parameters assigned and potential regional uncertainty in the flow direction.

The SAAT mapping was initially conducted at a watershed scale to provide a consistent mathematical approach to the vulnerability aspect of the scoring. For Elora and Fergus, these results were further reviewed at a Wellhead Protection Area scale and changes applied to improve the results and reduce uncertainty in the SAAT mapping. The vulnerability scoring used in the threats assessment is based on both the Wellhead Protection Area delineation and the SAAT vulnerability mapping and, therefore, the overall uncertainty is related to the combined uncertainty of these two tasks.

Efforts have been made to reduce the uncertainty in the hydrogeological mapping products, following the guidance outlined in the Technical Rules. However, the following missing information adds to the uncertainty of this assessment: there is no site specific information on the effective porosity of the bedrock; there are relatively few high quality monitoring wells within and surrounding the capture zone to confirm the local groundwater flow direction; and the influence on the nature of the fracturing and distribution of water bearing zones within the bedrock are not explicitly mapped.

~~Notwithstanding the above, the vulnerability scoring reflects the best estimate of the actual conditions at Elora and Fergus. The Wellhead Protection Areas, SAAT vulnerability and resulting vulnerability scoring for Elora and Fergus are, therefore, estimated to have a low uncertainty rating.~~

*Uncertainty for the WHPA-E Delineation and Vulnerability Scoring*

The methods used to delineate WHPA-E zones were generally consistent with MOE guidance and the Technical Rules. The dye tracer fieldwork and resultant confirmation of excellent calibration of the hydraulic model of the Grand River for the design flow regime provides confidence that this aspect of the upstream system is generally well understood.

There is some uncertainty in the use of statistical flow analyses, performed on the historical flow data sets, to define the "design" flow. While efforts were made to ensure that all flow data included in the analysis were accurate, it is not possible to eliminate all sources of error. Some uncertainty exists in the data sets in the form of minor gauge malfunctions and/or the effect of ice and vegetation on water levels and flows. Generally speaking, however, the Fergus Shand Dam flow gauge data set was found to be of sufficiently high quality and duration to minimize concerns in this regard.

Observations of bankfull or near bankfull flood stage during the dye tracer fieldwork, when flows from the reservoir were known to be 25 $m^3/s$, provide further confidence in the use of the 95% flow, determined through statistical analysis to be 32 $m^3/s$, as representative of design flow.

In the absence of detailed studies being completed on every transport pathway within WHPA-E, it is inherent that numerous assumptions must be incorporated into the completion of the delineation work. While these assumptions were conservative to ensure that any errors were on the side of caution, this approach increased uncertainty in the validity of resultant protection zones in these areas and may result in the inclusion of areas in WHPA-E that may not impact on Well F2.

A typical example of the conservative approach applied within the WHPA-E delineation includes the assumption that small wetlands within the zone provide zero detention time to contaminant inputs. This assumption is obviously conservative as it must take some finite time for inflows to these areas to travel to the associated outlet. However, in the absence of field evidence to support the inclusion of a finite detention time provided by these elements, professional judgement dictated the conservative approach.

Despite potential uncertainty and conservative assumptions associated with transport pathways, in most instances the secondary transport pathways are sufficiently short that, even if the analysis does contains uncertainty, there can be a high degree of confidence that the resultant WHPA-E delineation limits would not require revision. In other words, there is a relatively high degree of confidence that the resultant "area of concern" envelopes all contributing drainage areas within a two-hour travel distance.

The exception to this confidence lies with the assumed extents and general configuration of storm sewer systems that were assumed immediately upstream of the intake location. Although most of the hydrology and hydraulics are considered to be generally well understood, the uncertainty pertaining to those portions of the protection area within the urbanized limits requires that the Well F2 WHPA-E delineation be assigned an uncertainty of high. Further assessment and field work required to reduce this high uncertainty is not recommended at this time due to the low vulnerability of WHPA-E, the lack of significant threats and the fact that the well is not currently used for municipal supply.

The general characteristics of the WHPA-E for Well F2 suggest that the vulnerability score is consistent with the relative vulnerability of the hydrological features. For these reasons, the Study Team has a relatively high degree of confidence in the WHPA-E vulnerability scores for Well F2 and has ranked the uncertainty as low. The associated overall uncertainty assessment is summarized on **Table 6-26**.

**Table 6-26: Uncertainty Evaluation for Well F2 WHPA-E in Fergus**

| Location | Delineation Uncertainty | Vulnerability Uncertainty |
|---|---|---|
| Fergus Well F2 WHPA-E | High | Low |

***Managed Lands within the Centre Wellington Wellhead Protection Areas***

Managed Lands are lands to which nutrients are applied. Managed lands can be categorized into two groups: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow, and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses, sports fields, lawns and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer). Detailed methods on managed lands calculations are described in Chapter 3 of this Assessment Report.Determining the location and percentage of managed lands, the location of agricultural managed lands, and the calculation of livestock density were used to determine whether the application of agricultural source material (ASM), non-agricultural source material (NASM), and fertilizer were significant threats within the Wellhead Protection Areas.

To calculate the percentage of managed lands, Technical Rule 16(9) was used (MOE, 2009b). Mapping the percentage of managed lands area is not required where the vulnerability score for an area is less than the vulnerability score necessary for the activity to be considered a significant threat. Based on this statement in the Technical Rule 16 (9)s, the percentage of managed lands were only calculated where the vulnerability score in each Wellhead Protection AreaWHPA was greater than 4.

Managed lands calculations for Elora and Fergus were completed in WHPA-A to WHPA-D where the vulnerability was 6 or higher. **Table 6-27** provides the results of the calculations and **Map 6-30** and show the ranges of managed lands percentage for Elora and Fergus respectively.the Centre Wellington WHPAs.

**Table 6-27: Percent Managed Lands in the Centre Wellington Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Centre Wellington ~~Centre Wellington~~ | Elora | E1 | 57.69%~~32%~~ | 54.41%~~60%~~ | 59.69%~~82%~~ | 38.2%~~25%~~ |
| | | E3 | 49.20%~~32%~~ | 58.53%~~61%~~ | ~~64%~~ | ~~25%~~ |
| | | E4 | 76.78%~~87%~~ | 57.01%~~77%~~ | ~~41%~~ | ~~25%~~ |
| | Fergus | F1 | 20.71%~~5%~~ | 47.99%~~41%~~ | 58.49%~~90%~~ | ~~31%~~ |
| | | F2 | 41.41%~~25%~~ | ~~41%~~ | ~~90%~~ | ~~31%~~ |
| | | F4 | 11.32%~~0%~~ | ~~41%~~ | ~~90%~~ | ~~31%~~ |
| | | F6~~5~~ | 39.24%~~25%~~ | ~~74%~~ | ~~82%~~ | ~~31%~~ |
| | | F5~~6~~ | 48.95%~~47%~~ | 68.76%~~52%~~ | ~~88%~~ | ~~31%~~ |
| | | F7 | 60.47%~~31%~~ | 56.69%~~57%~~ | ~~64%~~ | ~~31%~~ |

~~Note that the managed lands percentage was only calculated in WHPA-D where the vulnerability score was greater than 4, i.e., 6 or more.~~

The percentage of managed lands within each WHPA-E was estimated according to the Technical Rules. The percentage of managed land within WHPA-E for well F2 is shown on **Map 6-33.**

***Livestock Density within the Centre Wellington Wellhead Protection Areas***

Technical Rule 16 also requires the mapping of livestock density. Livestock density is defined as the number of nutrient units over a given area, and is expressed by dividing the nutrient units by the number of acres in the agricultural managed land area or the livestock grazing area depending on the threat being assessed. Detailed methods on livestock density calculations are described in Chapter 3 of this Assessment Report.

~~The calculation of livestock density involves the following steps: estimate the number of each category of animal present; convert the numbers of each animal present into nutrient units (to allow for all animals to be compared on an equivalent unit of measure); and sum the total nutrient units of all animals present and divide by the agricultural managed land within the same area. For this study, properties with an agricultural property code (200 series MPAC codes) were reviewed using the GRCA 2006 orthoimagery to help in determining the detailed livestock density estimates. The maximum livestock density of an area was based on the assumption that all existing barns are in use to full capacity based on their size.~~

~~Nutrient units are calculated for an entire property; however, nutrient units on a property that crosses a Wellhead Protection Area boundary are to be prorated for the area within that Wellhead Protection Area zone. The nutrient units were prorated based on the percent of the parcel that is located within the vulnerable zone. Similarly to the managed lands mapping, T~~the livestock density mapping was completed for the entire WHPA-A, WHPA-B and WHPA-C zones and only within the WHPA-D zones with a vulnerability score of ~~six~~6.

**Table 6-28** summarizes the livestock density results in nutrient units/acre (NU/acre) in the Elora and Fergus ~~Wellhead Protection Areas~~WHPAs. **Map 6-31** ~~and~~ shows the livestock density results for ~~Elora and Fergus respectively.~~ the Centre Wellington WHPAs.

**Table 6-28: Livestock Density (NU/acre) in the Centre Wellington Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Centre Wellington ~~Centre Wellington~~ | Elora | E1 | 0.000~~0~~ | 0.160~~.7~~ | ~~0.76~~ | ~~0.32~~ |
| | | E3 | 0.24~~0.23~~ | 0.04~~0.2~~ | ~~0.16~~ | ~~0.32~~ |
| | | E4 | 0.15~~0~~ | 0.48~~0~~ | 1.16~~0.2~~ | ~~0.32~~ |
| | Fergus | F1 | 0.00~~0~~ | 0.28~~0.12~~ | 0.31~~1.03~~ | ~~2.25~~ |
| | | F2 | 0.00~~0~~ | ~~0.12~~ | ~~1.03~~ | ~~2.25~~ |
| | | F4 | 0.00~~0~~ | ~~0.12~~ | ~~1.03~~ | ~~0.3920~~0.11~~.25~~ |
| | | F6~~5~~ | 0.55~~0.54~~ | ~~0.45~~ | ~~0.12~~ | ~~2.25~~ |
| | | F5~~6~~ | 0.44~~0.6~~ | 0.46~~0.3~~ | ~~2.05~~ | ~~2.25~~ |
| | | F7 | 0.00~~0~~ | 0.01~~0.45~~ | ~~0.34~~ | ~~2.25~~ |

A coding of 0 indicates that there were no agricultural livestock barns to contribute nutrients and therefore the value for livestock density is 0.

Similarly, the livestock density within each WHPA-E was estimated according to the Technical Rules. Livestock density within WHPA-E for well F2 is shown on **Map 6-37.** The vulnerability scores for these WHPAs are less than the vulnerability score necessary for the related activities to be considered significant threats, according to the Ministry of Environment's Table of Drinking Water Threats.

***Uncertainty of the Livestock Density within the Wellhead Protection Areas***

The MECP~~OE~~ livestock density circumstance is calculated/averaged over the entire protection zone and does not represent the livestock density at an individual property. The degree of threat posed by nutrient application at the scale of an individual property would need to be established from field visits and additional information from land owners, such as that collected as part of the development of nutrient management plans. The data on actual farming practices is currently based on assumptions.

***Percent Impervious Surface Area within the Centre Wellington Wellhead Protection Areas***

To determine whether the application of road salt poses a threat in the Centre Wellington, the percentage of impervious surface where road salt can be applied per square kilometre was calculated as per Technical Rules 16(11) and 17. The 1km X 1km method, described in Chapter 3 was used for Centre Wellington wellfield . The application of road salt can only be a threat in areas with a vulnerability score of 6 or greater under the threats-based approach; therefore the percent impervious calculation was only completed in areas with a score of 6 or greater.

~~To calculate the percent impervious surface, information on land cover classification from the Southern Ontario Land Resource Information system (SOLRIS) was used. This provided land use information, including road and highway transportation routes, as continuous 15x15 metre grid cells across the entire Source Protection Area. All the cells that represent highways and other impervious surfaces used for vehicular traffic were re-coded with a cell value of 1 and all other land cover classifications were given a value of 0, to identify impervious surface areas.~~

~~Then, a focal sum moving window average was applied using the Spatial Analyst module of the ArcGIS software. For each 15x15 metre cell, the total number of neighbouring grid cells coded as impervious, within a 1x1 kilometre search area, was calculated. This total was then converted into the percentage of impervious surface by land area, using the area of each cell (225 sq. m) and the area of the moving window (1 sq. km). This provides a 1x1 kilometre moving window~~

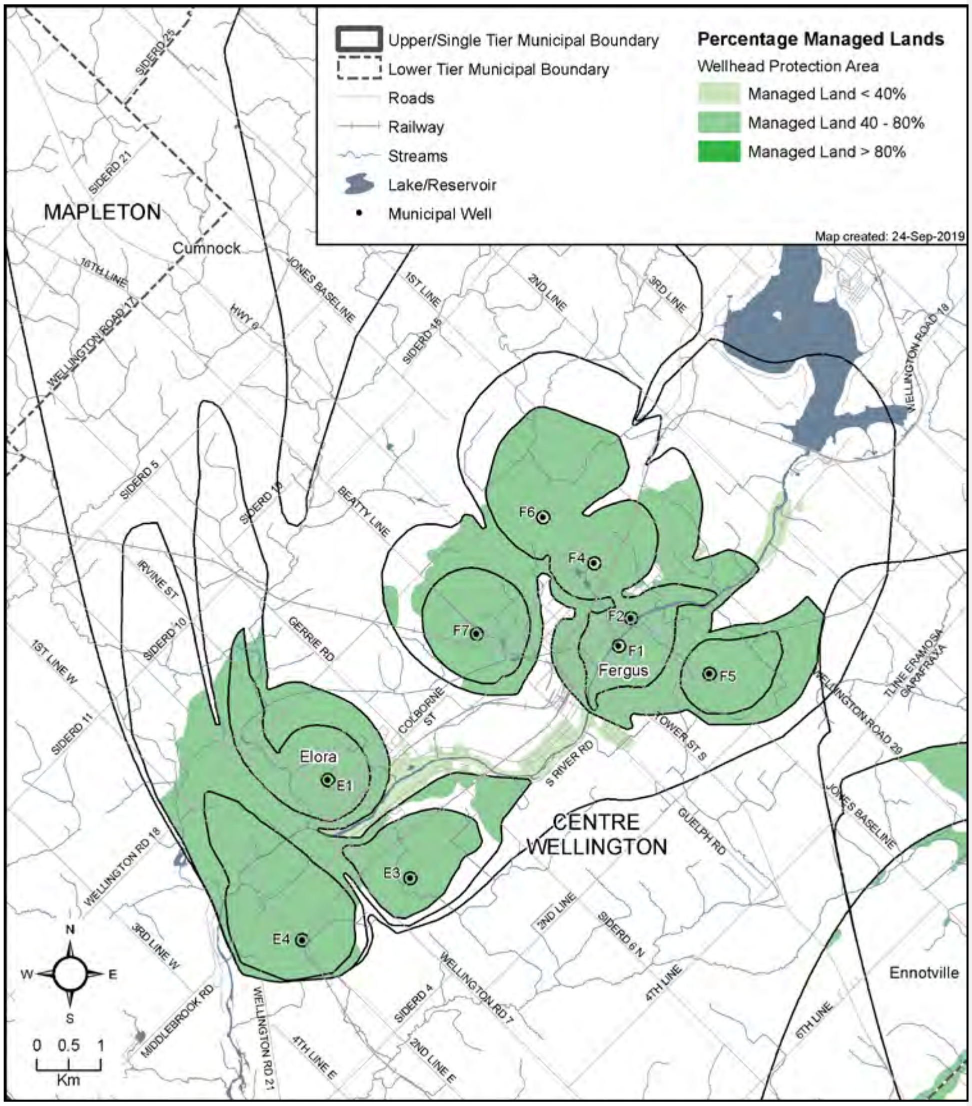
~~calculation of percent impervious surface, represented in 15x15 metre spatial increments. This dataset was calculated for the entire Source Protection Area, but was clipped to show those results only in the Wellhead Protection Areas and Intake Protection Zones. The analysis is more representative of road density and is better than the method described in the Technical Rules. As per Technical Rule 15.1, the Director has confirmed his agreement with the departure. The Director's letter of confirmation can be found in **Appendix B.**~~

The application of road salt can only be a threat in areas with a vulnerability score of 6 or greater; therefore the percent impervious calculation was only completed in areas with a vulnerability score of 6 or greater.

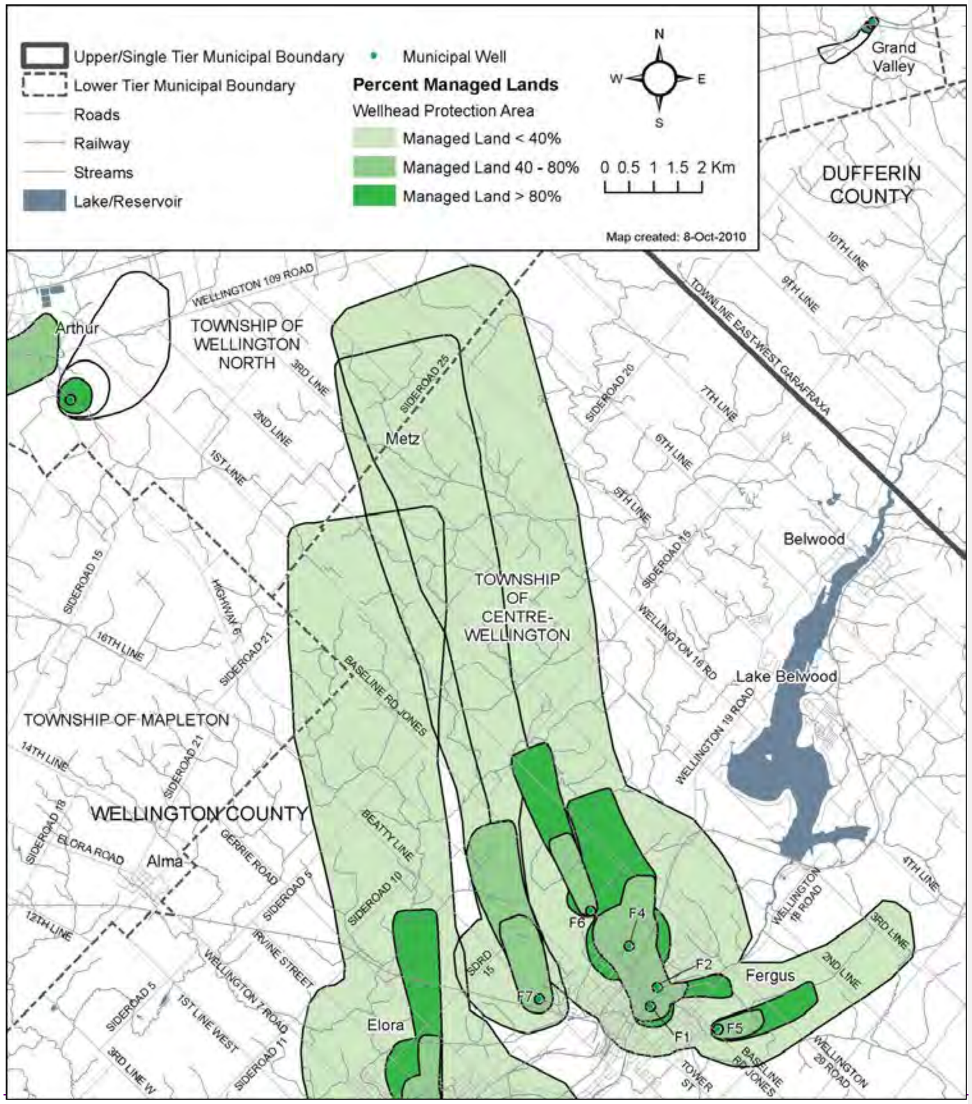
**Map 6-32** and  show the sumary of the percent imperviousness within the Centre Wellington Wellhead Protection Areas respectively.

The percentage of impervious surface area where road salt can be applied within the Fergus WHPA-E is shown on **Map 6-38.** The vulnerability scores for this WHPA is less than the vulnerability score necessary for the related activities to be considered significant threats, according to the ~~Ministry of Environment's~~MECP's Table of Drinking Water Threats.

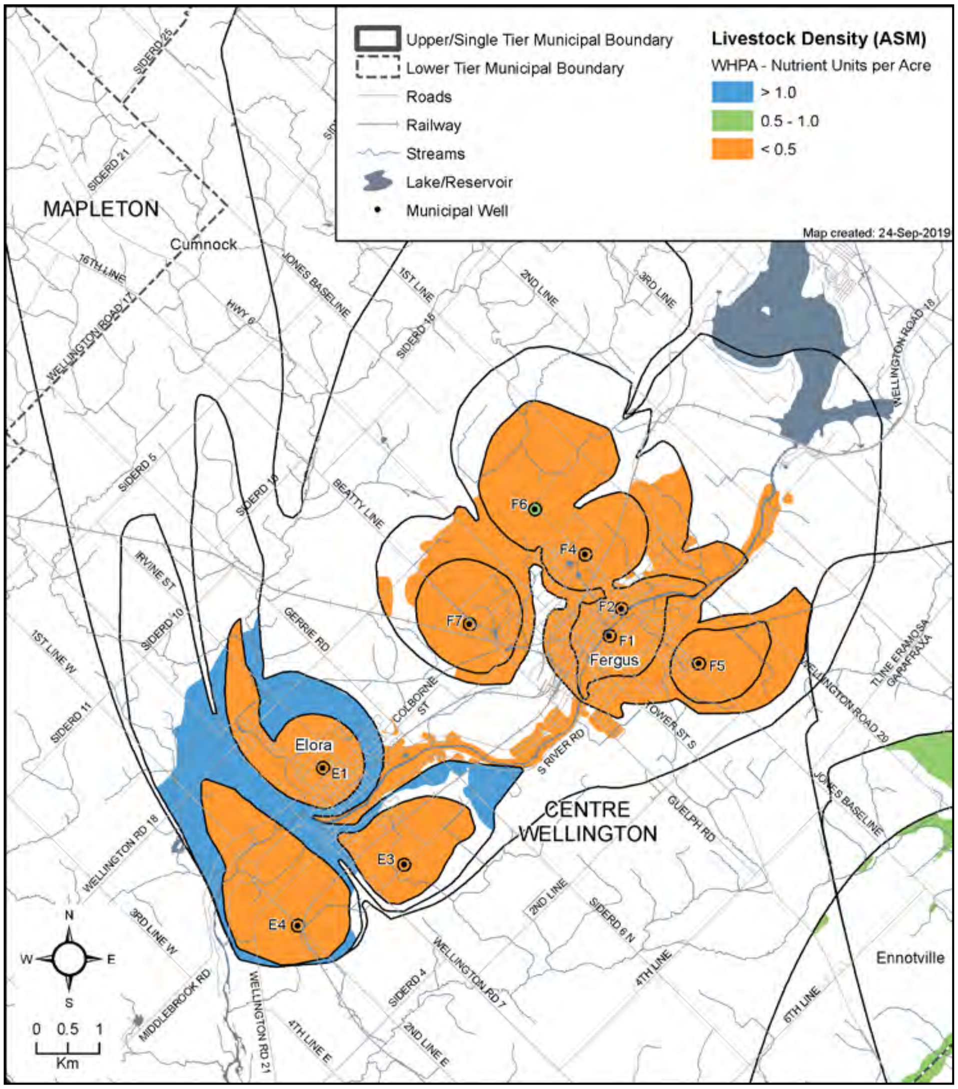
**Map 6-30: Centre-Wellington Well Supply Percent Managed Lands**



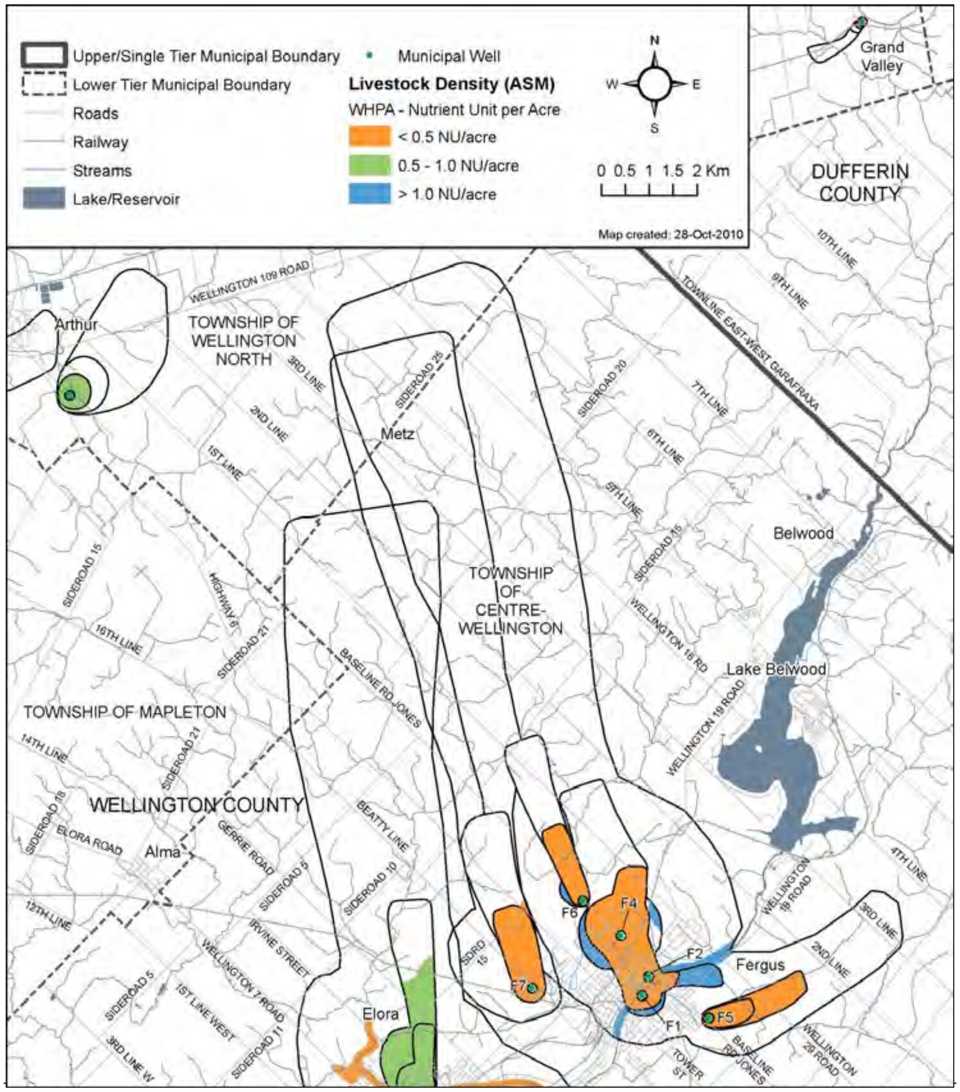
**Map 6-31: Fergus Well Supply Percent Managed Lands**



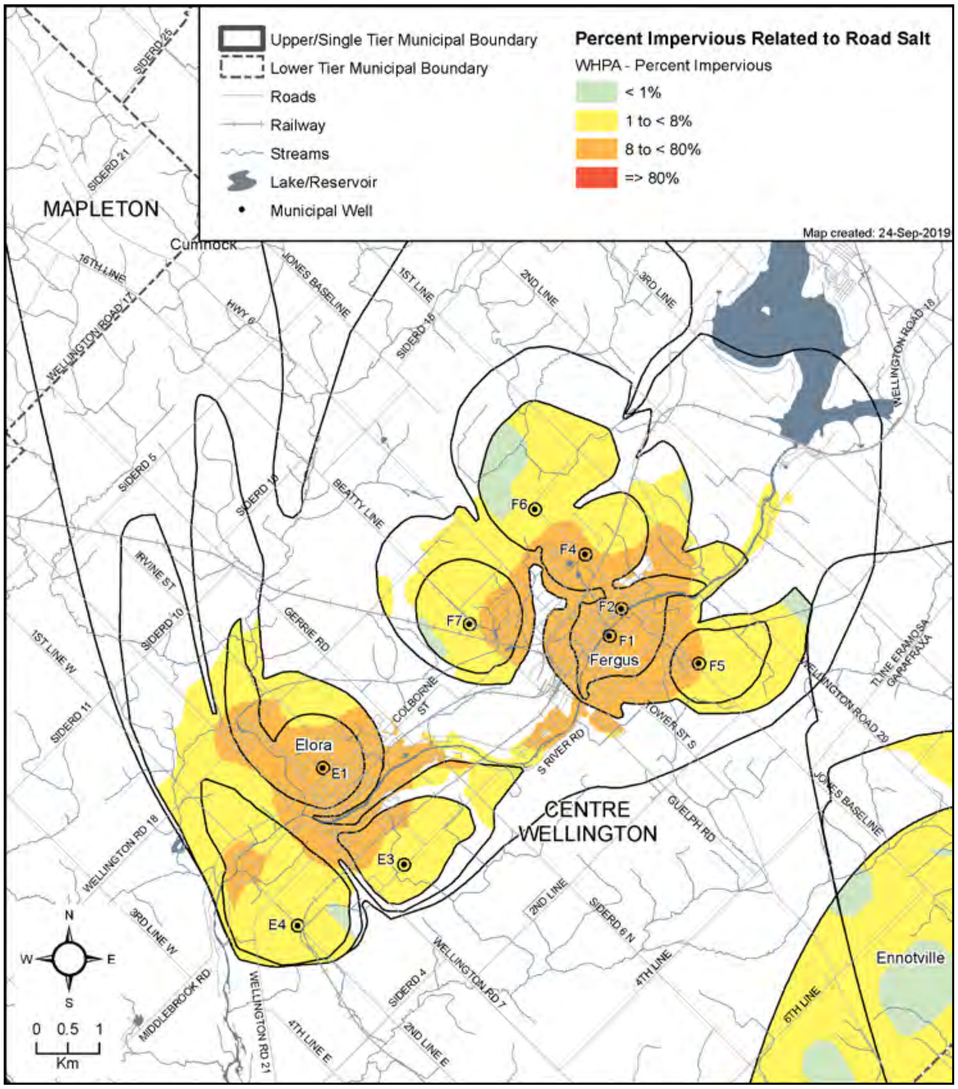
**Map 6-31: ~~Elora~~ Centre-Wellington Well Supply Livestock Density**



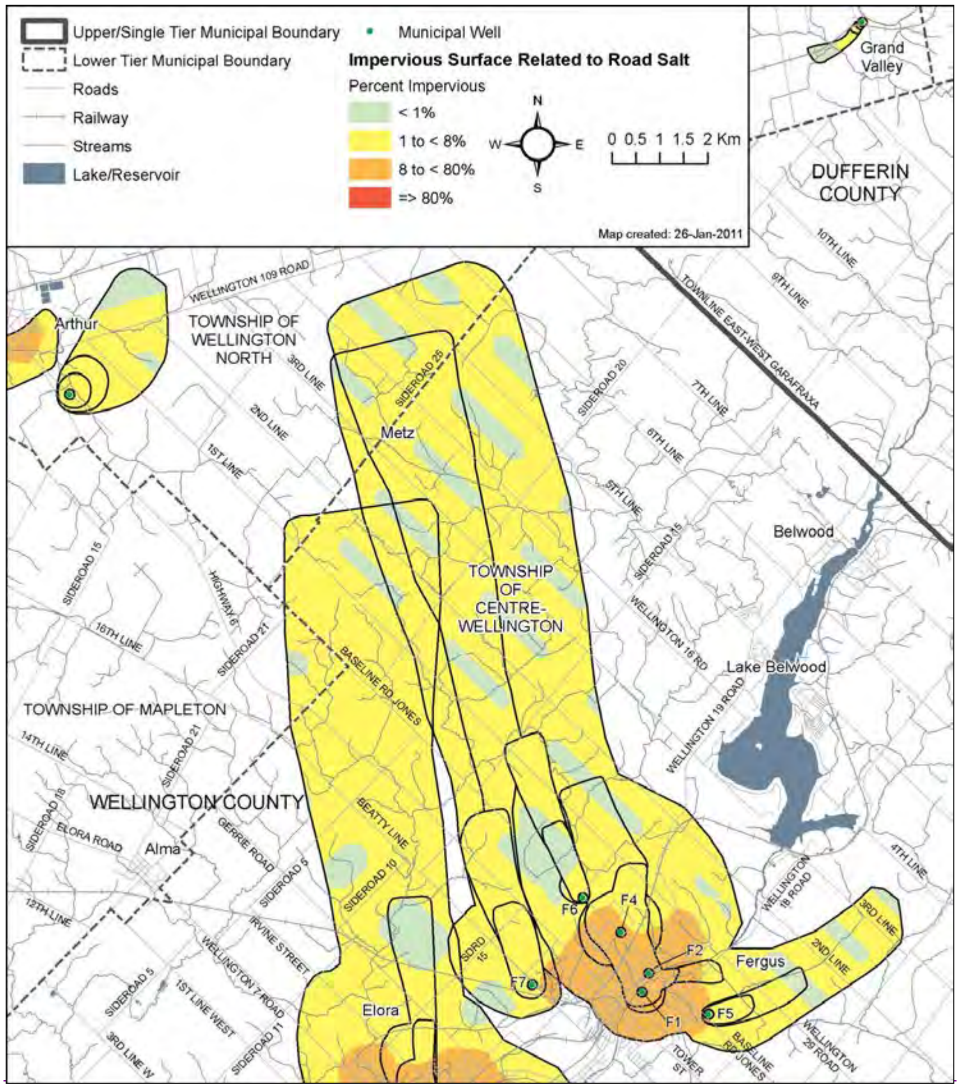
**~~Map 6-33: Fergus Well Supply Livestock Density~~**



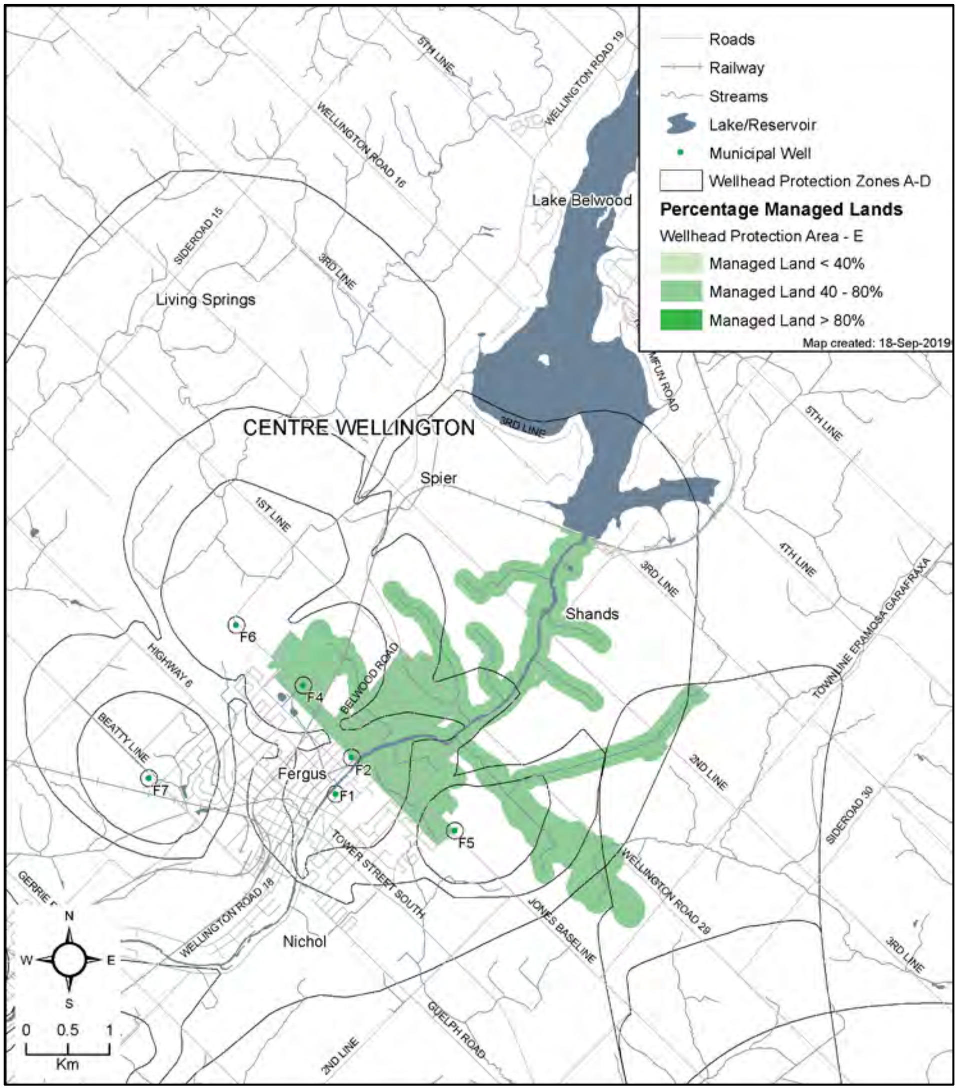
**Map 6-32: ~~Elora~~ Centre-Wellington Well Supply Percent Impervious Surfaces**



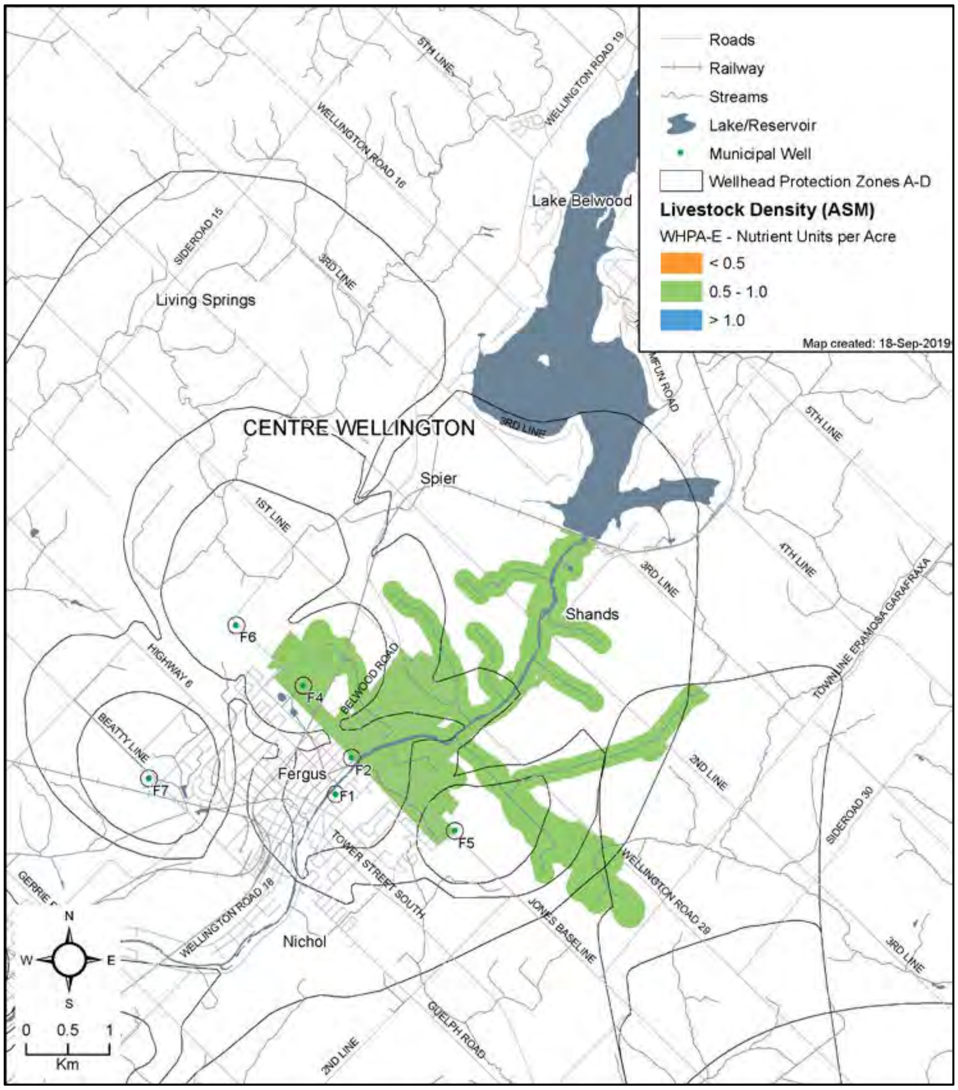
~~**Map 6-35: Fergus Well Supply Percent Impervious Surfaces**~~



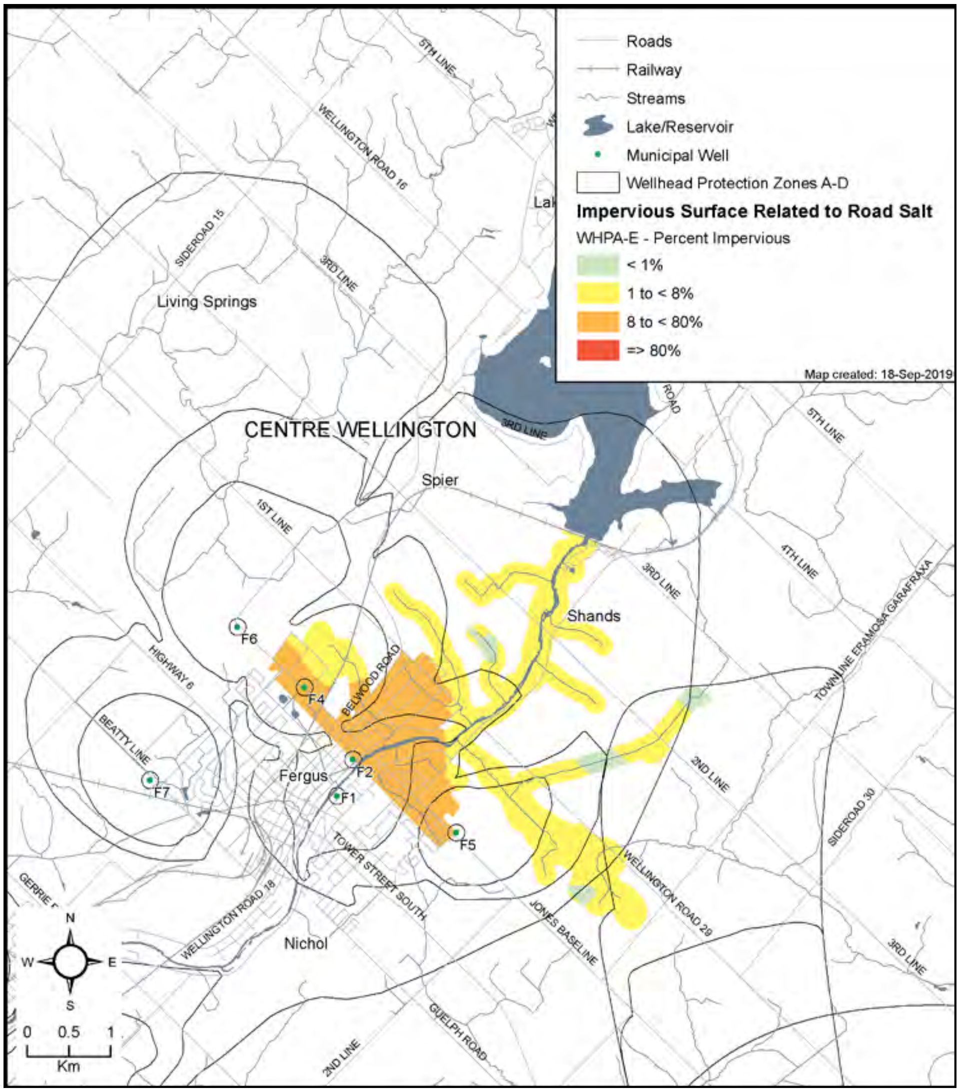
**Map 6-33: Centre Wellington Well Supply WHPA-E Percent Managed Lands (Fergus, Well F2)**



**Map 6-34: Centre Wellington Well Supply WHPA-E Livestock Density (Fergus, Well F2)**



**Map 6-35: Centre Wellington Well Supply WHPA-E Percent Impervious Surfaces (Fergus, Well F2)**



### 6.3.3 Drinking Water Threats Assessment

The Ontario Clean Water Act, 2006, defines a Drinking Water Threat as "an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat." A Prescribed Drinking Water Threats table in Chapter 3 of this Assessment Report lists all possible drinking water threats.

***Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Centre Wellington Well Supply***

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. ~~For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**.~~ The information above can be used with the vulnerability scores shown in **Map 6-27** and **Map 6-29** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

**Table 6-27** and **Table 6-28** provide a summary of the threat levels possible in the Centre Wellington Well Supply for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), and Pathogens. A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map 6-27** and **Map 6-29**.

**Table 6-29: Identification of Drinking Water Quality Threats in the Elora Wellhead Protection Areas**

| Threat Type | Vulnerable Area | Vulnerability Score | Threat Classification Level | | |
|---|---|---|---|---|---|
| | | | Significant 80+ | Moderate 60 to <80 | Low >40 to <60 |
| Chemicals | WHPA-A/B | 10 | ✔ | ✔ | ✔ |
| | WHPA-B/C | 8 | ✔ | ✔ | ✔ |
| | WHPA-B/C/D | 6 | | ✔ | ✔ |
| | WHPA-C/D | 2 & 4 | | | |
| Handling / Storage of DNAPLs | WHPA-A/B/C | Any Score | ✔ | | |
| | WHPA-D | 6 | | ✔ | ✔ |
| | WHPA-D | 2 & 4 | | | |
| Pathogens | WHPA-A/B | 10 | ✔ | ✔ | |
| | WHPA-B | 8 | | ✔ | ✔ |
| | WHPA-B | 6 | | | ✔ |
| | ~~WHPA-C/D~~ | ~~Any Score~~ | | | |

**Table 6-30: Identification of Drinking Water Quality Threats in the Fergus Wellhead Protection Areas**

| Threat Type | Vulnerable Area | Vulnerability Score | Threat Classification Level | | |
|---|---|---|---|---|---|
| | | | Significant 80+ | Moderate 60 to <80 | Low >40 to <60 |
| Chemicals | WHPA-A/B | 10 | ✔ | ✔ | ✔ |
| | WHPA-B/C | 8 | ✔ | ✔ | ✔ |
| | WHPA-B/C/D | 6 | | ✔ | ✔ |
| | WHPA-C/D | 2 & 4 | | | |
| | WHPA-E | 6.3 | | ✔ | ✔ |
| Handling / Storage of DNAPLs | WHPA-A/B/C | Any Score | ✔ | | |
| | WHPA-D | 6 | | ✔ | ✔ |
| | WHPA-D | 2 & 4 | | | |
| | WHPA-E | 6.3 | | | ✔ |
| Pathogens | WHPA-A/B | 10 | ✔ | ✔ | |
| | WHPA-B | 8 | | ✔ | ✔ |
| | WHPA-B | 6 | | | ✔ |
| | ~~WHPA-C/D~~ | ~~Any Score~~ | | | |
| | WHPA-E | 6.3 | | ✔ | ✔ |

### 6.3.4 Conditions Evaluation

Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the Technical Rules (MOECC, ~~2009b~~2017), lists ~~the following~~ criteria for drinking water sources, which is outlined in Chapter 3 of this Assessment Report.~~:~~

- ~~The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.~~
- ~~The presence of a single mass of more than 100 litres of one or more dense non-aqueous phase liquids in surface water in a surface water intake protection zone.~~
- ~~The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.~~
- ~~The presence of a contaminant in surface soil in a surface water intake protection zone if, the contaminant is listed in Table 4 of the Soil, Ground Water and Sediment Standards is present at a concentration that exceeds the surface soil standard for industrial/commercial/community property use set out for the contaminant in that Table; and~~

~~The presence of a contaminant in sediment, if the contaminant is listed in Table 1 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceed the sediment standard set out for the contaminant in that Table.~~

The above listed criteria were used to evaluate potentially contaminated sites within the Elora and Fergus WHPAs to determine if such a Condition was present at a given site.

Data Sources for the Conditions Evaluation

***Conditions Evaluation for the Centre Wellington Well Supply***

The results of the condition site assessment presented in the Approved Grand River Assessment Report (August 2012) indicated that no condition sites were identified within the Township of Centre Wellington. For the Township of Centre Wellington, sixteen (16) potential condition sites were identified in the Approved Assessment Report, however, there was a lack of information pertaining to contaminant concentrations and off-site migration at the time that prevented identification of condition sites under Technical Rule 126. This lack of information was identified as a data gap or uncertainty for the Centre Wellington portion of the Assessment Report and no condition sites were identified.

Since the approval of the Assessment Report in 2012, additional information has been obtained from Ministry of the Environment files, municipal files, and some responsible parties pertaining to condition sites within the Township of Centre Wellington. As a result, the available documents, reports and data pertaining to nineteen (19) potential condition sites were reviewed in 2015 to determine whether any of the sites met the technical rules as a condition or significant drinking water threat condition site. In 2015, six (6) sites were identified as condition sites while two (2) sites were identified as significant drinking water threat condition sites. In 2019, a review of available data and reports was completed to reassess the condition and / or significant drinking water threat condition status of the nineteen (19) sites and any additional sites identified since 2015. This review was completed primarily because of the redelineation of the wellhead protection areas.

During the 2019 review, nineteen (19) potential condition sites were reviewed, all were sites previously identified in 2015. There were no additional sites identified. ThreeEleven (311) of the nineteen (19) sites reviewed were not located within a municipal well head protection area and therefore are not considered condition sites under Technical Rule 126. The remaining sixteeneight (168) sites were located within municipal well head protection areas for either Elora, Fergus or Hamilton Drive wells. Fourteen (14) sites had sufficient information to be considered condition sites under Rule 126 while two (2) had insufficient information and therefore were not considered condition sites. Based in Fergus with vulnerability scores of 8 or 10 and therefore, depending on the site specific information related to contamination may be condition sites under Rule 126. Based on the documentation available at this time, six (6) sites within the Fergus WHPAs are considered condition sites under Technical Rule 126 and there is sufficient evidence to identify four (4) of the fourteen (14) two (2) of the six (6) sites as significant drinking water threat condition sites under technical rule 140 or 141. Three The two significant drinking water threat condition sites are located in Fergus and one significant drinking water threat condition site is located in Elora. The site in Elora and two of the sites in Fergus are related to petroleum hydrocarbon contamination and there is evidence of off-site contamination. The remaining site located in Fergus is related to trichloroethylene contamination and there is evidence of off-site contamination.

In 2015, two sites in Fergus were identified as significant drinking water threat condition sites and one of these sites is still identified as such in 2019. The remaining site is identified as a moderate drinking water threat condition site in 2019 due to a change in the wellhead protection areas and a reduction in the vulnerability scoring related to the site.

### 6.3.5 Drinking Water Issues Evaluation

The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)). Elevated concentrations of selected parameters that are naturally occurring or where effective treatment is in place are not considered drinking water Issues.

~~Once a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the Issue within an Issue Contributing Area and manage these threats appropriately. If at this time the Issue Contributing Area can not be identified or the Issue can not be linked to threats then a work plan must be provided to assess the possible link.~~

~~If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are as significant drinking water threats, regardless of the vulnerability.~~

***Drinking Water Issues Evaluation for the Centre Wellington Well Supply***

Potential Issues were evaluated through a review of raw water data from each of the production wells provided by Centre Wellington ~~Public Works~~Environmental Services from 2005, 2007, 2009 and 2011 to 2019 ~~and 2009~~ and from treated water chemistry data for the parameters listed in Schedule 23 and 24 of Ontario Regulation 170/03 for 2006, 2007 and 2009, where available. The ~~Public Works~~municipality also supplied nitrate concentrations from 2003 to 2019~~09~~.

In addition, historical summaries of water quality were reviewed from previous reports including Threats Assessment and Issues Evaluation (Blackport Hydrogeology Inc. and Triton Engineering Services Limited, 2008) ~~and~~, Water Resource Characterization Groundwater Management Study (Blackport Hydrogeology Inc., 2002b) and Investigation of Chloride in Drinking Water (Golder Associates Ltd., 2018). The raw water quality data available for the review were compared to the Ontario Drinking Water Quality Standards and the Technical Support Document to identify parameters approaching or exceeding a standard.

The microbiological data for the raw water from the municipal wells was obtained through a review of the 2015, 2016, 2017 and 2018 Annual Drinking Water Reports for Centre Wellington. ~~provided by Centre Wellington Public Works was reviewed for 2008 and from comments provided in previous reports, such as Threats Assessment and Issues Evaluation (Blackport Hydrogeology Inc. and Triton Engineering Services Limited, 2008).~~ The raw water quality data available for the review were compared to the Ontario Drinking Water Quality Standards to identify parameters approaching or exceeding a standard.

The Issues evaluation for Centre Wellington focused on the water quality parameter groupings outlined in the Ontario Drinking Water Quality Standards (ODWQS) identified in Ontario Regulation 169/03 under the *Safe Water Drinking Act* and the related technical support document. These parameters include: a) Pathogens. b) Schedule 1 Parameters, c) Schedule 2 and 3 parameters and, d) Table 4 parameters.

Parameters have been screened for closer investigation where any of the following criteria have been met:

- Consistent presence of microbiological parameters;
- The parameter has a health related Maximum Acceptable Concentration (MAC) associated with it and the concentration in the raw or treated water exceeds half of the MAC level (with the exception of fluoride); and
- The parameter does not have a health related MAC but the concentration observed exceeds the objective or guideline associated with the ODWS.

Water quality parameters meeting the screening threshold above were further reviewed to determine whether to identify them as Issues. The considerations included:

- Whether the concentration is at or trending towards a health related MAC;
- The frequency with which the parameter meets the screening threshold;
- Capabilities of the treatment facility;
- The ability of the parameter to interfere with/upset the treatment process;
- Whether the parameter is related to issues raised by the public; and
- Importance of the well to the overall supply.

In the Grand River *Assessment Report* (2012), chloride was identified as having an increasing trend in Elora Well E3, however, was not identified as a drinking water issue per the Technical Rules under the *Clean Water Act* in the Approved Grand River Assessment Report. Since the approval of the Assessment Report in 2012, additional chloride data has been collected for all municipal wells in Elora and Fergus, except Well F2, and historical data incorporated into the data set. In 2014, the Township commissioned Golder Associates to review the sodium and chloride data at Elora and Fergus wells to recommend what further action wa~~i~~s required including whether there wa~~i~~s sufficient evidence to identify a drinking water issue as per the Technical Rules under the *Clean Water Act.* In 2015, a drinking water issue under Rule 115.1 for Well E3 in Elora and Well F1 in Fergus was declared. Declaration of an issue under this Technical Rule required further monitoring of the issue but did not require delineation of an issues contributing area. Therefore, the 2015 Assessment Report did not delineate an issues contributing area for these wells, however, the municipality was required to complete further monitoring. Following the continued municipal monitoring of the issue, ~~Further,~~ in 2018, Golder Associates completed a study on chloride concentrations at the Fergus and Elora wells which recommended, as it pertains to Issues, the following:

- the continuation of chloride investigations at production wells F1, F6, F7, and E3 with quarterly sampling of chloride, sodium, nitrate, sulphate, iron and manganese; and,
- the development of a chloride Issue Contributing Area for well F1 and E3.

***Elora Drinking Water Issues Evaluation***

~~A review of the water quality data for Elora did not identify any Issues under Rule 114 with the drinking water sources. The review of the water quality data for Elora did identify a drinking water issue under Rule 115.1 for Well E3.~~ The 2018 Golder Associates review of the water quality data for the Elora~~Fergus~~ Wellfield identified a chloride Issue for drinking water source E3 under Rule 114. The chloride Issue Contributing Area is mapped on **Map 6-36**.

Well E1, in the north part of Elora, has ~~generally has good water quality, with~~ sodium and chloride concentrations below 20 mg/L and nitrate concentrations less than ~~2~~ 0.1 mg/L or non-detect. The Ontario drinking water quality standard for nitrate is 10 mg/L, the aesthetic objective for chloride, sulphate and iron are 250, 500 and 0.3 mg/L, respectively. Sulphate concentrations are below 3~~4~~00 mg/L and are naturally occurring. Aluminum was detected at 0.5 mg/L in one sample in 2009 which is above the operational guideline of 0.1 mg/L. When re-sampled, aluminum was detected at 0.06 mg/L. ~~Previous~~ All measurements of aluminum ~~in 2005 and 2007~~to 2019 were below the detection limit. Zinc concentrations ~~appear to be increasing since 2005 but~~ are well below the aesthetic objective of 5 mg/L and in almost all cases belwo the detection limit of . The 2014 review confirmed the above findings related to sodium and chloride concentrations (Golder, 2014).

Well E3, in the south part of Elora, currently ~~has good~~meets ODWQS for all health related parameters. ~~water quality,~~ S~~s~~odium concentrations ~~are below~~range from 5 to 50 mg/L, nitrate concentrations are below 1.3~~2~~ mg/L and sulphate concentrations ~~are below~~range from ~~-~~31 to 283~~40~~ mg/L. Sulphate concentrations have shown a sharp increase in 2011, 2015 and 2017 with values ranging from 278 to 283 mg/L, while sulphate concentrations in 2005 to 2009 and 2013 ran~~e~~ge from 30 to 34 mg/L. Sulphate concentrations are higher with higer pumping rates at E3 (Golder, 2018).

~~The 2014 review, however, indicated that~~ c~~c~~hloride concentrations range from 0.5~~1~~ to 165~~52~~ mg/L for Well E3 and appear to be increasing although variable. ~~The chloride concentration in July 2014 (152 mg/L) was over 50% of the aesthetic objective while in June 2014, the chloride concentration was 20 mg/L. The source of this variation is not clear currently and further study is required.~~ The chloride concentrations measured during some of the sampling events from 2~~3~~013 onward were greater that 50% of the Aesthetic Objective of 250 mg/L. As detailed in ~~the figure~~Figure 7-1 ~~below~~, the well E3 chloride data shows an increasing trend that approaches the 50 percent of Ontario Drinking Water Aesthetic Objective of 250 mg/L ~~within fifteen years (2030)~~ (Golder, ~~2014~~2018).

According to the Golder 2018 report, groundwater at well E3 is derived mainly from the bedrock aquifer and receives chloride from a surface (anthropogenic) source, which results in decreased chloride when it is pumped at a high rate. Due to the fact that the chloride is from an anthropogenic source and concentrations at the well have been above 50% of the AO and are on an increasing trend, chloride should be considered and Issue at well E3 (Golder, 2018).

~~It is recommended that the chloride concentrations at Well E3 be described a drinking water issue per Technical Rule 115.1 under Section 15 (2) (f) of the *Clean Water Act, 2006*. Under this Technical Rule,~~ A~~a~~n Issues Contributing Area is ~~not~~ delineated for Elora Well E3 and therefore ~~there can be no~~ significant threat activities are identified which are associated with the c~~C~~hloride I~~i~~ssue. The chloride Issue Contributing Area at Elora Well E3 is shown on **Map 6-36**.

~~The only applicable policies would relate to the monitoring of the chloride issue. Since the chloride concentrations are variable, although apparently increasing, this issue approach allows the Township time to complete further sampling and study into the trends, timing and fate / transport mechanisms for chloride at well E3.~~

Well E4, also located in the south part of Elora, ~~has good~~ currently meets ODWQS for all health related parameters~~water quality~~. There appears to be little groundwater impacts from surface sources of contamination. Chloride concentrations are below 10 mg/L, sodium concentrations are below 20 mg/L, nitrate concentrations are below 1 mg/L and sulphate concentrations are below 250~~300~~ mg/L. ~~Again, s~~Sulphate is naturally occurring in the area. It should be noted that zinc and iron concentrations increased in 2009 compared to previous and current concentrations; however, both are below the aesthetic objective.

~~The 2014 review confirmed the above findings related to sodium and chloride concentrations (Golder, 2014).~~Review of microbiological data for the Elora wells collected weekly indicates that no *E. coli* was detected in the three municipal wells in 2008. Total coliforms were detected ~~once~~

in 2008 and 2018 in Well E4 and Well E1, respectively. ~~at a concentration of 1 CFU/100 mL.~~ The absence of any *E. coli* detections, the minimal detections of total coliforms in the raw water samples collected from the municipal wells and no previous issues indicate that microbial water quality is not an Issue. However, it is important to monitor and ensure that the pathogen loading in the ~~Wellhead Protection Area~~WHPA is minimized or eliminated in accordance with the principles of source water protection.

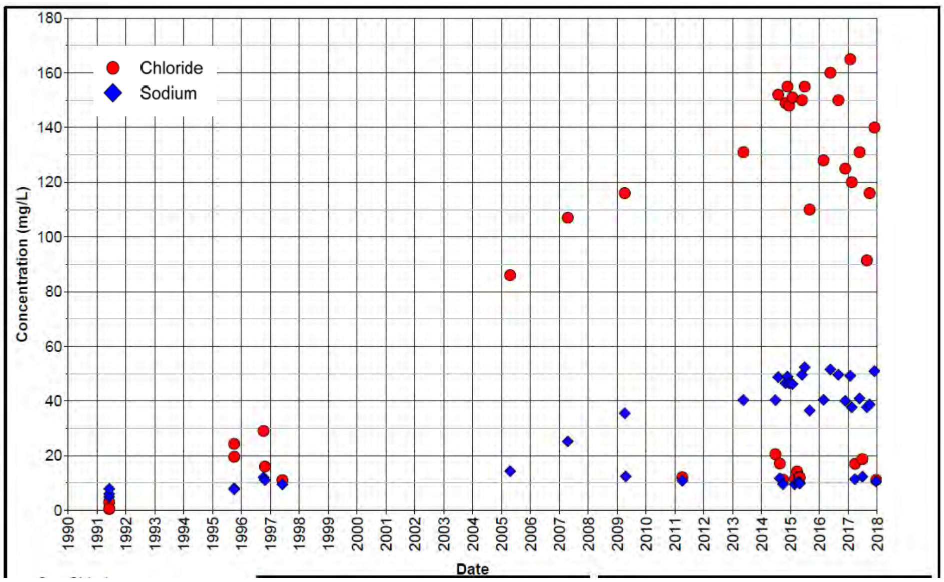



**Figure 7-1: Sodium and Chloride Concentrations at Well E3, Elora, Township of Centre Wellington.**

***Fergus Drinking Water Issues Evaluation***

A review of the water quality data for the Fergus Wellfield identified chloride and trichoroethylene Issues for drinking water source F1 under Rule 114. The c~~C~~hloride and t~~T~~richloroethylene Issue Contributing Area is mapped on **Map 6-36**.

~~No Issues under Rule 114 were identified with the drinking water sources for the Fergus wells. The presence of trichloroethylene (TCE) was noted at Well F1 as described below.~~

~~Well F1, with the exception of TCE and chloride, generally has good water quality~~Fergus well F1 has ~~slightly eve~~elevated c~~C~~hloride concentrations that range up to 160 mg/L~~, but are are below 80 110 mg/L~~, sodium concentrations ~~are slightly above 20~~range ~~from 14 to 60~~up to 93 mg/L, nitrate concentrations are less than 1.5~~2~~ mg/L and sulphate concentrations are elevated and ~~are generally below~~range from ~~500~~ 481 to 670 mg/L.~~. (Golder, 2010d).~~

The ~~2014~~ 2018 Golder review indicated that chloride concentrations range from 21 to 128~~10~~ mg/L for Well F1 and appear to be increasing, but ~~vary significantly~~show variation. The chloride c~~C~~oncentrations ~~remain below~~measured during a sampling event in 2019 was above the 50% of the On~~a~~tario Drinking Water Aesthetic Objective (AO) of 250 mg/L.~~.~~ ~~The source of this variation is not clear currently and further study is required (Golder, 2014).~~

Groundwater at well F1 appears to be derived mainly from the overburden and shallow bedrock and receives chloride from a surface (anthropogenic) source, which results in increased chloride in the well when it is pumped at a high rate (Golder, 2018). Due to the fact that the chloride is from an anthropogenic souce and concentrations at the well have been above 50% of the AO and are potentially on an increasing trend, chloride should be considered an Issue at well F1.

Well F1 has historically contained elevated concentrations of TCE (Golder, 2010d). Since 2000, measured TCE concentrations have ranged from less than 1 µg/L to 32 µg/L. For comparison purposes, the Ontario Drinking Water Standard has recently been updated and the criterion is 5 µg/L. TCE concentrations have averaged about 15 µg/L from 2001 to 2003, decreasing to 12 µg/L from 2004 to 2006, and decreasing again to an average concentration of 6.6 µg/L from 2007 to 2009. Recent TCE concentrations from 2016 to 2018 range from 0.76 µg/L to 11.7 µg/L, with an average concentration of 7.6 µg/L. ~~In 2009, the concentrations ranged from 1.6 µg/L to 13.8 µg/L averaging 5.9 µg/L, which is a little above the applicable criterion (5 µg/L). The well operates with an air stripper and seems to function well, as the Township indicates that water quality results for TCE are at or below detection limits and the water continues to be used for public water supply.~~TCE concentrations have been declining and are occasionally below the maximum allowable concentration (MAC) of 5 µg/L; however, overall TCE concentrations remain above the MAC of 5 µg/L. Based on these exceedances and the absence of a known TCE source, Centre Wellington has now identified TCE at Well F1 as an issue under Technical Rule 114, such that TCE management policies under the Clean Water Act (Government of Ontario 2017) can be implemented.

The occurrence of TCE at F1 was investigated in 1990 after TCE was discovered in two private wells in September 1989. The report indicated that there may be numerous sources of TCE, with the sources occurring at various depths. In general, most of the sources are in close proximity and it is assumed that pumping F1 would contain them. With respect to the TCE at F1, Blackport Hydrogeology Inc. (2002c) indicates that the source of contamination was not verified. Further, Blackport Hydrogeology Inc. and Triton Engineering Services Limited (2008) concluded that the source of TCE is likely distant from the well as the elevated concentrations of TCE were found in a deeper zone of the open bedrock well.

In addition to F1 operating with an air stripper since 1991, treatment was added to two bedrock wells at a private site in about 1993 where water from these two wells has been pumped and treated continuously since that time with the treated water being discharged into a local storm water drain. All of these wells essentially act as containment wells to minimize the potential for further spreading of the TCE. The Township submits annual water quality and pumping reports to the MECP~~OE~~ for Well F1 consistent with the Drinking Water Regulations.

~~All available data indicates that the TCE treatment system is performing as designed and has done so for more than 10 years. Triton Engineering Services indicates that the system was originally designed to treat 1137 L/min with a raw water concentration of 100 µg/L. With an average taking from 2006 to 2008 of 537 L/min and the maximum raw water TCE concentration measured during that time at less than 20 µg/L, it appears that excess treatment capacity is available. Triton Engineering Services also indicate that there have been no incidences of the system being, or coming close to being, overwhelmed and that the system has been operating well within the design objectives since it was put into operation. Since the concentrations in the raw water appear to be decreasing to below the drinking water standard and the air stripper is effective in reducing the concentrations to below the drinking water standard, it is anticipated that the treatment system is sufficient in addressing this concern and no additional management plan is warranted at this time. It should be noted that the existing management plan should be formalized.~~

~~Well F2, located north of the Grand River in Fergus, is not currently in use for water supply purposes and historical data appears to be sparse. Summaries of water quality from previous studies indicate that the water quality is generally good. It appears that chloride concentrations are less than 90 mg/L, sodium concentrations are slightly above 20 mg/L, nitrate concentrations are less than 1 mg/L, sulphate concentrations are less than 200 mg/L and iron concentrations are around 0.1 mg/L. Blackport (2002c) indicates that iron concentrations become elevated if the well is pumped at a high rate.~~

Well F4, located in the northern part of Fergus, ~~generally has good water quality with~~ has elevated concentrations of iron. The iron concentrations in well F4 are greater than 0.6 mg/L, which is greater than the aesthetic objective of 0.3 mg/L. The iron is naturally occurring. Treatment is in place at F4 to filter out the iron to less than 0.3 mg/L prior to delivery into the distribution system. Chloride concentrations are generally less than 30 mg/L, sodium concentrations are slightly above 20 mg/L, nitrate concentrations are less than 0.3 mg/L and sulphate concentrations are less than 400 mg/L. ~~The 2014 review confirmed the above findings related to sodium and chloride concentrations (Golder, 2014).~~

Well F5, located in the southern limits of Fergus~~, has good quality water~~. Chloride and sodium concentrations are less than 20 mg/L, nitrate concentrations are less than 0.6 mg/L and sulphate concentrations are generally less than 100 mg/L. In 2009, a~~A~~luminum concentrations ~~may be increasing at well F5 and were first~~ recorded an above the operational guideline of 0.1 mg/L~~ in 2009~~; however concentrations have since been below the operational guideline. ~~The 2014 review confirmed the above findings related to sodium and chloride concentrations (Golder, 2014).~~

Well F6, located north of Fergus contains elevated levels of sulphate greater than the aesthetic objective of 500 mg/L. The sulphate is naturally occurring and is believed to be elevated at well F6 due to the influence of deeper flow systems within the well. ~~Chloride concentrations are less than 100 mg/L,~~ S~~s~~odium concentrations are slightly above 20 mg/L~~,~~ and nitrate concentrations have not been detected. ~~It should be noted that the chloride concentration~~Chloride concentration were around 40 mg/L up to the mid-2008 and since 2009, concentrations have been variable ranging from 10 to 88 mg/L. The concentrations are below 50% of the Ontatio Drinking Water Aesthetic Objective of 250 mg/L. An investigaton by Golder (2018) determined that high pumping at well F6 resulted in decreased chloride concentrations and that surficial recharge dominates at the high pumping. The low sulphate concentrations at high pumping indicates that a bedrock (natural) source of chloride at well F6 (Golder, 2018). ~~increased in 2009 compared to previous concentrations measured, but is below the aesthetic objective~~. Iron concentrations are variable and exceeded the ~~aesthetic~~ Aesthetic ~~objective~~ Objective of 0.3 mg/L in 2009, 2011 and 2015. Iron is naturally occurring in the groundwater system. ~~The 2014 review indicated that chloride concentrations range from 10 to 88 mg/L for Well F6 and appear to be increasing but vary significantly. Concentrations remain below 50% of the Onatrio Drinking Water Aesthetic Objective of 250 mg/L. The source of this variation is not clear currently and further study is required (Golder, 2014).~~

Well F7 is~~,~~ located on the western side of Fergus~~, has good water quality~~. ~~Chloride concentrations are less than 28mg/L, S~~Sodium concentrations are occasionally slightly above 20 mg/L, nitrate has not been detected and sulphate concentrations ~~are less than~~range from 45~~100~~ mg/L to 317 mg/L. ~~The 2014 review confirmed the above findings related to sodium and chloride concentrations (Golder, 2014).~~ Chloride concentrations measured at well F7 range from 7 to 29 mg/L. There is no long term historical record of water quality at F7, however, the available data indicates that chloride concentrations are low and variable with no apparent increasing trend. The concentrations are below 50% of the Ontatio Drinking Water Aesthetic Objective of 250 mg/L. An investigaton by Golder (2018) determined that high pumping at well F7 resulted in increased chloride concentrations and that a bedrock water source dominates at the high pumping. The higher sulphate concentrations at high pumping indicates that a bedrock (natural) source of chloride at well F6 (Golder, 2018)

Review of microbiological data for the Fergus wells (F1, F4, F5, F6, F7) collected weekly indicates that no *E. coli* was detected ~~in 2008.~~ from 2015 to 2018. Total coliforms were ~~only~~ detected ~~three~~ a total of seven times ~~in 2008~~from 2015 to 2018 ~~at F1 at concentrations of 1 CFU/100 mL.~~ and once resampled to detection of total coliforms were present. No samples were collected from F2 as it was not in use.

GUDI assessments have also been conducted at Wells F1 and F2 as they are located adjacent to the Grand River and have only a limited thickness of overburden above the bedrock. The studies concluded that Well F1 showed a low risk of contamination from surface sources but Well F2 was classified as GUDI. The absence of any *E. coli* detections and the minimal detections of total coliforms in the raw water samples collected from the municipal wells indicate that microbial water quality is not an Issue. However, it is important to monitor and ensure that the pathogen loading in the Wellhead Protection Areas is minimized or eliminated in accordance with the principles of source water protection.

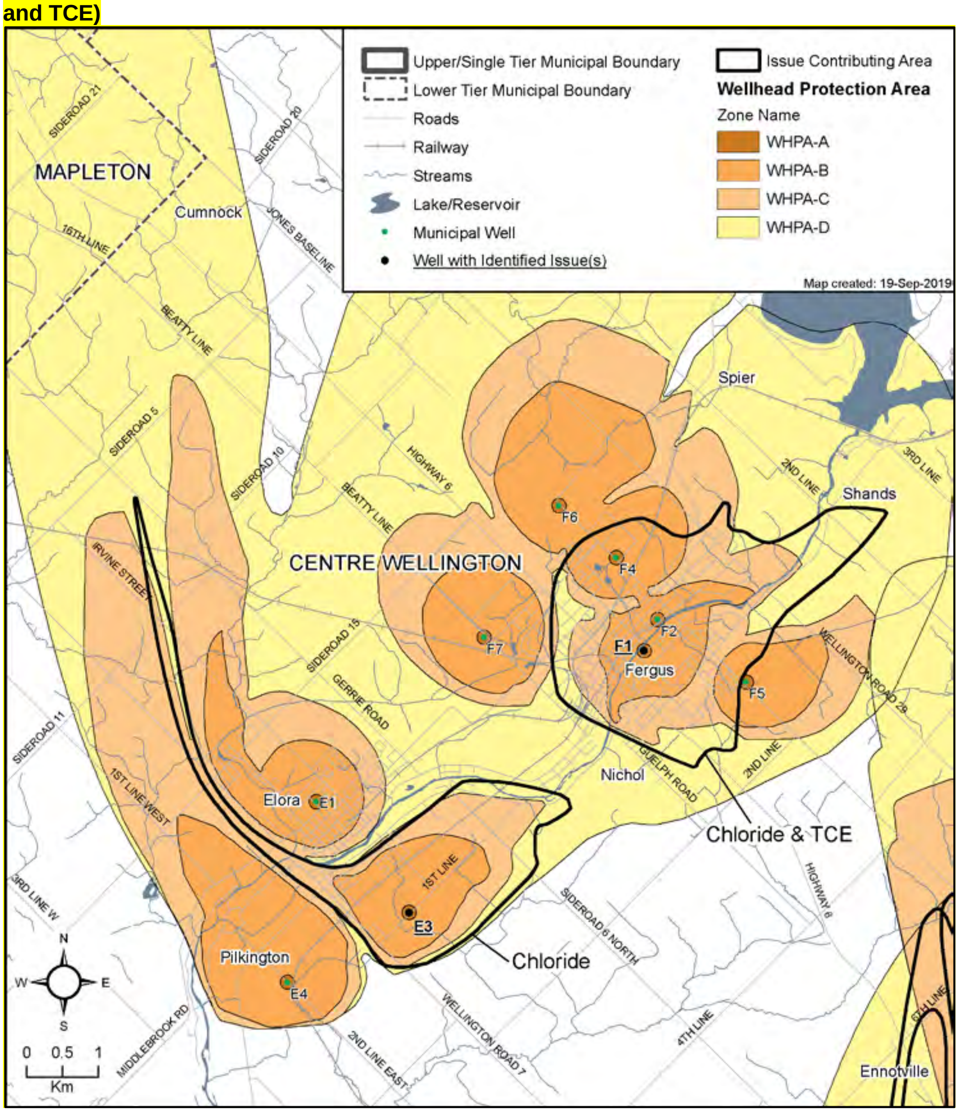
***Summary of Drinking Water Issues Evaluation***

Chloride concentrations at Well E3 and F1 appear to be on an increasing trend with concentrations measured above 50% of the Ontario Drinking Water Aesthetic Objective of 250 mg/L. Measured chloride concentrations at wells E3 and F1 is from shallow sources and potential chloride sources exist within the capture zones; therefore, Issue Contributing Areas were delineated for Wells E3 and F1. TCE concentrations continue to remain near 50% of the MAC; therefore a TCE Issue Contributing Area was delineated for F1.

ICAs were delineated for Wells F1 and E3 using backward particle pathlines simulated using the Base Case model scenario, where the time-of-travel to each well is less than or equal to 25 years. Delineation of the ICAs was done using the same method as described above in Section 6.3.2 for delineating the Centre Wellington WHPAs. A 25-year capture zone for each well, for each set of pumping rates, was delineated and then combined to create a single ICA for each well. The pumping rates used were both exisiting and future rates (Matrix, 2018). The Issue Contributing Areas are shown on **Map 6-36**.

~~The review of the data for the Elora and Fergus wells indicated no Issues under Rule 114 are present.~~

**Map 6-36: Issue Contributing Areas for Elora E3 (Chloride) and Fergus F1 (Chloride and TCE)**



### 6.3.6 Enumeration of Significant Drinking Water Quality Threats

The Technical Rules require an estimation of the number of locations at which an Activity is a significant drinking water threat and the number of locations at which a Condition resulting from past activity is a significant drinking water threat.

#### *6.3.6.1 Initial Enumeration of Significant Drinking Water Threats*

For the 2012 Assessment Report, tThe initial enumeration of land use activities that may be associated with prescribed drinking water threats was based on a review of multiple data sources, including public records, data provided through questionnaires completed by municipal officials, previous contaminant/historical land use information, and data collected during windshield surveys. No site specific information was collected. ~~As more site specific information becomes available during the source protection planning process, the presence of drinking water threats and their current level of management can be confirmed.~~

Drinking water threats as defined in the Ontario Clean Water Act (2006) were identified within the Centre Wellington Wellhead Protection Areas through an enumeration of land use activities that may be associated with Prescribed Drinking Water Threats (Ontario Regulation 287/07).

~~The main objective of the assessment was to identify significant threats. A significant threat to a source of drinking water has a high likelihood of rendering a current or future drinking water source impaired, unusable or unsustainable, combined with a potential route for the threat to enter the source water.~~

***Data Sources for the Enumeration of Significant Drinking Water Threats***

For the initial enumeration in the 2012 Assessment Report, tThe key data sources used to identify threats on properties within the Wellhead Protection Areas include the following:

- Municipal Property Assessment Corporation (MPAC) assessment information;
- Hazardous Waste Information Network (HWIN) database;
- Technical Safety and Standards Authority (TSSA) database;
- Discussions with Triton Engineering Services to identify current and historical land use activities;
- Review of previous threats inventory by Triton Engineering Services;
- Review of air photos; and
- Review of Schedule B of the Municipal Official Plan for the Township of Centre Wellington (2005).

The Township of Centre Wellington operates under both the County of Wellington Official Plan and the Township's Official Plan. The general policies apply to the entire Township and the land use of the County Official Plan applies to the rural areas. The Township Official Plan applies to the urban centres of Fergus and Elora. The Township provided copies of their Official Plan that was approved by the Ontario Municipal Board in May 2005 and a Consolidated Official Plan as of July 2008. The following provides some of the pertinent information directly from the Consolidated Official Plan as it relates to land uses and source water protection.

A review of these land uses within vulnerability zones of 10 (i.e., locations of significant chemical and pathogen threats) within the urban boundary indicates that all of the land uses, except Highway Commercial and Residential Transition Area, are present. In addition, all the land uses, except Residential Transition Area are present within WHPA-C, which are possible locations for DNAPL threats. The same threats that were associated with the various MPAC property codes can also be assumed for similar land use planning zones, for example, application of commercial fertilizer to recreational areas.

The completed threat enumeration has involved numerous assumptions regarding the threat types and circumstances associated with various property types based on current land use information and existing data sources. An inventory of potential future land uses and associated threats, constrained within the official plan, would involve additional assumptions. It should also be noted that the approvals process in Wellington County requires a site specific investigation and impact assessment associated with the proposed activities and the appropriate monitoring and mitigation plans. Therefore, before the County would approve any zoning change, or issuance of a building permit, these conditions of the Counties current groundwater management plan would need to be met.

***Assumptions for the Enumeration of Significant Drinking Water Quality Threats***
A standardized set of assumptions (**Table 6-29**) were made for each land use type and activity, a summary is provided below:

- All properties with identified agricultural managed lands were based on MPAC codes;
- Areas were applied pesticides were determined by calculating the area of the parcel with agricultural managed lands;
- Assumptions with respect to type of facility, mass or material and storage;
- Assumed surrounding land uses;
- Only areas outside the municipal wastewater serviced areas and were identified as being on septic systems; and
- Assumed hazard scores based on property codes.

**Table 6-31: Land Use Activity Assumptions for the Purpose of Enumerating Significant Drinking Water Quality Threats in the Centre Wellington Well Supply**

| Scenario | Assumption |
|---|---|
| Agricultural property with residence and outbuildings | • Storage and handling of pesticides, fuel, commercial fertilizer, agricultural source material, septic system.<br>• Application of pesticide, commercial fertilizer, agricultural source material. |
| Agricultural property with residence and outbuilding – buildings not in WHPA | • Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied. |
| Agricultural property without farm buildings and structures | • Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied. |
| Residence with no gas line | • Oil furnace |

**Table 6-31: Land Use Activity Assumptions for the Purpose of Enumerating Significant Drinking Water Quality Threats in the Centre Wellington Well Supply**

| Scenario | Assumption |
|---|---|
| Organic solvent | • Storage below grade in a quantity that would make it a significant threat |
| No sanitary sewer infrastructure | • Septic system |
| Presence of any chemical | • Storage is below grade |
| Multiple PINs associated with one Assessment Roll number | • One threat point assigned to the entire assessed property. |
| Where an assessment line transects a property, but has one PIN | • One threat point assigned to the entire property. |
| Lawn/turf | • Potential application of commercial fertilizer (ID dependent on the percent of managed land and the application of NU to the surrounding properties) |
| Municipal well sites | • Commercial fertilizer not applied unless the well is within a municipal park, in which case there is potential that fertilizer is applied. |
| All properties | • If buildings and structures are located outside the vulnerable area – circumstance IDs associated with storage and handling are not applied |
| Septic system | • In serviced villages where sanitary services are being phased in, but have not yet reached the mandatory connection date, it is assumed private septic systems are still present. |
| Sanitary sewers | • A sanitary sewer is a linear feature. For the purposes of enumeration of threats, where a sanitary sewer is present one threat point is assigned to represent the sanitary sewer in each WHPA. |
| Storm sewer piping | • Storm sewer piping is not considered to be part of a storm water management facility. |

### *6.3.6.2 Enumeration of Significant Drinking Water Threats for 2019 Assessment Report*

Since the initial enumeration of significant drinking water threats for the 2012 Assessment Report, a substantial amount of work has been completed by municipal Risk Management staff and consultants to verify threats at a site level. This work has included additional air photo analysis, site visits, windshield surveys, review of databases and site specific files / reports. The focus of this work is to compete verification of significant drinking water threats and where warranted negotiate risk management plans and to conduct inspections. This work has been focused within the wellhead protection areas delineated in the 2012 and 2015 Assessment Reports. New wellhead protection areas have now been delineated, however, there is overlap between the 2015 and the new wellhead protection areas.

For purposes of updating significant drinking water quality threats in the newly delineated wellhead protection areas, a review is being conducted of the existing database of verified threats, municipal servicing data and air photos. Results will be updated in the Assessment Report prior to public consultation. For purposes of identifying significant drinking water quality threats within the Chloride Issues Contributing Area, all properties present within the Issues Contributing Area have been identified as significant drinking water quality threats.

***Significant Drinking Water Quality Threats in the Elora Wellhead Protection Areas***

The results of the Elora threat enumeration are presented by threat type. A summary of the threat ranking results for each Wellhead Protection Area, grouped by threat type, is presented in **Table 6-30**.

**Table 6-32: Significant Drinking Water Quality Threats in the Elora Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 4 | WHPA-A WHPA-B |
| 2 | Sewage System or Sewage Works- ~~Septic~~ Onsite Sewage Systems | 1 | WHPA-A |
| | Sewage System or Sewage Works- Sanitary Sewers and related pipes | 1 | WHPA-A WHPA-B |
| 3 | Application of Agricultural Source Material to Land | 3 | WHPA-A |
| 8 | Application of Commercial Fertilizer | 2 | WHPA-A |
| 10 | Application of Pesticides to Land | 3 | WHPA-A |
| 12 | Application of Road Salt | 793 | ICA |
| 13 | Handling and Storage of Road Salt | 793 | ICA |
| 14 | Storage of Snow | 793 | ICA |
| 16 | Handling and Storage of DNAPLs | 30 | WHPA-A WHPA-B WHPA-C |
| 17 | Handling and Storage of Organic Solvents | 4 | WHPA-A WHPA-B |
| **Total Number of Activities** | | **48** | |
| **Total Number of Properties** | | **34** | |

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

***Significant Drinking Water Threats in the Fergus Wellhead Protection Areas***

The results of the Fergus threat enumeration are presented by threat type. A summary of the threat ranking results for each Wellhead Protection Area, grouped by threat type, is presented in **Table 6-31**.

**Table 6-33: Significant Drinking Water Quality Threats in the Fergus Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 26 | WHPA-A WHPA-B |
| 2 | Sewage System or Sewage Works- Onsite SewageSeptic Systems | 23 | WHPA-A WHPA-B |
| | Sewage System or Sewage Works- Sanitary Sewers and related pipes | 1 | WHPA-A WHPA-B |
| 3 | Application of Agricultural Source Material to Land | 2 | WHPA-A |
| 10 | Application of Pesticides to Land | 2 | WHPA-A |
| 12 | Application of Road Salt | 3863 | ICA |
| 13 | Handling and Storage of Road Salt | 3863 | ICA |
| 14 | Storage of Snow | 3863 | ICA |
| 14 | Storage of Snow | 1 | WHPA-A |
| 15 | Handling and Storage of Fuel | 1 | WHPA-B |
| 16 | Handling and Storage of Dense Non-Aqueous Phase Liquids | 79 | WHPA-A WHPA-B WHPA-C |
| 17 | Handling and Storage of Organic Solvents | 26 | WHPA-A WHPA-B |
| **Total Number of Activities** | | **161** | |
| **Total Number of Properties** | | **108** | |

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

According to the Ministry of the Environment's Table of Drinking Water Threats, there are no significant threats in WHPA-E zone for Well F2 based on the vulnerability scores.

***Limitations and Uncertainty for the Enumeration of Significant Drinking Water Threats***

- The threat assessment is a desktop scale analysis based on the assumptions used for the threat rankings. The assessment has involved only minor field verification or site visits to validate the information. The current assessment identifies significant water quality threats based on a number of assumptions and site visits to confirm actual site conditions and circumstances were not conducted. Site visits may be needed to confirm the actual site conditions and circumstances and in some cases to develop site specific response and risk management activities.

- The threat assessment has relied on a number of pre-existing data sources to complete the evaluation. In some cases the existing data sources are not current. Activities taking place on a given property may change from year to year or month to month.

- The MPAC property codes, used to identify the use of the property and the associated threats, do not always represent the current land use activity on the property. As such,

**Commented [KD1]:** This section will need to be updated once the threat enumeration is complete for the new areas. This section could get moved to the 2012 / 2015 enumeration section.

threats may be applied to a property where they do not exist or vice versa, threats may have been missed on a property where they do exist.

- To confirm whether the sites identified as potential Conditions meet the criteria to be a Condition threat, all documentation relating to the potential Conditions would need to be obtained from the MOE or other agencies and reviewed to understand the current status of these sites.

- The location of a threat Activity on a property was assumed to be over the most vulnerable portion of a property where more than one vulnerability score zone was present on the property.

- As noted in Section 6.3.2, the vulnerability score has not been updated to be consistent with the most recent geological understanding developed during the Tier 3 studies.

- The results of this assessment are to be used for development of source protection plans at the wellhead protection area scale of analysis only; and should not be used, and are not intended for use, at the scale of the individual property.

## 6.4 Township of Guelph-Eramosa

Two municipal groundwater systems are located within the Township of Guelph-Eramosa: Rockwood Water Supply and Hamilton Drive Water Supply. The area serviced by these two systems is shown on **Map 6-37.** The Guelph serviced area is also shown on this map to provide additional context. **Table 6-32** and **Table 6-33** summarize the municipal groundwater systems and the average monthly and annual pumping rates for both systems.

**Table 6-34: Municipal Residential Drinking Water System Information for the Township of Guelph-Eramosa in the Grand River Source Protection Area (Rockwood and Hamilton Drive Water Supply Systems)**

| DWS Number | DWS Name | Operating Authority | GW or SW | System Classification[1] | Number of Users served[2] |
|---|---|---|---|---|---|
| 220005599 | Rockwood Water Supply System | ~~Ontario Clean Water Agency (OCWA)~~Guelph / Eramosa Township | GW | Large Municipal Residential System | ~~3,970~~1635 |
| 220009197 | Hamilton Drive Water Supply System | ~~Ontario Clean Water Agency (OCWA)~~Guelph / Eramosa Township | GW | Large Municipal Residential System | 216~~653~~ |

[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*

[2] Based on ~~Ontario Clean Water Agency 2008 Annual Summary Reports (2009a, 2009b)~~ Watson & Associates Economists LTD. The Township of Guelph / Eramosa Water and Wastewater Rate Study (July 2015)

**Table 6-35: Annual and Monthly Average Pumping Rates for Rockwood and Hamilton Drive Water Supply Systems**

| Well or Intake | Annual Avg. Taking[1] (m³/d) | Monthly Average Taking[1] (m³/d) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| **Rockwood** | | | | | | | | | | | | | |
| Well 1 | ~~285.48~~292.96 | 3.31~~352.84~~ | 240.10 ~~261.93~~ | 230.13 ~~189.52~~ | 232.65 ~~185.07~~ | 392.77 ~~251.03~~ | 331.92 ~~348.57~~ | 305.18 ~~252.61~~ | 315.27 ~~323.81~~ | 361.69~~303.80~~ | 296.36~~227.61~~ | 318.40~~427.17~~ | 487.76 ~~301.81~~ |
| Well 2 | ~~216.87~~238.05 | 279.64 ~~68.0~~ | 3.89~~151.86~~ | ~~174.39~~ 205.83 | ~~284.90~~ 257.76 | 237.49 ~~371.52~~ | 325.94 ~~296.97~~ | 303.58 ~~326.94~~ | 277.76 ~~265.45~~ | 333.69~~270.07~~ | 292.67~~216.42~~ | 230.56~~10.6~~ | ~~165.42~~ 107.84 |
| TW3/02 | ~~410.94~~380.55 | ~~422.52~~ 617.10 | ~~418.40~~ 625.08 | 370.23 ~~466.13~~ | 355.13 ~~451.94~~ | 382.15 ~~398.71~~ | 335.65 ~~387.62~~ | ~~448.92~~ 337.81 | ~~341.52~~ 312.42 | ~~355.54~~285.63 | ~~421.16~~294.04 | ~~401.89~~307.56 | ~~417.01~~ 343.77 |
| **Hamilton Drive** | | | | | | | | | | | | | |
| Cross Creek | ~~91.48~~69.80 | ~~73.23~~54.90 | ~~72.78~~74.62 | ~~77.53~~74.95 | ~~88.3~~64.27 | ~~113.93~~ 90.11 | ~~117.38~~ 108.75 | ~~124.92~~ 83.76 | ~~94.46~~77.16 | ~~99.46~~63.31 | ~~70.96~~ 41.90 | ~~80.91~~ 42.88 | ~~78.63~~ 60.88 |
| Huntington | ~~90.48~~73.08 | ~~78.5~~68.33 | ~~73.86~~41.11 | 47.31~~69.36~~ | ~~86.49~~64.39 | ~~97.51~~80.49 | ~~111.05~~ 57.04 | ~~113.95~~ 111.78 | ~~105.94~~ 98.23 | ~~98.44~~90.49 | ~~84.27~~ 72.77 | ~~81.16~~ 71.57 | ~~85.22~~ 73.50 |

[1] source: Based on ~~Ontario Clean Water Agency~~Guelph / Eramosa Township ~~2008~~ 2018 Annual Summary Report~~s~~ (~~2009a, 2009b~~2019)

Hydrogeological Setting

The Township of Guelph/Eramosa is located within the Speed/Eramosa River Subwatershed and the Hopewell Creek and Cross Creek catchments of the Grand River Drainage Basin. Land in the area generally slopes towards the Eramosa River and Speed River.

Overburden Geology

Overburden units deposited during the Quaternary Period (2 million years before present [ybp] to 10,000 ybp) detail a period of repeated ice advance and retreat of ice lobes that originated from the Erie-Ontario lake basin (Karrow 1967). Overburden deposits range in thickness from 10 to 30 m near Hamilton Drive and from less than 1 m to 15 m in Rockwood according to water well logs. These overburden deposits are largely fine-grained till and glaciolacustrine deposits. Due to the predominance of largely fine-grained overburden sediments, overburden has not been typically targeted as a source of municipal water supply in these areas (Matrix, 2018).

Coarse-grained materials in the area may form shallow overburden aquifers, as seen south of the City of Guelph, but these granular deposits are not laterally extensive. However, there is a potential connection between the surface and the deeper production zone of the middle Gasport Formation through overburden aquifers in buried bedrock valleys where the thickest overburden sediments are present. The bedrock valley infill tends to be coarser in nature; mainly sand with minor silt-rich beds and capped by finer grained sediments at surface near Rockwood (Burt and Webb 2013). Just north of Rockwood and southeast of Everton, the valley sand is interpreted to be partially overlain by coarser grained glaciofluvial outwash that outcrops at surface.

~~The quaternary geology of the Township consists primarily of Wentworth Till. Wentworth Till is described as sandy silt till that does not readily transmit water. Outwash deposits of sand and gravel occur as kames and eskers across the Township (Golder, 2006a). Ice contact stratified drift deposits and glaciofluvial deposits are located in the Rockwood area. The area of the Hamilton Water Supply System wells is dominantly Wentworth Till with some glaciofluvial deposits and sand deposits. Bedrock outcrops and organic deposits are found along the Speed River and Eramosa River.~~

~~The overburden thickness in the Township is generally less than 25 m. Overburden is thickest along glacial deposits ranging from 25 to 75 m (Golder, 2006a). The Rockwood area consists of minimal overburden cover that ranges from no overburden in the area of the Eramosa River to just over 6 m in the area of the production wells. At the Cross Creek area the overburden can be up to 21 m thick while at the Huntington site the overburden is only 3 m thick.~~

Bedrock Geology

Bedrock geology beneath the Study Area consists of Paleozoic limestone, dolostone, and shale formations that overlie deeply buried Precambrian crystalline basement rocks (Armstrong and Carter 2006). Bedrock formations dip regionally to the southwest and record deposition related to sea level changes in a shallow subtropical sea during the Paleozoic Era (approximately 440 to 420 million years ago).

~~The bedrock in the study area consists of the Silurian age dolostone of the Guelph and Gasport Formations. The bedrock in the Rockwood area consists of dolostone from the Gasport Formation. The bedrock in the area of the Cross Creek and Huntington Wells consists of brown or tan dolostone of the Guelph Formation and is encountered at depths between 3 m and 21 m below ground.~~

Hydrogeology

Bedrock aquifers in the Guelph Formation and Gasport Formation are the ~~principal~~ main source of groundwater in the Township. The spatial distribution and subsurface geometries of the major bedrock units are important in understanding patterns in the groundwater flow system and potential hydraulic connections between aquifer units.

The Guelph Formation is the shallowest bedrock unit, is characterized as an aquifer, and near Hamilton Drive ranges in thickness from 2 to 28 m and generally thins toward the south. Near Rockwood, this unit is only present west of the Eramosa River, west of Rockwood, and ranges in thickness from 2 to 15 m (Matrix, 2018).

The Reformatory Quarry Member of the Eramosa Formation lies beneath the Guelph Formation and is characterized as a weak aquitard. Near Hamilton Drive, the Reformatory Quarry Member ranges in thickness from 0 to 50 m. It is thickest in the west and near the municipal wells, thinning toward the east. In Rockwood, this unit is more prevalent in the vicinity and west of the municipal wells, and ranges in thickness from 0 to 19 m. The distribution of this unit is controlled by post-depositional erosion; its absence is most visible near buried bedrock channels (Matrix, 2018).

The Vinemount Member of the Eramosa Formation lies beneath the Reformatory Quarry Member and is characterized as a regional aquitard. Near Hamilton Drive, the Vinemount Member ranges in thickness from 1 to 9 m. The Vinemount Member plays a significant role in subsurface groundwater flow, separating upper and lower bedrock aquifers. In Rockwood, the Vinemount Member is shown to be eroded by channels and infilled with overburden sediments, suggesting potential hydraulic interaction of deep aquifers (e.g., Gasport Formation) with either the near-surface aquifers or surface water (e.g., Eramosa River) in topographic valleys (Matrix, 2018).

The Goat Island Formation, which thickens and thins in response to the absence or presence of reef mounds in the underlying Gasport Formation, ranges in thickness from 0 to 26 m near Hamilton Drive. In Rockwood, this unit is prevalent and ranges in thickness from 0 to 17 m. The presence of this unit is controlled by post-depositional erosion; its absence is most visible near buried bedrock channels (Matrix, 2018).

The Gasport Formation is one of the main source aquifers in the area of Rockwood and Hamilton Drive. The upper Gasport Formation ranges in thickness from 4 to 33 m in the Hamilton Drive area and 0 to 33 m in the Rockwood area, while the middle Gasport Formation is approximately 12 m thick across these areas. Coarse-grained fill sequences in these valleys suggest a potential hydraulic connection between the middle Gasport Formation and the near-surface aquifers. The lower Gasport Formation ranges in thickness from 4 to 13 m near Hamilton Drive and 0 to 26 m in Rockwood. The Gasport Formation horizons appear relatively constant in thickness, except where eroded by bedrock valleys and built up as reef mounds. In areas where the Vinemount Member has been eroded, the Gasport Formation may be hydraulically connected to the near-surface aquifer units and/or surface water features (Matrix, 2018).

The Cabot Head Formation acts as a regional aquitard and represents the bottom of the active groundwater flow system.

~~The aquifer in the Rockwood area has a maximum thickness of approximately 60 m. The permeability of the dolomite is due to the chemical dissolution of dolomite along fractures, reef structures and bedding planes, resulting in a large variety of openings within the bedrock. As a result the permeability of the bedrock aquifer can vary substantially. Municipal wells are often~~

~~drilled to the bottom of the formation (60 m at Rockwood Wells 1 and 2) in order to intercept as many water bearing fractures as possible. The aquifer is regarded as being unconfined as there are no overlying confining layers and areas of exposed bedrock occur frequently in the area of the wells.~~

~~Within the study area, highest recharge areas are associated with topographically elevated areas and permeable formations such as sand and gravel deposits in the vicinity of Eden Mills (Golder, 2006a). Most of the remainder of the Township is considered to be a recharge area, but with lower vertical gradients. Groundwater discharge within the town is associated with tributaries of the Eramosa River.~~

### 6.4.1 Rockwood Water Supply System

The Rockwood Water Supply System services a population of approximately 1,635~~3,970~~ people (2015~~08~~) in the Village of Rockwood. ~~and consists of three municipal groundwater wells and two pumphouses: the Station Street Pumphouse and the Bernardi Pumphouse. A fourth well is not currently online but has been identified as a future municipal supply well.~~ There are four municipal supply wells in the Town of Rockwood and two pumphouses (Station Street and Bernardi). The production zone of the middle Gasport Formation is the target bedrock supply aquifer in this area. Drinking water for Rockwood is currently supplied from three wells including Rockwood Well 1 (TW1-67), Well 2 (TW1-76), and Well 3 (TW3/02). A fourth Rockwood bedrock well (Well 4; TW2-14) was constructed in 2014, on a site previously identified as being suitable for a production well (i.e., site of TW2-02; Burnside 2015). Well 4 was permitted in 2015 as part of a consolidated Permit To Take Water (PTTW) for the four wells and Well 4 will eventually be put into production. Rockwood Well 1 and Well 2 are contructed approximately 60 m bgs into the fractured Gasport bedrock aquifer. Rockwood Well 3 and Well 4 are constructed approximately 50 m bgs and 62 m bgs, respectively into the Gasport bedrock aquifer.

Rockwood Wells 1 and 2 are designated Groundwater Under the Direct Influence of surface water (GUDI) "based on the karstic nature of the area, the proximity of the bedrock to the surface and the immediate response to pumping recorded in the shallow bedrock at a nearby monitoring well. These occurrences indicate that the wells likely respond directly to recharge over the bedrock outcrops." (Burnside, 2010). Rockwood Wells 3 and 4 are not designated as GUDI.

~~Rockwood Wells 1 and 2 are both inside the Station Street Pumphouse located west of Main Street and south of the Canadian National Railway Line. Rockwood Well 2 (also known as TW#1-67) was constructed in 1967 as a municipal source for the village. Rockwood Well 2 is a 300 milimetres (mm) diameter well drilled to a depth of 59.1 metres (m). A second well, Well 1 (also known as TW#1-76), was constructed in 1976. Rockwood Well 1 is a 250 mm diameter well that is 60.4 m deep and is completed as an open hole in the bedrock starting from 10 m. The overburden is approximately 6 m thick at both wells and consists of stony gravel with some clay. The bedrock is part of the heterogeneous, layered and fractured Gasport aquifer.~~

~~In March 2002, 150 mm and 200 mm diameter liners were installed in Rockwood Wells 1 and 2, respectively. The liner in Well 1 was installed to a depth of 36.5 m and the liner in Well 2 was installed to a depth of 38.4 m. The liners were installed to seal off shallow water producing intervals that caused cascading conditions from the open bedrock hole (Burnside, 2002b).~~

~~Rockwood Well TW3/02 (also known as the Bernardi Well and Well 3), is located approximately 5 m to the north of the Bernardi Pumphouse. The Bernardi Pumphouse is located southeast of the Eramosa River and adjacent to the Town boundary. Well 3 was drilled in 2002 as a 150 mm diameter test well and was reconstructed to a diameter of 250 mm in 2004 so it could be used as a supply well. At this site, overburden sediments were encountered from ground surface to 12.6 m below grade. Brown/ grey limestone bedrock was encountered between 12.6 and 66 m. Below 66~~

m, the well penetrated red shale to a depth of approximately 73 m. The bottom of the well below 50 m was sealed and a large fracture between 45.7 to 48.8 m was further developed to enhance the production from the well (Burnside, 2002c).

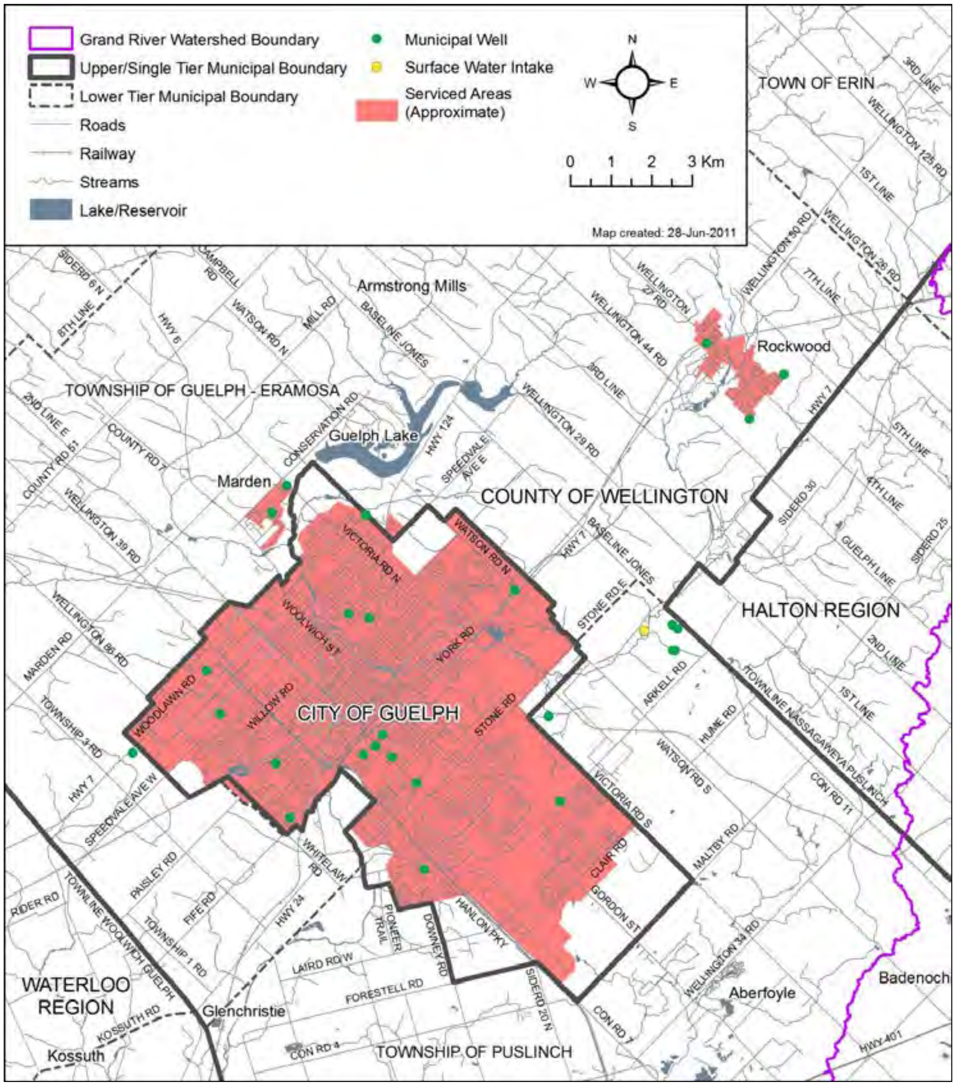
Rockwood Well TW2/02 (Well 4) is not currently online, but has been identified as a future municipal supply well. TW2/02 is located east of Highway 7 and south of the Eramosa River. This Well was drilled in 2002 as a 150 mm diameter test well to a depth of 68.58 m below grade. At this site, overburden sediments were encountered from ground surface to 12.6 m below grade. Brown/ grey limestone bedrock was encountered between 12.6 and 62 m. Below 62 m, the well penetrated red and grey shale to a depth of approximately 68.58 m (Burnside, 2002c). The well was constructed at the same time as TW3/02 when the Village was looking for future water supply wells. Both wells were tested and TW3/02 was chosen for development, however, plans to use TW2/02 for future supply remain in place.

### 6.4.2 Hamilton Drive Water Supply System

The Hamilton Drive Water Supply System services a population of approximately 216653 people (2008) in a community located just north of the City of Guelph. The system services the geographical area bounded by Victoria Road to the east, Conservation Road to the north, Highway 6 to the west and the Speed River to the south. The Hamilton Drive Water Supply System consists of two municipal groundwater wells located at two pumphouses: the Cross Creek Pumphouse and the Huntington Pumphouse. The Cross Creek Well, also known as Cross Creek PW3, was drilled in 1990. The well was completed as a 250 mm diameter well with a steel casing to 21.3 m and a 200 mm steel casing to 39.6 metres. The well is an open bedrock hole in bedrock from 39.62 m to a depth of 99 m bgs within the Reformatory Quarry member of the Eramosa Formation. The bedrock is overlain by 21.3 m of clay overburden. The Huntington Well also known as Huntington Estates PW1, is was drilled in 1986 and is a 200 mm well with an open hole in bedrockbedrock interval from 12.5 to 71.9 m below gradebgs. The well is completed inwithin the Guelph and middle Gasport Formations and is overlain by 3 m of till..

The Cross Creek and Huntington Estates Wells are not designated as GUDI.

**Map 6-37: Guelph, Rockwood and Hamilton Drive Water Supply System Serviced Areas**



### 6.4.3 Vulnerability Analysis

***Delineation of Wellhead Protection Areas***

The delineation of Wellhead Protection Areas represents the foundation of a municipal groundwater protection strategy. Wellhead Protection Areas associated with the municipal water supply represent the areas within the aquifer that contribute groundwater to the well over a specific time period. According to the *Clean Water Act* Technical Rules (November 2009), four Wellhead Protection Areas are required, one a proximity zone and the three others time-related capture zones:

- WHPA-A 100 m radius from wellhead
- WHPA-B 2-year Time of Travel (TOT) capture zone
- WHPA-C 5-year Time of Travel capture zone
- WHPA-D 25-year Time of Travel capture zone

***Modelling Approach for the Rockwood and Hamilton Drive Water Supply Systems***

The numerical modelling completed for the Rockwood and Hamilton Drive study area used the FEFLOW groundwater flow model developed for the Guelph/Guelph-Eramosa Tier 3 Assessment (Matrix, 2017). In the area of Rockwood and Hamilton Drive, the Tier 3 model was calibrated to long-term average water levels, baseflow estimates, and to transient water level response data from constant rate pumping tests performed at Rockwood Wells 3 and 4. Transient verification simulations were also performed for the Hamilton Drive and Rockwood areas, and results showed that the model was able to represent the expected response of the shallow and deeper groundwater systems to varying recharge and pumping stress over a 5-year period (2008 to 2012; Matrix 2017).

The capture zones and WHPAs delineated for this study are based on a Base Case scenario model and three alternative uncertainty scenarios developed as part of a sensitivity analysis.

Base Case Scenario

The calibrated Guelph/Gueph-Eramosa Tier 3 FEFLOW model is referred to as the Base Case scenario. The pumping rates for the Rockwood wells (**Table 6-34**) represent future rates derived during the Tier 3 Assessment and were based on water use forecasts to reach build-out in 2026 (Matrix, 2017). The total future pumping rate derived for all of Hamilton Drive during the Tier 3 Assessment was 185 $m^3$/day and was based on water consumption forecast estimates to 2020 (Matrix, 2017). This rate was assigned to both the Cross Creek and Huntington Estates wells for the current WHPA delineation work assuming that either well may have to accommodate the future demands of the subdivision community in the event that the other well goes offline for maintenance or other reasons.

**Table 6-36: Water Takings from Municipal Production Wells in the Rockwood and Hamilton Drive Well Supply**

| Well | Permit to Take Water ($m^3$/day) | Rate Used to Delineate WHPA ($m^3$/day) |
|---|---|---|
| Rockwood 1 | 1,965 | 763 |
| Rockwood 2 | 1,965 | |
| Rockwood 3 | 1,310 | 572 |
| Rockwood 4 | 1,310 | 572 |

| | | |
|---|---|---|
| Huntington Estates | 812 | 185 |
| Cross Creek | 916 | 185 |

Sensitivity Scenarios

A sensitivity analysis was completed to estimate the effects of model parameter uncertainty on the size and shape of the predicted capture zones. Some groundwater flow model input parameters have greater uncertainty than others. The sensitivity analysis involved adjusting the calibrated Base Case model parameters and evaluating the change in particle tracking results used to delineate the capture zones. Specifics on the sensitivity scenarios are in the Matrix 2018 report 'Township of Guelph/Eramosa Wellhead Protection Area Delineation, Vulnerability Scoring, and Transport Pathways Assessment Report.'

Virtual particles can be released in a groundwater flow model and tracked forward or backward in time through the subsurface for various time intervals. The computed pathlines travelled by these particles are projected to the ground surface and plotted on a plan view map. Time-of-travel capture zones are subsequently created by drawing polygons around the well and the particle pathlines for specific time intervals. As such, capture zones represent the land areas beneath, which water and contaminants located at and below ground surface may migrate toward a well within a specified period. All particle tracks of the Base Case and sensitivity scenarios were rotated by +/- 5 degrees around each municipal well to account for some uncertainty in the groundwater flow direction.

~~The Township delineated Wellhead Protection Areas (WHPAs) for the municipal supply wells as part of their previous groundwater management study (Golder, 2006b). The Wellhead Protection Areas were delineated using the FEFLOW Guelph-Puslinch Groundwater Model. The groundwater model was calibrated (using a regional parameterization approach) to groundwater elevations from over 4,500 water well information system (WWIS) locations and 302 higher quality monitoring wells, as well as base flow estimates from both longterm and non-permanent stream flow monitoring stations. The NRMS error for the calibration is reported as being 2.9% for all data combined which is considered to be within the acceptable limits of less than 10% for numerical models (Golder, 2006b).~~

~~The groundwater model used for the delineation of the Wellhead Protection Area was developed by Golder (2006b). The model assumes that the groundwater flow systems are equivalent porous media at the scale of the time-related capture zones under consideration. While groundwater flow in bedrock aquifers occurs primarily in the fractures, the use of an equivalent porous medium approach can still provide a reasonable approximation of the Time of Travel related capture zones of a bedrock supply well provided the scale of observation is much greater than the scale of individual fractures, and consideration is given to the selection of a reasonable "effective" porosity. The effective porosity assumed for the travel time calculations was 5 percent (Golder, 2006b). The model was calibrated primarily through the adjustment of hydraulic conductivities in the hydrostratigraphic units in the model to match simulated hydraulic head distribution with observed groundwater elevations and groundwater discharge rates to streams in the study area. Minor adjustments were also completed to internal stream and model perimeter boundary conditions. The calibration targets for the model were regional steady state groundwater elevations and the water balance for the model as defined by the stream flow base estimates. Overall the normalized root mean squared (RMS) from the calibrated model based on 4,400 calibration locations was~~

~~2.9% (Golder, 2006b). This is well below the generally acceptable limit of 10% for NRMS error for groundwater models.~~

~~To develop time of travel capture zones groundwater particles were released at the pumping wells in the models and tracked backwards towards their source of origin (recharge). At each well location, particles were released in all hydrostratigraphic units “open” to the wellbore. The time-related pathlines that are subsequently generated by the model from this analysis are then overlain and a single time of travel capture zone drawn around the “family” of pathlines generated at each well. To check the capture areas generated from the backward tracking analysis (and in some cases to refine the time of travel outline produced) a series of forward particle tracking simulations were completed. The resulting capture zone from this process represents the two-dimensional (2-D) projection of the particle outlines to ground surface.~~

***Delineation of the Rockwood and Hamilton Drive Wellhead Protection Areas***

The Rockwood WHPAs ~~cover a total of 4,942 ha as~~are shown on **Map 6-38.** In general, t~~T~~he WHPAs ~~of~~ for all Rockwood Wells ~~1 and 2~~ extend~~s~~ in a northerly direction. The “Y” shape at Rockwood Well 1 and 2 is heavily influenced by the Eramosa River, where the pumping well captures groundwater flowing toward the well from both sides of the river. In the area of Rockwood Well 3 and 4, the refined hydrogeologic characterization, as part of the Tier 3 Assessment (Matrix 2017), suggests that the Vinemount aquitard is absent. The lack of a lower hydraulic conductivity confining layer in this area results in a capture zones that travel upwards into the overburden and do not extend as far in the upgradient direction.

~~The WHPA extends 3 km before bifurcating into two branches. The WHPA-D extends approximately 8 km away from the supply wells. The WHPA of Rockwood Well TW3/02 and TW2/02 both extend in north northeast (NNE) direction. The WHPA-C and WHPA-D of these wells overlap. The east side of the Rockwood wells 1 and 2 WHPA combines with the WHPA-D of Rockwood wells TW3/02 and TW2/02. The WHPA-D zone for Wells TW3/02 and TW2/02 extend approximately 16 km away from TW3/02 and crosses the Township boundary into Erin Township and into the Credit Valley Source Protection Area.~~

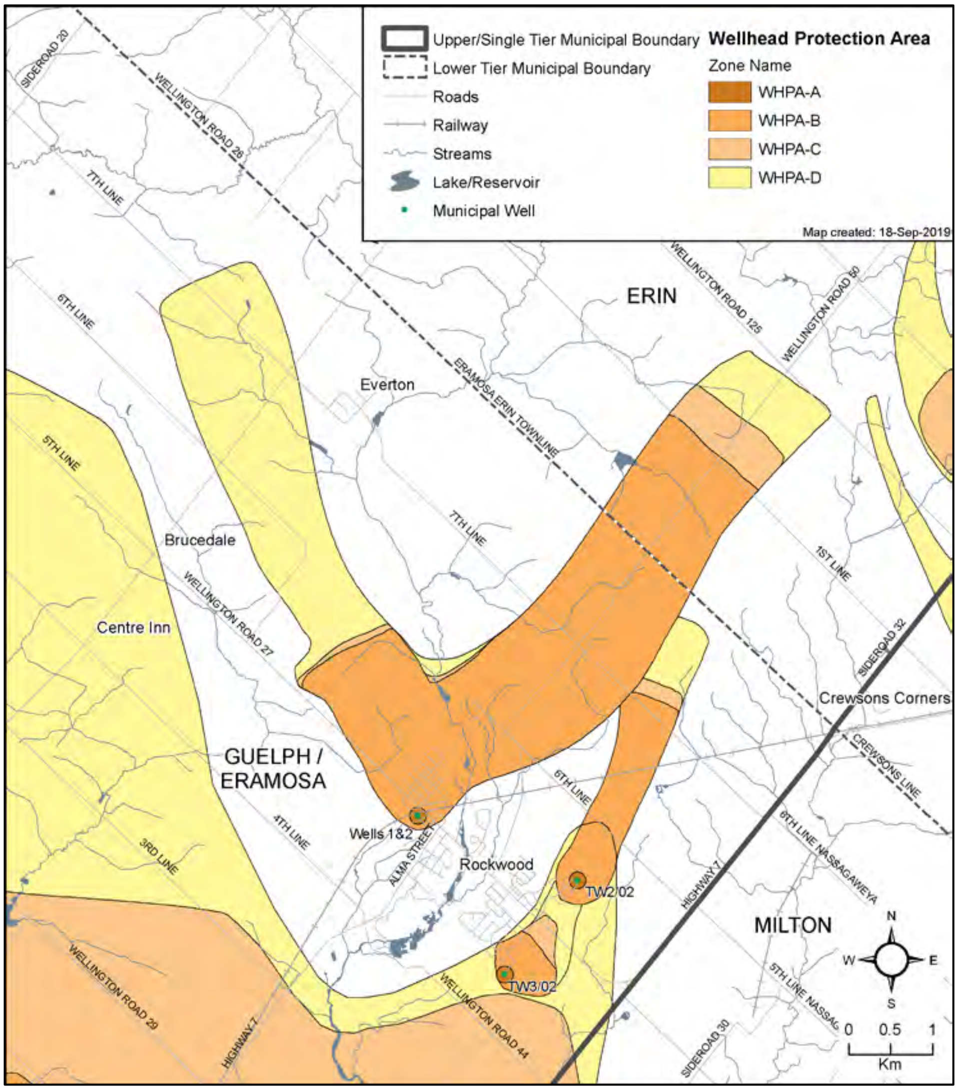
The Cross Creek and Huntington WHPAs extend in a north northwest (NNW) direction with their zones overlapping within the WHPA-~~D~~ B, C and D as presented in **Map 6-39.** The WHPA-D for both Cross Creek and Huntington extends approximately ~~10~~ 17 km from the supply wells~~ and the WHPA-D for Huntington extends approximately 7 km~~. ~~The combined zones cover an area of 1,735 ha (Burnside, 2010b).~~

***Delineation of WHPA-E and WHPA-F for the Rockwood Wellhead Protection Area***

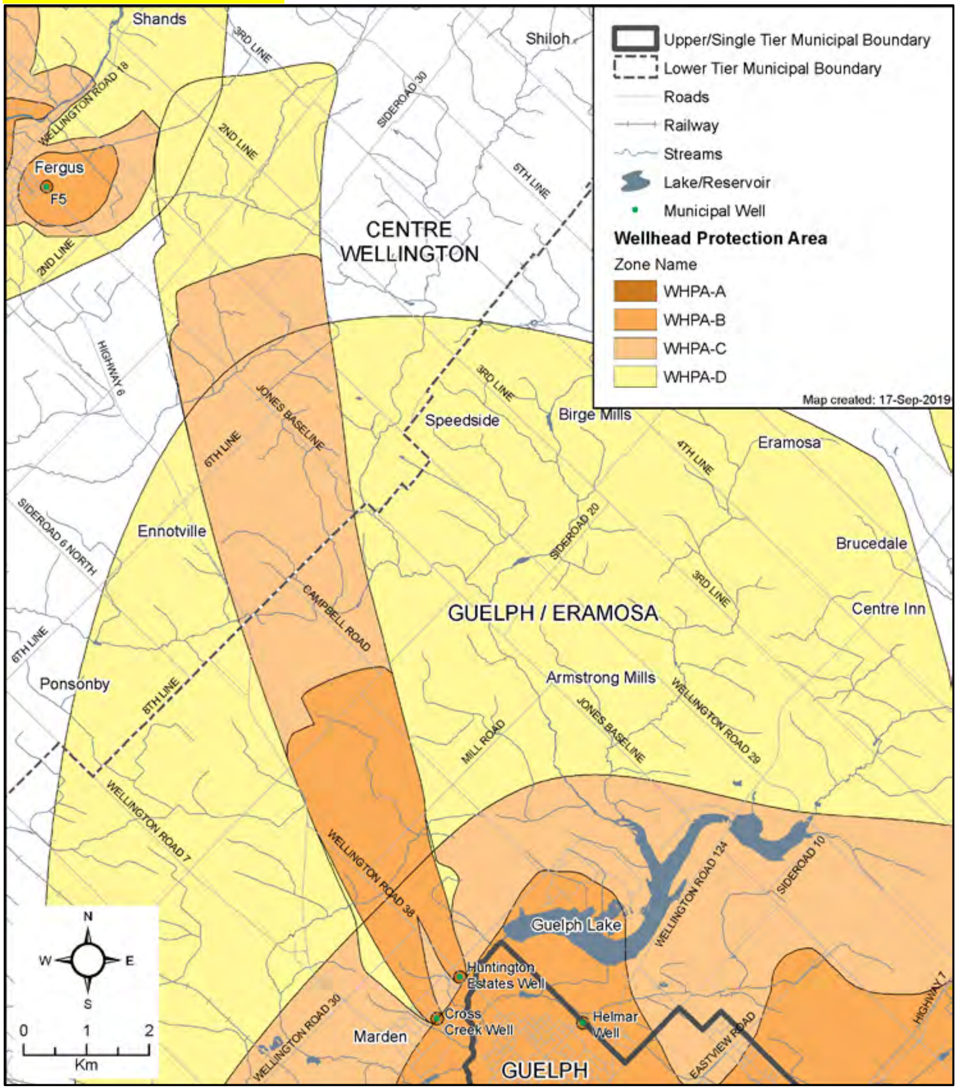
~~The Technical Rules: Assessment Report (Clean Water Act, 2006) requires that all wells that are identified as groundwater under direct influence of surface water (GUDI) delineate an additional protection zone that is representative of its surface water vulnerability, known as a WHPA-E. GUDI wells are identified in accordance with subsection 2 (2) of O. Reg. 170/03 (Drinking Water Systems) of the Safe Drinking Water Act, 2002.~~

Rockwood Wells 1 and 2 are classified as GUDI wells as a result of a study completed by Burnside in 2002. The wells are classified as GUDI due to the highly porous bedrock that outcrops at the surface in the vicinity of the well; however, there is no permanent surface water feature located in the vicinity of the wells that has been associated with the GUDI status. In light of the absence of a surface water body with which the GUDI status is linked it is not possible to delineate a WHPE-E that is compliant with Rule 47 (5) of the Technical Rules (MOECC, ~~2009b~~2017).

**Map 6-38: Rockwood (Wells 1, ~~and~~ 2, ~~TW2/02~~3, and ~~TW3/02~~4) ~~and Hamilton Drive (Hungington and Cross Creek Wells)~~ Water Supply Wellhead Protection Areas**



**Map 6-39: Hamilton Drive (Hungington and Cross Creek Wells) Water Supply Wellhead Protection Areas**



***Uncertainty of the Delineation of the Rockwood and Hamilton Drive Wellhead Protection Areas***

The delineation of the WHPAs was completed by Golder in the Wellington County Groundwater Protection Study, 2006 through the use of a FEFLOW groundwater model. The model was constructed and calibrated with available hydrogeological data and hydrogeological mapping products as described in Section 4.1 and the Wellington County Groundwater Protection Study Report (Golder, 2006a).

Uncertainties within the model are associated with limitations in the availability of subsurface information and can be related to projected variability in the aquifer properties (e.g. hydraulic conductivity; porosity) or uncertainties with the conceptual model (e.g. groundwater-surface water interactions; location of flow boundaries; recharge rates; continuity in aquitards; direction of regional groundwater flow).

To account for some of these uncertainties Golder has applied a factor of safety to the WHPAs. The factor of safety has been applied to two components of the WHPAs: the width and length of the capture zones and the orientation of the capture zones. The width and length of the capture zones were increased by 20% to account for uncertainty in the hydraulic characteristics of the aquifer system. The orientation of the capture zone was adjusted by 5 degrees (plus and minus) along its centre line to account for some uncertainty in the regional flow direction by increasing the width of the capture zones at increasing distances from the pumping well. This reflects the concept that the available data is typically concentrated around the pumping well and that the uncertainty in the hydrogeological understanding increases at increasing distances from the supply wells (Golder, 2006a).

Based on known variations in hydraulic properties, the factor of safety approach is not considered to adequately address the issue of uncertainty. It is known that slight variations of aquifer properties may impact the shape and orientation of the capture zones. The safety factor, while attempting to cover some of this likely variation, does not give an indication of the likely impact of variations in actual model properties as there is no correlation between the factor of safety and the model parameters.

Although the calibration results were good, the lack of information on the impact of variations in model parameters on the resulting capture zones suggests that additional work needs to be completed to allow for a full evaluation of uncertainty.

***Intrinsic Vulnerability Scoring in Wellhead Protection Areas***

Groundwater intrinsic vulnerability mapping for the Rockwood and Hamilton Drive wellfields was previously completed by EarthFX Inc. (2008) using the SAAT method. Golder (2010a) reviewed the vulnerability mapping and made adjustments based on hydrogeological knowledge at the WHPA scale. The intrinsic vulnerability was further refined in the Centre Wellington area by GRCA staff in May 2019. Smoothing (refinements) of the intrinsic vulnerability was done in areas where the existing vulnerability scoring was too complex to be implementable. This was done using the smooth line tool in ArcGIS (Polynomial Approximation with Exponential Kernel), with a 400 m smoothing tolerance. Further manual adjustment was then made in a few minor areas to remove any tight loops created by the tool. The Rockwood and Hamilton Drive intrinsic vulnerability mapping is shown on **Map 6-41** **and** **Map 6-44**.

Following their delineation, the intrinsic vulnerability of the aquifer within each Wellhead Protection Area is assessed using one of the methods approved under the *Clean Water Act* Technical Rules. The resulting maps rank aquifer vulnerability as high, medium or low.

Aquifer vulnerability mapping was completed within the GRCA watershed using the Surface to Aquifer Advection Time (SAAT) approach. The GRCA retained Earthfx to complete the vulnerability mapping using the SAAT method for most of the Grand River watershed (Earthfx, 2008).

The SAAT approach estimates the average time required by a water particle to travel from a point at the ground surface to the aquifer of concern. The SAAT is approximated by using the vertical component of the advective velocity integrated over the vertical distance and the average porosity. The travel times generated are categorized into groups being <5 years, 5 to 25 years and > 25 years.

Calculation of the SAAT, as conducted by Earthfx, was based on the use of empirical formulae provided by the MOE. These formulae provide methods for the computation of two separate components of the SAAT, the unsaturated zone advection time (UZAT) and the water table to aquifer advection time (WAAT). UZAT was computed based on values assumed for depth to water table, mobile water content and infiltration rate. For the assessment a depth to water map was generated using an interpolated water table map and the elevation of the land surface. Mobile water content was approximated based on the specific yield of each soil type and infiltration was approximated using a GAWSER recharge model in which infiltration was assumed to be equal to the recharge rate. In areas where several layers of varying materials were present, the calculations were done for each layer and then summed over the entire unsaturated portion of the sub-surface.

Where required, the WAAT component of the SAAT was also computed. It is noted by Earthfx that the WAAT was only computed in two instances; the first where the target aquifer was known to be confined and the second where no aquifer material was recognized. The factors included in the computation of the WAAT were aquifer porosity, thickness of the geologic layer, vertical hydraulic conductivity and the difference between the head in the confined aquifer and the water table. Hydraulic conductivities were estimated based on the geologic materials listed in the boreholes logs. Vertical hydraulic gradients were estimated by subtracting the interpolated potentiometric surface from the interpolated water table. The thickness of each layer above the target aquifer and the location of the top of the target aquifer were determined from the borehole logs.

The regional mapping produced by the Earthfx report was reviewed on a local scale in the vicinity of the water supply wells. The vulnerability mapping was refined based on the following considerations: locations of bedrock outcrops, surficial geology, overburden thickness, SAAT point values and hydrogeologic interpretations.

In the Township of Guelph/Eramosa adjustments to the regional SAAT mapping were applied to reflect bedrock outcrops as high vulnerability, areas of less than 3 m of overburden thickness as high vulnerability and local qualitative adjustments to refine the alignment with the local SAAT scores.

**The SAAT travel times were grouped to create ratings which were then used to construct an aquifer vulnerability map of the study area. Time of travel**

**values less than 5 years are rated as High Vulnerability. Values between 5 and 25 years are Medium vulnerability. Any value greater than 25 years is classified as having a Low Vulnerability. The various vulnerability ratings based on the travel times is shown in** Table **6-38. The intrinsic vulnerability for the Rockwood and Hamilton Drive well supply systems are shown on** Map **6-43 and** Map **6-49. Table 6-38: SAAT Vulnerability Ratings**

| Time of Travel (years) | Vulnerability Rating |
|---|---|
| <5 | High |
| 5 to 25 | Medium |
| >25 | Low |

At the completion of the vulnerability mapping and scoring, the Township of Guelph/Eramosa completed an assessment of transport pathways. The results of the transport pathway assessment were reviewed using professional judgment to determine whether to increase the vulnerability based on the presence of the pathways.

***Identification of Transport Pathways and Vulnerability Adjustment***

Following a review of the intrinsic vulnerability scoring maps, an assessment of transport pathways was undertaken to determine whether adjustments to the vulnerability assessment were warranted. Technical Rules 39 – 41 address the general process of how transport pathways would increase vulnerability. Transport pathways for groundwater based drinking water systems include: wells (current, unused, or abandoned), pits and quarries, mines, construction activities or deep excavations, storm water infiltration, septic systems, and buried municipal infrastructure.

The Technical Rules (MOECC, 2017) indicate that consideration should be given to the cumulative impact of any potential transport pathways; the impact of any discrete pathway should not be viewed in isolation. Therefore, following the assessment of risk for each feature, a density analysis was completed to determine where clusters of high risk pathways existed. A 50 m buffer was created around each of the high-risk pathways identified.

The transport pathways area of influence for the Rockwood and Hamilton Drive Wellhead Protection Areas, the is shown on **Map 6-42 and Map 6-46**, respectively.

***Vulnerability Scoring for the Rockwood Wellhead Protection Areas***

Several data sources were reviewed to assess the relative risk of transport pathways to cross-cut natural protection over the municipal production aquifers in the Rockwood and Hamilton Drive WHPAs. Other than wells, no transport pathways are interpreted to warrant an update to vulnerability mapping. A total of 332 high-risk wells were identified within the Rockwood and Hamilton Drive WHPAs. Where a high density of these wells are located outside of areas of high vulnerability and areas already adjusted for the presence of transport pathways (Burnside 2010), updates to the existing vulnerability mapping were made. This adjusted vulnerability mapping was carried forward and used for vulnerability scoring within the Rockwood and Hamilton Drive WHPAs.

Following the adjustment of the vulnerability mapping based on the transport pathways assessment, vulnerability scoring was completed for Rockwood and Hamilton Drive wellfields. The WHPAs for each well were overlain on the adjusted vulnerability mapping and scores were assigned. The corresponding final vulnerability mapping are shown on **Map 6-43 and Map 6-47.**

In Rockwood, the SAAT around Well TW2/02 was increased to high based on information from TW2/02's water well log. Overburden thickness and water well logs were reviewed to the east of Rockwood Wells TW3/02 and TW2/02 resulting in the extension of the medium vulnerability zone in this direction (Golder, 2010a).

The Rockwood Wellhead Protection Areas are located in areas dominantly classified as medium to high vulnerability with only the WHPA-D of Rockwood Wells TW3/02 and TW2/02 classified as low. Areas of high vulnerability are located in areas of bedrock outcrop and thin overburden. These areas tend to be located along the Eramosa River. The initial vulnerability scoring for Rockwood is shown on **Map** 6-42 with an inset on **Map** 6-47**.**

***Vulnerability Scoring for the Hamilton Drive Wellhead Protection Areas***

For the Hamilton Drive area, areas of high vulnerability were mapped along Marden Creek and along the Speed River Valley south of Hamilton Drive (Golder, 2010a).

The Cross Creek and Huntington WHPAs are located in areas classified dominantly as medium vulnerability with some low vulnerability areas within the far northern parts of the WHPA-D zones. Some areas of high vulnerability are mapped where bedrock outcrops along the drainage courses such as the Speed River, Marden Creek and Cox Creek. The initial vulnerability scoring for Hamilton Drive is shown on **Map** 6-50**.**

***Identification of Transport Pathways and Vulnerability Adjustment***

Following a review of the initial vulnerability scoring maps, an assessment of transport pathways was undertaken to determine whether adjustments to the vulnerability assessment were warranted. Technical Rules 39 – 41 address the general process of how transport pathways would increase vulnerability. Transport pathways for groundwater based drinking water systems include: wells (existing and abandoned), pits and quarries, mines, construction activities, storm water infiltration, septic systems, sanitary sewer infrastructure.

***Transport Pathways in the Rockwood and Hamilton Drive Wellhead Protection Areas***

Domestic water wells are the most common man-made transport pathway in rural areas. Improperly constructed wells can potentially introduce a cumulative impact to drinking water sources especially when the casing deteriorates. Similarly, if the well is no longer in use, improper abandonment also provides a transport pathway for a contaminant to impact a drinking water source.

It is a requirement of Ontario Regulation 903 that unused wells be properly abandoned by a licensed well contractor. However, proper well abandonment is not actively enforced or monitored therefore it is difficult to assess how many abandoned wells may exist within the WHPAs.

A review of water well records from the MOE water well database and a field survey were conducted to identify wells within the WHPAs. The wells were then ranked based on their risk to the supply aquifer. The survey resulted in the identification of 118 water wells within the Rockwood 2 year TOT zone (WHPA-B) and classified 108 of the wells as high risk wells. 72 water wells were identified within the Hamilton Drive WHPAs and 60 were classified as high risk

Septic systems are considered transport pathways as they can provide a conduit for contaminants to travel through the ground to the water table. Septic systems are generally built in the upper few metres of the sub-surface and consist of a tank and drainage tiles which distribute effluent allowing it to infiltrate into the ground. In the case of thin confining layers or in unconfined aquifer conditions, these shallow penetrating systems may present a significant conduit for contaminants to the aquifer of concern. The Village of Rockwood has a municipal sewage collection system, however septic systems may still be present that were used before servicing was available. For the purposes of this assessment in ground individual septic systems are assumed present at all rural residences outside of the serviced area.

Utilities that are constructed in the sub-surface are potential transport pathways as the disturbed soil surrounding them can provide a pathway for contaminants to enter into the aquifer below. Utilities that may act as transport pathways include storm-water trunk sewers and sanitary infrastructure. The depth of excavation for the construction of utilities will determine the risk that the wells pose on the municipal supply aquifer. Municipal sewage sewer lines are located within the village of Rockwood. Underground utilities are located within the WHPA within the Rockwood limits. The areas of risk are already mapped as high vulnerability therefore no increase in vulnerability is required.

Aggregate operations are defined as activities that involve the extraction of material from the surface and in the current study include both pits and quarries. Pits and quarries present a transport pathway as their creation serves to remove a potential layer or layers of protection from the regional aquifer. In some cases, these excavations may extend to below the groundwater table in which case the pit or quarry is a direct conduit to the aquifer..

As part of the assessment, study aggregate operations have been mapped based on existing databases, the review of aerial photography and satellite imagery along with a windshield survey of the WHPAs. There is one aggregate operation located within the WHPA-D of Rockwood Wells 1 and 2. Satellite photography indicates that excavations likely extend below groundwater table as surface water ponds are visible.

***Adjusted Vulnerability Scoring***

The increase in vulnerability as a result of transport pathways is generally limited to one rank (low to medium or medium to high) except in extreme cases where the constructed pathway is considered to increase the vulnerability of the aquifer from low to high.

At the completion of the transport pathways assessment, the Technical Rules allow investigators to modify the vulnerability scoring if there is a concern that the identified transport pathways within the Wellhead Protection Areas may increase the vulnerability of the aquifer beyond that represented by the intrinsic vulnerability. Modification of the vulnerability score is performed by increasing the vulnerability of the underlying aquifer vulnerability map from either a low to moderate value or moderate to high value. An initial aquifer vulnerability value of high cannot be increased.

The updated assessment report will be revised to better illustrate the transport pathways affecting the intrinsic vulnerability scores.

***Adjusted Vulnerability Scoring for the Rockwood Wellhead Protection Areas***

The increase in vulnerability due to transport pathways is provided for the Rockwood Wellhead Protection Areas in. The following locations were increased:

- Along Main Street and Harris Street within Rockwood Well TW3/02 WHPA-B the vulnerability was increased from moderate to high. These streets have houses that were present before servicing and likely have wells that are no longer in use;

- The hamlet of Everton was increased to high due to the high density of wells; and
- The area of an aggregate operation located on Wellington Road 125 within WHPA-D of Rockwood Wells 1 & 2 was increased from moderate to high.

The transport pathways for the Rockwood Wellhead Protection Areas are shown on **Map** 6-44**,** the area of influence is shown on **Map** 6-45 and the final vulnerability scoring is shown on **Map** 6-46**.** An insert of the final vulnerability scoring is shown on **Map** 6-48**.**

***Adjusted Vulnerability for the Hamilton Drive Wellhead Protection Areas***

An area of vulnerability increase occurred along Wellington Road 22 within WHPA-D due to a high density of high risk wells. The transport pathways for the Hamilton Drive Wellhead Protection Areas are shown on **Map** 6-51, the area of influence is shown on **Map** 6-52 and the final vulnerability scoring is shown on **Map** 6-53**.**

***Uncertainty in the WHPA Delineation and Vulnerabilty Scoring for the Rockwood and Hamilton Drive Water Supply Systems***

The uncertainty analysis factors considered in this assessment follow Part I.4, Rule 14 of the Technical Rules (MOECC, 2017). **Table 7-43** shows a summary of the uncertainty for the WHPA delineation and vulnerability analysis for the Rockwood and Hamilton Drive Water Supply Systems.

**Table 7-43: Uncertainty Assessment for the Rockwood and Hamilton Drive Water Supply Systems**

| Uncertainty Assessment Factor | Uncertainty Designation | Description |
|---|---|---|
| 14(1) The distribution, variability, quality, and relevance of data used in the preparation of the Assessment Report | Low | Good coverage of Ontario MECP water well record data surrounding the Study Area as well as high-quality data local to the well fields and regionally. Water levels from multiple periods. Averaging of multiple water levels at individual wells was completed to best reflect average conditions. |
| 14(2) The ability of the methods and models used to accurately reflect the flow processes in the hydrological system. | High | The groundwater flow model has been shown to reflect bedrock groundwater flow processes by representing water levels under long-term average and pumping conditions. However, the sensitivity analysis illustrates that the orientation and size of the capture zones, and the impact of the Eramosa River, is very sensitive to the range of model parameters used. Additionally, the model contains a two-layer conceptualization of overburden and may not reflect local conditions. |
| 14(3) The quality assurance and quality control procedures applied | Low | Each step of the model development process relied on data that had been collected and/or reviewed by professional engineers or geoscientists. The development of the model was fully documented (Matrix, 2017) and that document was reviewed by leading academics and industry professionals for the purposes of fulfilling the requirements of the Act. |
| 14(4) The extent and level of calibration and validation achieved for models used or calculations or general | Low | In the Rockwood and Hamilton Drive areas the Tier 3 model was calibrated to steady-state as well as transient conditions. Further, transient verification was conducted at well locations in Rockwood and Hamilton Drive, and showed that the model was able to represent the |

**Table 7-43: Uncertainty Assessment for the Rockwood and Hamilton Drive Water Supply Systems**

| Uncertainty Assessment Factor | Uncertainty Designation | Description |
|---|---|---|
| assessments completed | | response of the shallow and deeper groundwater systems to varying recharge and pumping stress over a longer time period. These calibration efforts and the final parameters derived are both consistent with field observations and those that would be expected based on the conceptual model. |
| 14(5) The accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features | High | The groundwater vulnerability mapping is based on the SAAT methodology completed by EarthFX (2008) and refined by Golder (2010) and Burnside (2010); however, the hydrogeologic conceptual model of the Study Area was reworked as part of the Tier 3 Assessment (Matrix, 2017). The vulnerability mapping was not refined to reflect the current conceptual model. Further, an assessment of the differences between the current conceptual model, and the one that the previous vulnerability mapping is based on, has not been completed to verify whether the groundwater vulnerability categories still effectively assess the relative vulnerability of the underlying hydrogeological features. |

Uncertainty in the delineation of the WHPAs was addressed through the simulation of multiple scenarios. The scenarios for WHPA delineation produced similarly shaped capture zones, which were all encompassed in the final WHPA delineation. Further, the reliability of the delineated WHPAs is supported by the reasonability of the calibrated model. The groundwater flow model is calibrated using model parameters that reflect hydraulic field tests and have values that are within expected ranges for the various hydrogeological units. This results in a low uncertainty for the capture zone delineation. There is a low uncertainty rating associated with the time-of-travel delineation; however, there is a high uncertainty rating associated with the vulnerability mapping, which was not updated or reassessed using the current conceptual model (Matrix, 2017). There is also a high uncertainty related to overburden representation in the model. As a result, an uncertainty rating of high should be assigned to the assessment of vulnerability of each WHPA. This high uncertainty is identified as a data gap and updates to the vulnerability mapping should be considered in the future.

~~The Technical Rules: Assessment Report (Clean Water Act, 2006) requires an assessment of uncertainty as part of the vulnerability assessment. The uncertainty assessments seeks to provide a qualitative summary of data and analysis reliability as performed during the study. Uncertainty associated with a vulnerability assessment can be attributed to a number of factors including:~~

- ~~Density of input data~~
- ~~Quality and reliability of data, and~~
- ~~Assumptions made when reducing or synthesizing data.~~

The vulnerability assessment completed by Earthfx was based on the Surface to Aquifer Advection Time (SAAT). The SAAT calculation was based on a number of empirical formulae provided in past guidance documents from the MOE.

The calculation of SAAT is made up of two components; the unsaturated zone advection time (UZAT) and the water table to aquifer advection time (WAAT). In the Earthfx study both components were computed based on simplifying assumptions included in MOE provided formulae. It was noted that the UZAT was computed based on estimates for groundwater recharge derived from a GAWSER model. Also values for specific yield of soils were obtained from existing literature. The results of the UZAT analysis showed a high degree of variance which may be attributed to variance in the input GAWSER model. The results of the analysis indicate that there is a 95.5 % certainty that the UZAT time calculated is within +/-42 years of the actual time at any well. This indicates that the variability of the UZAT value (margin of error) is greater than the divisions of the vulnerability range i.e. the vulnerability could vary across the entire range of classifications from low to medium or high based on its margin of error. The potential for this high variation indicates that the uncertainty related to this component is high. UZAT was computed at various water well points across the study area. There was considerable effort made within the study to improve the quality of the spatial and lithologic data provided by each data point. In this regard only wells with a location accuracy of less than 100 m were used as part of the study. It can be interpreted that the computations performed represented values that were correct spatially across the study area.

The second component of the SAAT vulnerability, WAAT, was computed based on a formula provided by the MOE and was applied in areas where the target aquifer was known to be confined or where no aquifer material was recognized. The calculation assumes that flow within this zone can be approximated by the Darcy law for groundwater flow. The results of a statistical analysis indicate a high variance in the computed values which points to a high variance and high degree of uncertainty in the underlying data. The computation is known to be dependent on estimates of hydraulic properties, and interpolation of potentiometric surfaces which are based on sparse and unreliable data. The resulting product can be regarded as being an amalgamation of all the primary data uncertainties. Based on the uncertainty associated with the input data it is concluded that the WAAT calculation can be regarded as having a high uncertainty.

Finally the SAAT is derived by combining the previously discussed components of UZAT and WAAT. It is noted that the UZAT was computed using a GAWSER model to estimate recharge. The GAWSER model is known to be built on certain simplifying assumptions that have not been expounded in the background report from Earthfx. In light of this no level of uncertainty can be attached to the results of this model. Using the results of the UZAT and WAAT calculations as outlined in the Earthfx report it is concluded that the level of uncertainty associated with the computation of SAAT is high.

While the corrections applied to well locations resulted in spatially correct analyses, the underlying uncertainty in the computations themselves results in an overall ranking of high uncertainty for the process.

The Earthfx team performed a comparative analysis of vulnerability methods using Intrinsic Susceptibility Index (ISI) to compare with the values for SAAT. It was indicated that the SAAT ranking compared favorably to the ISI in the high vulnerability areas with more significant deviations in the medium and low ranked areas. The statistical analysis performed on the ISI however indicated that there was also a high uncertainty in these values.

**Table 7-43** shows a summary of the uncertainty for the vulnerability analysis for the Rockwood and Hamilton Drive Water Supply Systems.

**Table 7-43: Uncertainty Assessment for the Vulnerability Analysis for the Rockwood and Hamilton Drive Water Supply Systems**

| | Uncertainty Type | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|
| Rockwood Vulnerability Uncertainty | Vulnerability Ratings (SAAT) and conceptualization | Low | High | High | High |
| | Distribution and quality of data | Low | High | High | High |
| | WHPA delineation | Low | High | High | High |
| | Overall – Vulnerability Scores | Low | High | High | High |
| Hamilton Drive Vulnerability Uncertainty | Vulnerability Ratings (SAAT) and conceptualization | Low | High | High | High |
| | Distribution and quality of data | Low | High | High | High |
| | WHPA delineation | Low | High | High | High |
| | Overall – Vulnerability Scores | Low | High | High | High |

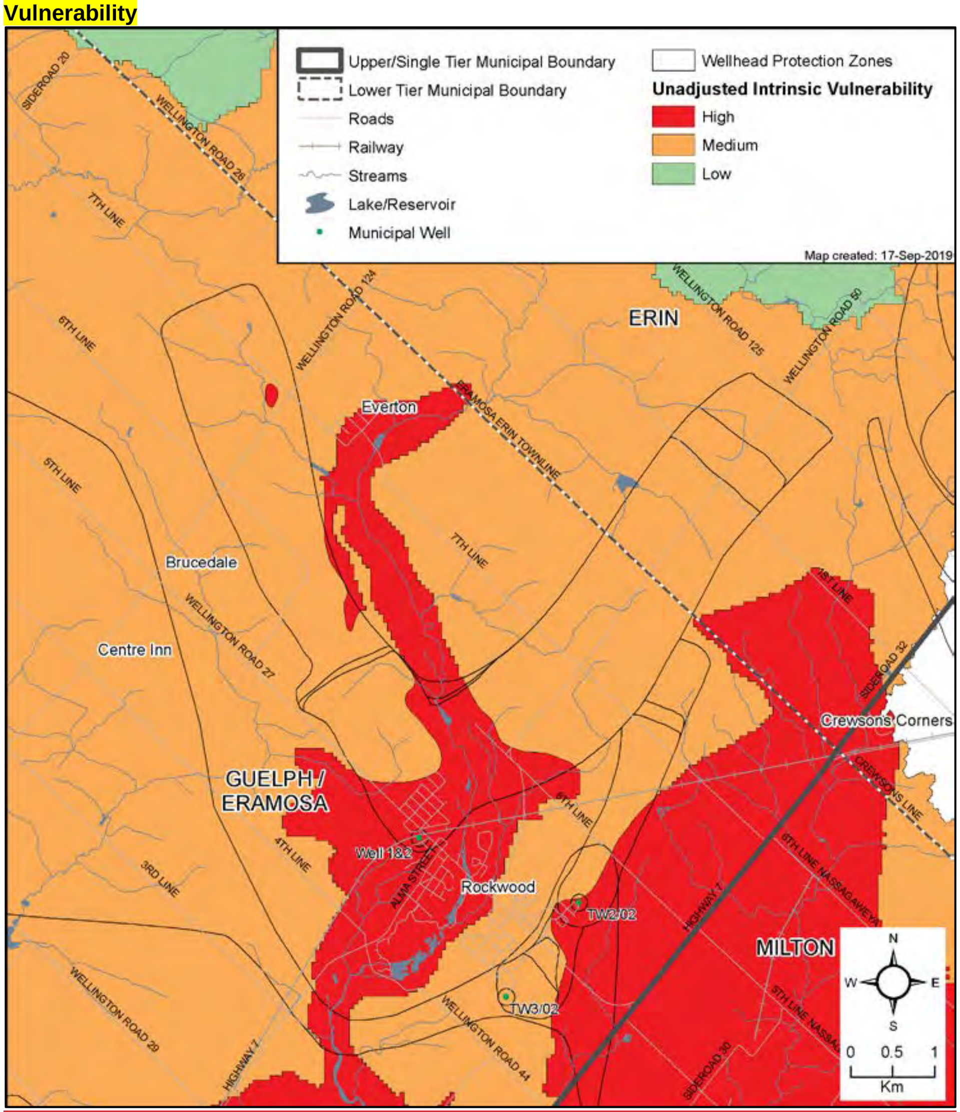
***Peer Review***

A peer review of the report *Vulnerability Analysis, Issues Evaluation and Threats Assessment, Township of Guelph/Eramosa* (Burnside, 2010) was completed by Brian Luinstra of Luinstra Earth Sciences. The overall impressions of the report by the peer review are as follows:

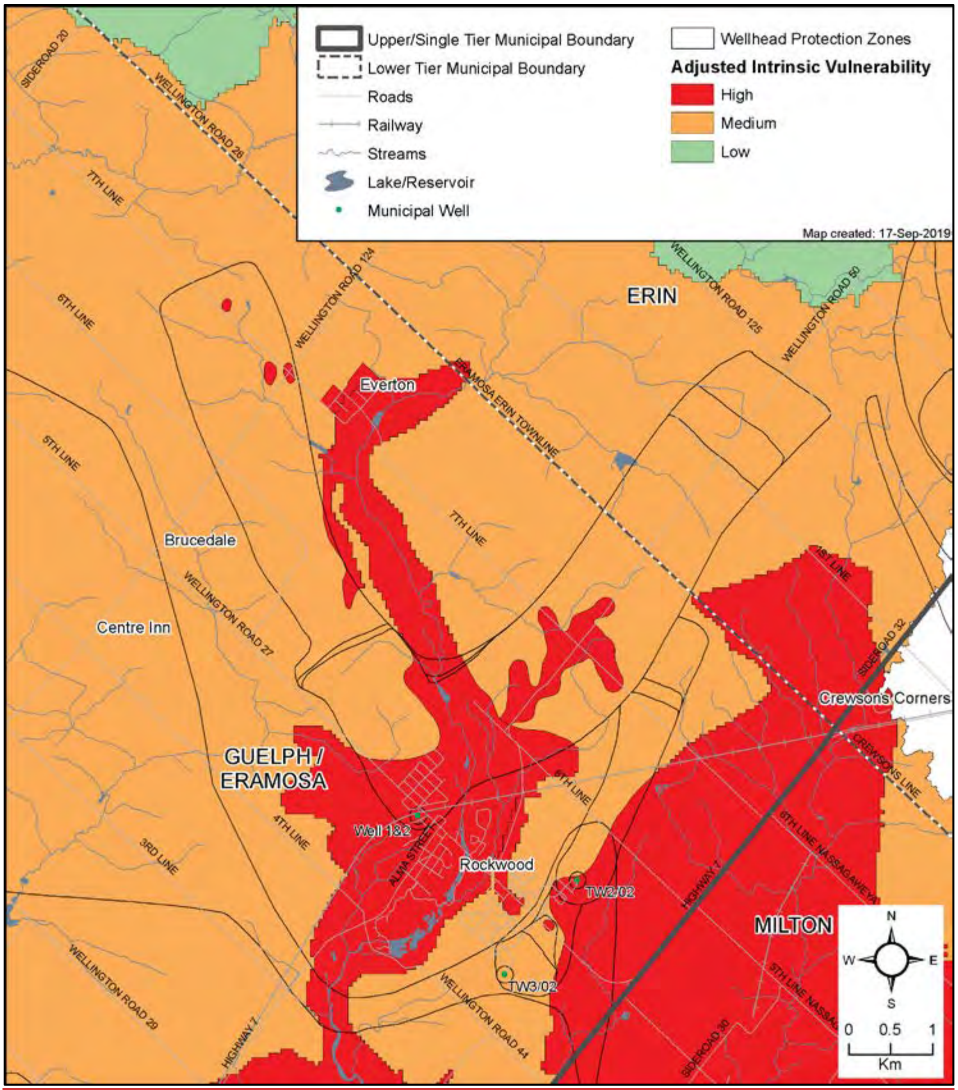
*"In the Peer Reviewer's professional opinion, the overall results appear reasonable and are consistent with the requirements outlined in the Ontario Ministry of Environment Technical Rules for completion of the Assessment Report under the Clean Water Act, 2006. The exception to this is the lack of delineated WHPA-E and WHPA-F for the Rockwood Wells #1 and #2, as well as the Issues analysis for this system. The overall approach to developing the vulnerability scores, evaluating Issues and assessing threats are consistent with the Technical Rules. The report is comprehensive and very well written, and maps appropriate for the intended use of the information."*

Responses to the peer review comments were incorporated into the final report. The responses to the peer review comments enhanced the overall defensibility of the report but did not impact the outcome of the Wellhead Protection Areas or vulnerability scoring.

**Map 6-40: Rockwood Water Supply Wellhead Protection Area Unadjusted Instrinsic Vulnerability**

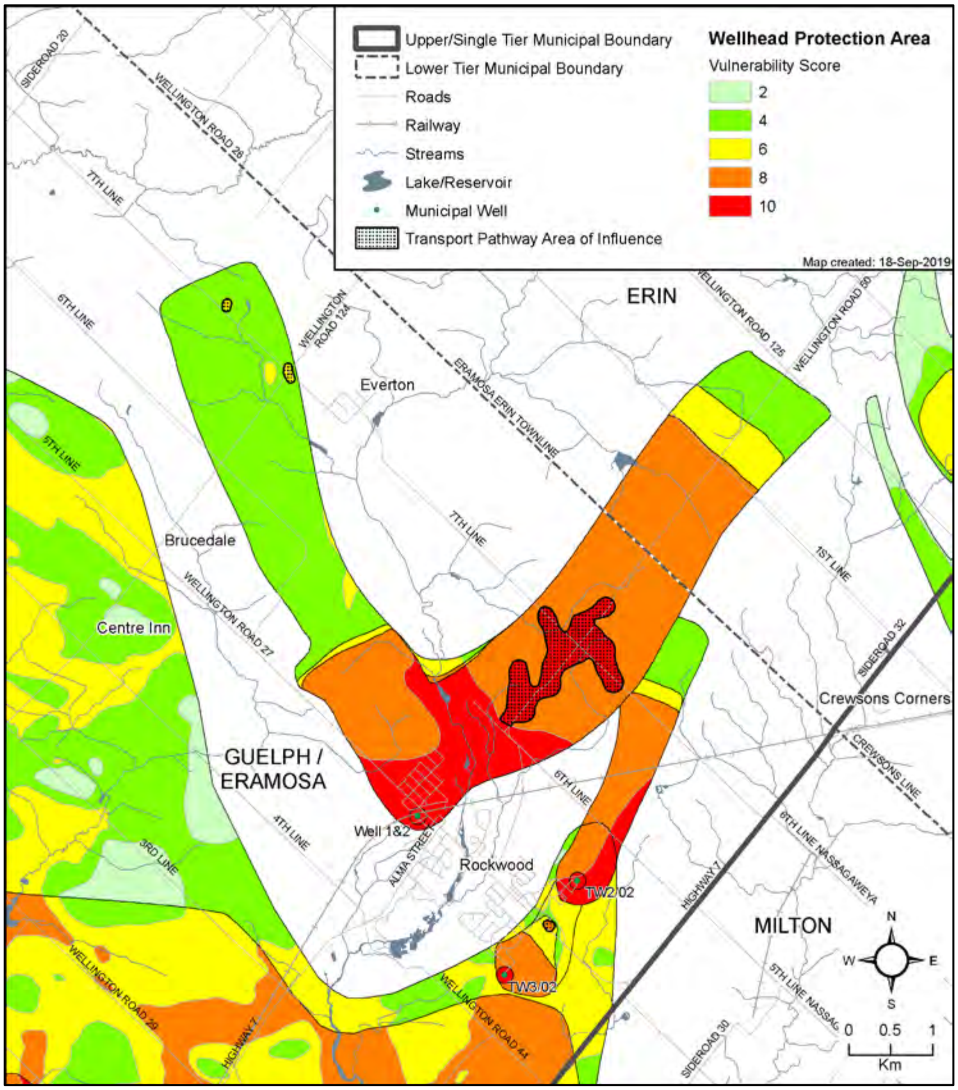


**Map 6-41 Rockwood Water Supply Adjusted Intrinsic Vulnerability**

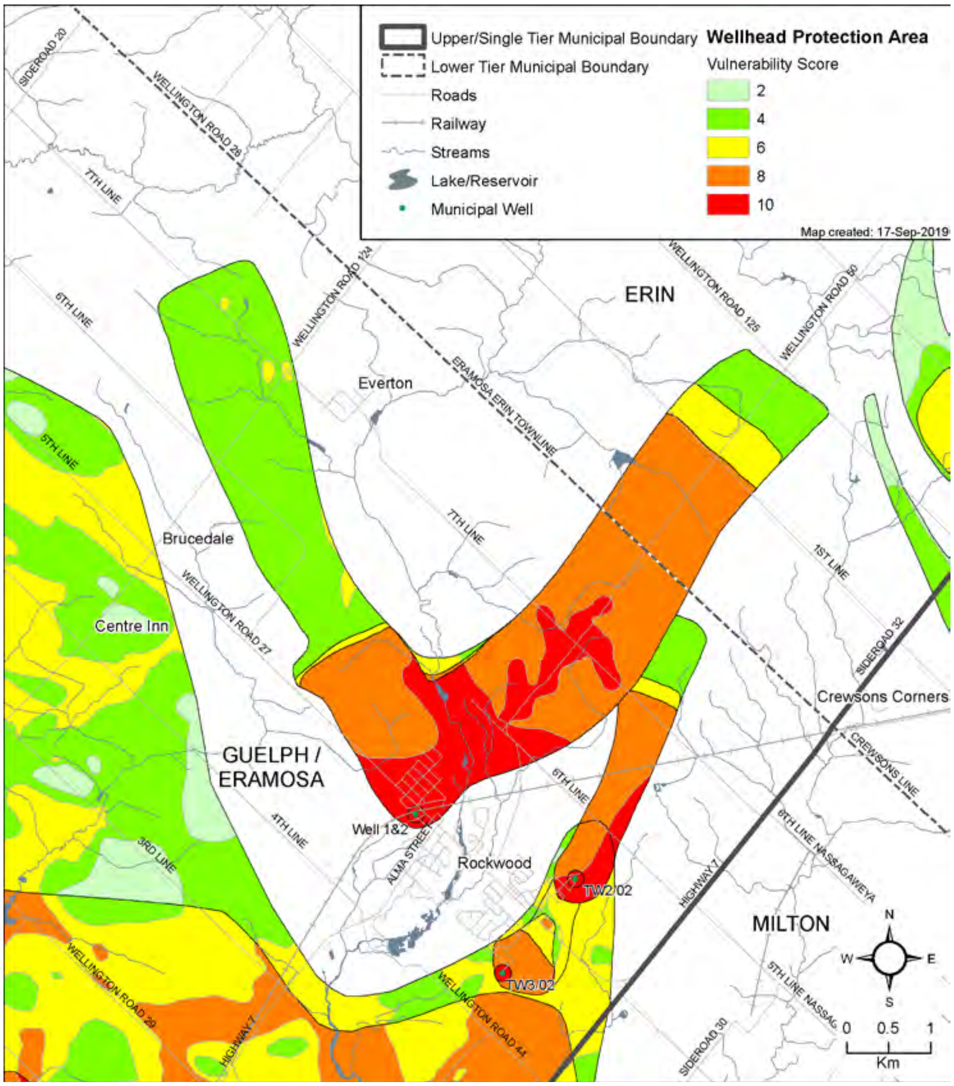


**~~Map 6-44: Rockwood Water Supply Transport Pathways~~**

**Map 6-42: Rockwood Water Supply Transport Pathway Area of Influence**

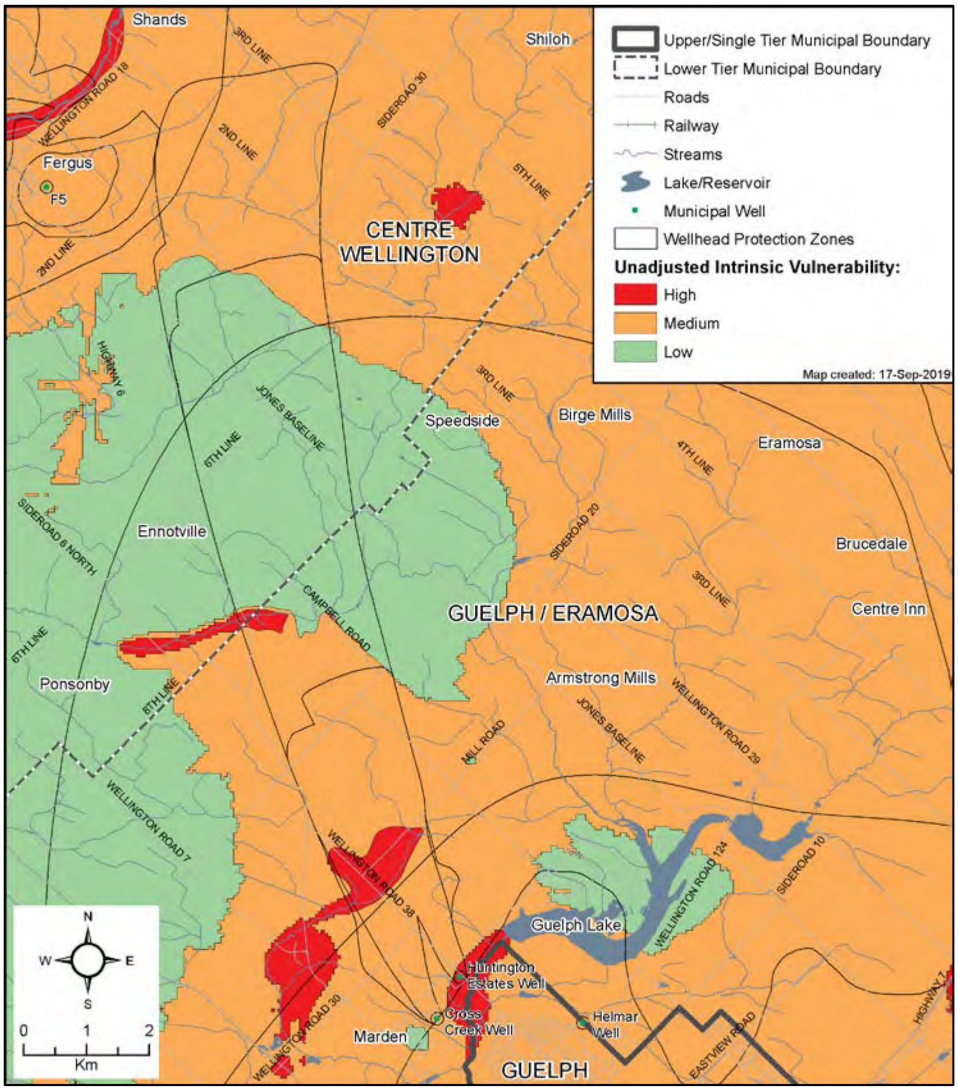


**Map 6-43: Rockwood Water Supply Wellhead Protection Area Final Vulnerability**

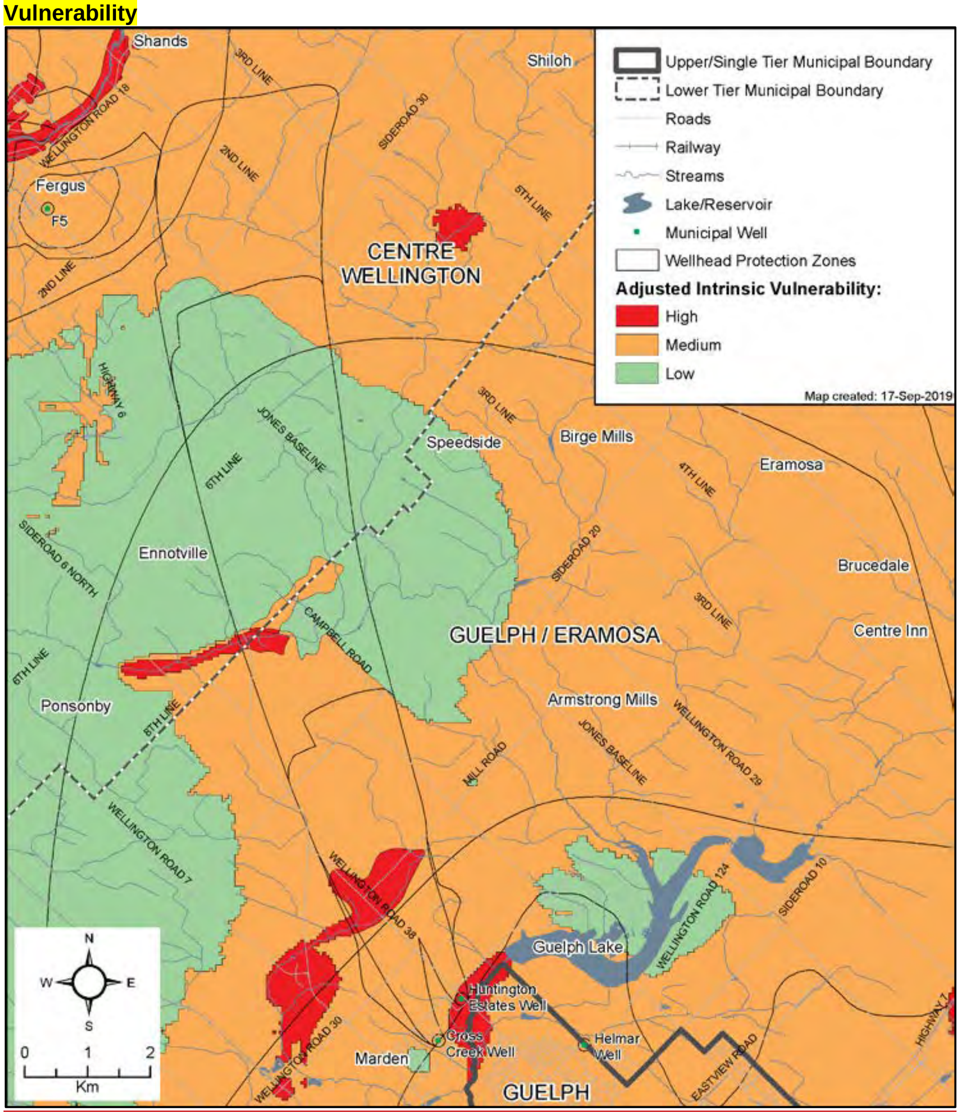



Publicly available Web-GIS mapping of vulnerable areas including vulnerability has been developed and is available through [www.sourcewater.ca](http://www.sourcewater.ca).

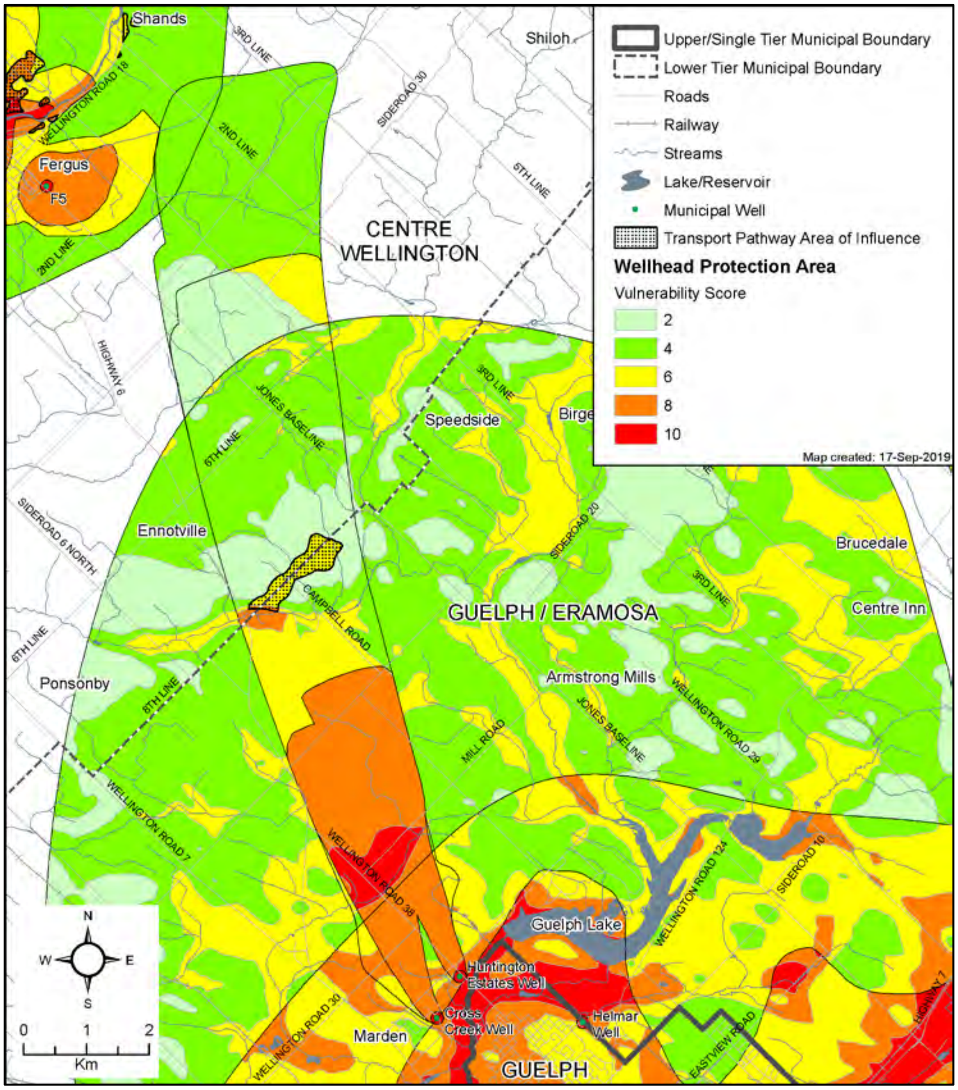
~~**Map 6-47: Rockwood Water Supply Wellhead Protection Area Initial Vulnerability (Insert)**~~
~~**Map 6-48: Rockwood Water Supply Wellhead Protection Area Final Vulnerability**~~
**Map 6-44 Hamilton Drive Water Supply Unadjusted Intrinsic Vulnerability**



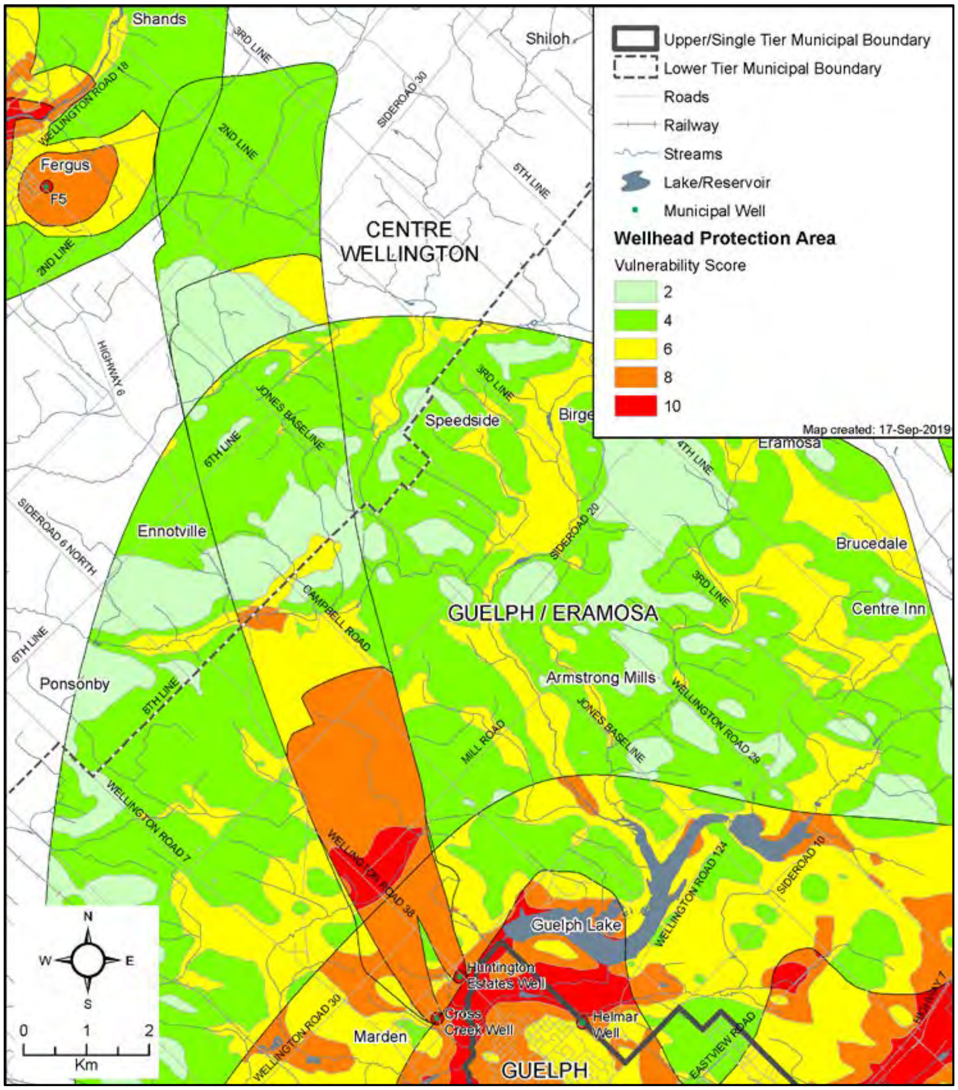
**Map 6-45: Hamilton Drive Water Supply Wellhead Protection Area Adjusted Intrinsic Vulnerability**



~~**Map 6-48: Hamilton Drive Water Supply Transport Pathways**~~
**Map 6-46: Hamilton Drive Water Supply Transport Pathways Area of Influence**



**Map 6-47: Hamilton Drive Water Supply Wellhead Protection Area Final Vulnerability**



***Managed Lands within the Rockwood and Hamilton Drive Water Supply Systems***
Managed Lands are lands to which nutrients are applied. Managed lands can be categorized into two groups: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow, and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses, sports fields, lawns and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer). Detailed methods on managed lands calculations are described in Chapter 3 of this Assessment Report.

Based on Technical Rule 16 (9), the percentage of managed lands were only calculated where the vulnerability score in each WHPA was greater than 4.

Managed lands calculations for Rockwood and Hamilton Drive were completed in WHPA-A to WHPA-D where the vulnerability was 6 or higher. **Table 6-35** provides the results of the calculations and **Map 6-48 and Map 6-49** illustrate the results.

~~Determining the location and percentage of managed lands, the location of agricultural managed lands, and the calculation of livestock density were used to determine whether the application of agricultural source material (ASM), non-agricultural source material (NASM), and fertilizer were significant threats within the Wellhead Protection Areas.~~

~~To calculate percentage of managed lands, Technical Rule 16(9) was used (MOE, 2009b). Similar to the calculation of impervious surfaces, mapping the percentage of managed lands area is not required where the vulnerability score for an area is less than the vulnerability score necessary for the activity to be considered a significant threat. Based on this statement in the Technical Rules, the percentage of managed lands were only calculated where the vulnerability score in each Wellhead Protection Area was greater than four.~~

**~~Managed lands and livestock density calculations for the Rockwood and Hamilton Drive Wellhead Protection Areas were completed in WHPA-A, WHPA-B, WHPA-C and parts of WHPA-D where the vulnerability was 6 or higher.~~ Table 6-37: Managed Lands Percentage in the Rockwood and Hamilton Drive Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|
| Guelph/ Eramosa | Rockwood | Well 1&2 | ~~48.39%~~17.71% | ~~67.64~~56.90 % | 72.90% (west); 3.55% (centre); ~~55.76%~~32.64% (east); | 44.24% (west); 0% (centre); N/A (east) |
| | | ~~TW3/02z~~Well 3 | ~~71.98%~~66.03% | ~~69.82~~58.20 % | ~~55.76~~36.89%~~%~~ | ~~N/A~~36.23~~5.99~~% |
| | | ~~TW2/02~~Well 4 | ~~38.05~~25.54% | ~~69.82%~~60.84% | ~~55.76~~92.69% | N/A |
| | Hamilton Drive | Cross Creek | ~~75.18~~71.79% | ~~57.74%~~ ~~68.26%~~75.58% | 75.80%~~84.22%~~ ~~62.07%~~ | ~~22.25%~~ ~~22.25%~~49.02% (west); N/A~~73.04%~~ (north); N/A (east) |
| | | Huntington | ~~77.46~~68.47% | | | |

A coding of N/A indicates that the vulnerability score in this area is 4 or less.

***Livestock Density within the Rockwood and Hamilton Drive Water Supply Systems***

The calculation of livestock density is required to determine the amount of Nutrient Units (NU) generated in each vulnerable Wellhead Protection Area scenario. This calculation is only completed when there are building structures that could house livestock on a farm parcel that intersects a vulnerable Wellhead Protection Area. Detailed methods on livestock density calculations are described in Chapter 3 of this Assessment Report. ~~This means that for each farm parcel that has a portion of their land in the Wellhead Protection Area and also has a livestock barn on their property (regardless of whether the barn is in the Wellhead Protection Area), the livestock density in Nutrient Units per acre (NU/ac) would be calculated. The Nutrient Units generated by each farm parcel is area weighted to determine the proportion applied in each Wellhead Protection Area. The total amount of Nutrient Units applied in each Wellhead Protection Area is divided by the amount of agricultural managed land in that same Wellhead Protection Area to determine the livestock density. The agricultural managed lands in each Wellhead Protection Area scenario was calculated as per Part II, Technical Rule 16(10) (MOE, 2009b), and as previously described. Each parcel of land that intersects each Wellhead Protection Area needs to be assessed for the presence of a livestock barn. The nutrients that are generated by the livestock are assumed to be applied only onto that farm parcel.~~

~~Barns on farm parcels with codes related to livestock were looked at more carefully to determine what type of livestock could be housed and in which structures. Air photo interpretation with some knowledge of key identifying features of housing structures and land use practices allowed some confidence in selecting the correct structure as a livestock housing structure.~~

~~Once a livestock housing barn was selected, the type of livestock that was assumed to be housed in the barn was estimated with help from the farm code description and air photo interpretation. A polygon was drawn to cover the footprint of the structure to represent of the area of housing space for the livestock. The area of the barn was multiplied by the conversion factor for that livestock type, relating the area of the barn (in square metres) per Nutrient Unit, as supplied by OMAFRA in the Technical Memorandum issued by GRCA for Lake Erie Region Technical Studies (September 23, 2009) (GRCA, 2009a). This amount of nutrients is assumed to be applied to all the AML area on that farm unit evenly.~~

~~To verify the air photo interpretation, drive-by site visits were done to capture a photograph of the barn from the road-side.~~

~~Once all the livestock barns were found and the NUs calculated, the total NU applied to only the area within the Wellhead Protection Area is needed. Using area weighting, the livestock density (in NU/acre) of each farm parcel was applied to only the area within the Wellhead Protection Area and summed with all the other NU calculations on farm parcels in the Wellhead Protection Area.~~

~~The total NU generated by all the barns is divided by the total AML in the Wellhead Protection Area, as calculated in the Managed Lands Methodology, regardless of the type of farm (livestock or non-livestock). The livestock density in the Wellhead Protection Area is thus the sum of all NU applied within the Wellhead Protection Area divided by the total AML area (in acres).~~

The results of the calculations for livestock densities are provided in **Table 6-36 and Map 6-50 and Map 6-51,** for the Rockwood and Hamilton Drive Wellhead Protection Areas.

**Table 6-38: Livestock Density (NU/acre) in the Rockwood and Hamilton Drive Wellhead Protection Areas**

| Township | Location | Well | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Guelph/ Eramosa | Rockwood | Well 1&2 | 0.00 | 0.94~~13~~ | 0.57 (west); 2.81 (centre); 0.01 (east)~~0.48~~ | 0.01~~4~~ (west); 0.00 (centre); N/A (east)~~0.16~~ |
| | | ~~TW3/02~~Well 3 | ~~0.57~~0.16 | ~~1.06~~0.30 | ~~0.48~~0.52 | ~~N/A1.84~~0.87 |
| | | ~~TW2/02~~Well 4 | 0.00 | ~~1.06~~0.37 | 0.29~~0.48~~ | N/A |
| | Hamilton Drive | Cross Creek | 0.00 | ~~0.73 1.16~~0.63 | ~~0.74 1.45~~0.65~~72~~ | 5.82 (west); N/A~~0.01~~ (north); N/A (east)~~0.08 0.08~~ |
| | | Huntington | 0.00 | | | |

A coding of 0 in **Table 6-36** indicates that there were no agricultural livestock barns to contribute nutrients and therefore the value for livestock density is 0. A coding of N/A indicates that the vulnerability score in this area is 4 or less.

***Percent Impervious Surface Area in Wellhead Protection Areas***

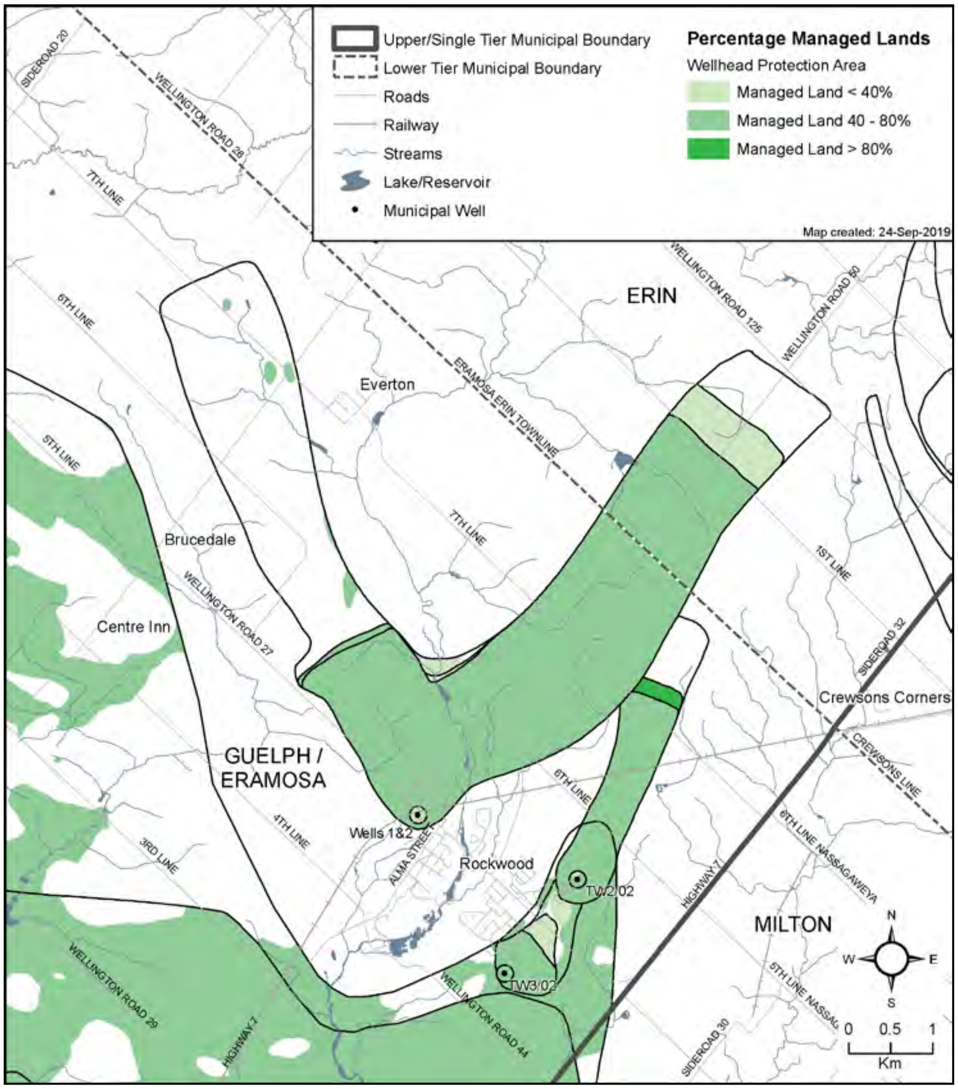
To determine whether the application of road salt poses a threat in the Township of Guelph-Eramosa, the percentage of impervious surface where road salt can be applied per square kilometre was calculated as per Technical Rules 16(11) and 17. The 1km X 1km method, described in Chapter 3 was used for Rockwood and Hamilton Drive wellfields. The application of road salt can only be a threat in areas with a vulnerability score of 6 or greater under the threats-based approach; therefore the percent impervious calculation was only completed in areas with a score of 6 or greater.

~~The areas were calculated using road mapping from the National Road Network (Natural Resources Canada) and satellite air photography to identify large parking lots and paved areas. Using a 1 km x 1 km grid centered over each vulnerable area, the percentage of impermeable surfaces within each square kilometre was calculated. The Technical Rules require that the grid is centred on the centroid of the source protection area. As per Technical Rule 15.1, the Director has provided confirmation that he agrees to the departure. The Director's letter of confirmation can be found in **Appendix B.** The percentage of impervious surfaces is an indicator for the potential for impacts due to road salting. In areas with high levels of impervious surfaces (roads) there is an increased likelihood that road salts will impact water quality.~~

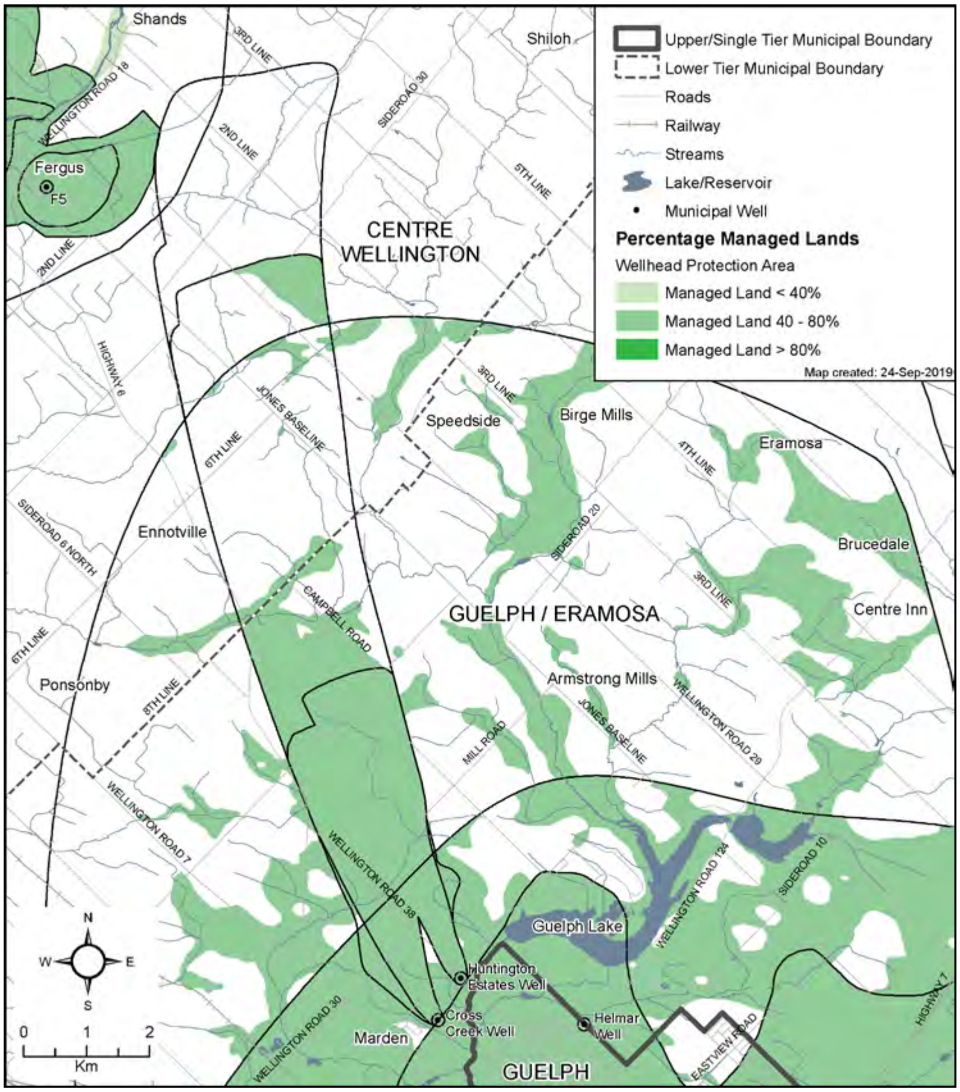
The application of road salt can only be a threat in areas with a vulnerability score of 6 or greater; therefore the percent impervious calculation was only completed in areas with a score of 6 or greater.

The impervious surface percentages were calculated in each ~~Wellhead Protection Area~~WHPA for the Township of Guleph/Eramosa. The results indicate a low to moderate percentage of impervious surfaces for both Rockwood ~~(0% and 8.2%)~~ and Hamilton Drive ~~(0% and 6.2%)~~ as shown in **Map 6-52 and Map 6-53.** With the current thresholds in the MECP's~~OE's~~ Tables of Drinking Water Threats the application of road salt is not a significant threat.

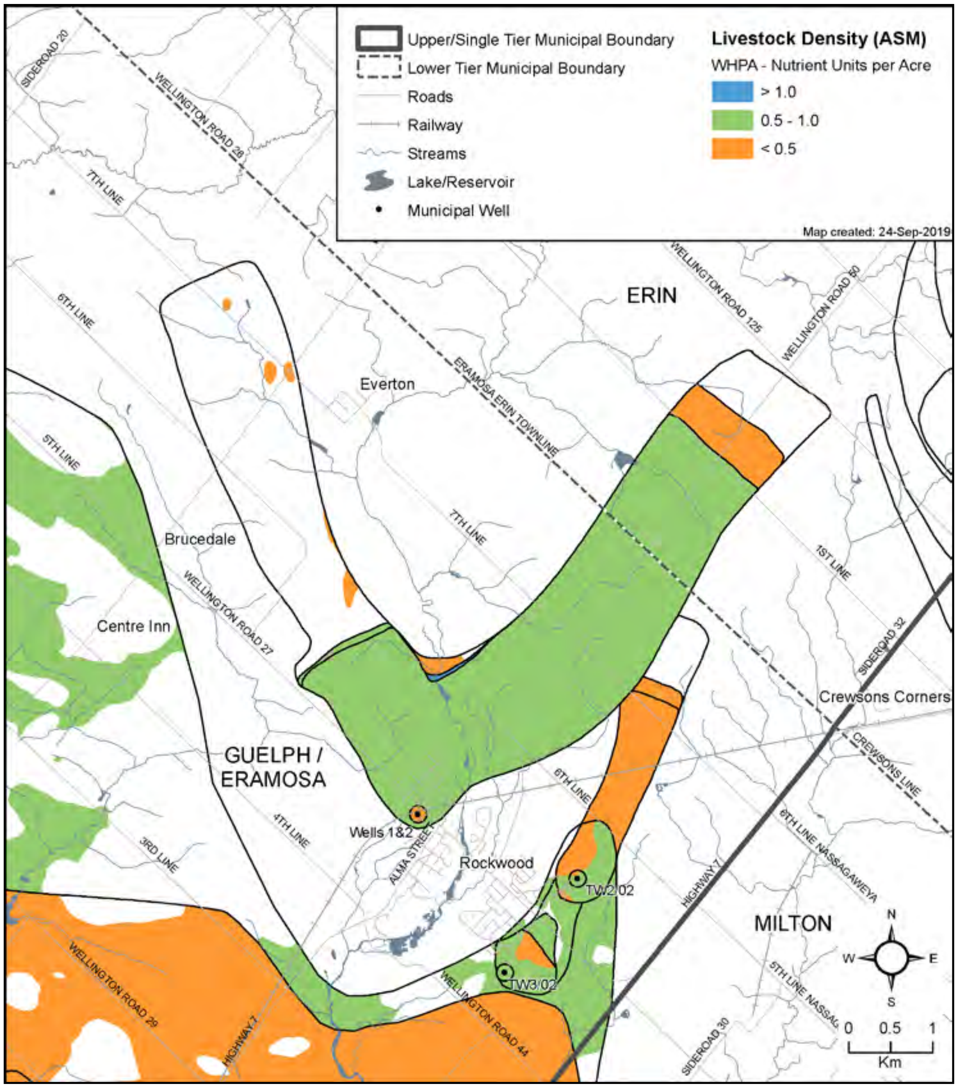
**Map 6-48: Rockwood Water Supply Percent Managed Lands**



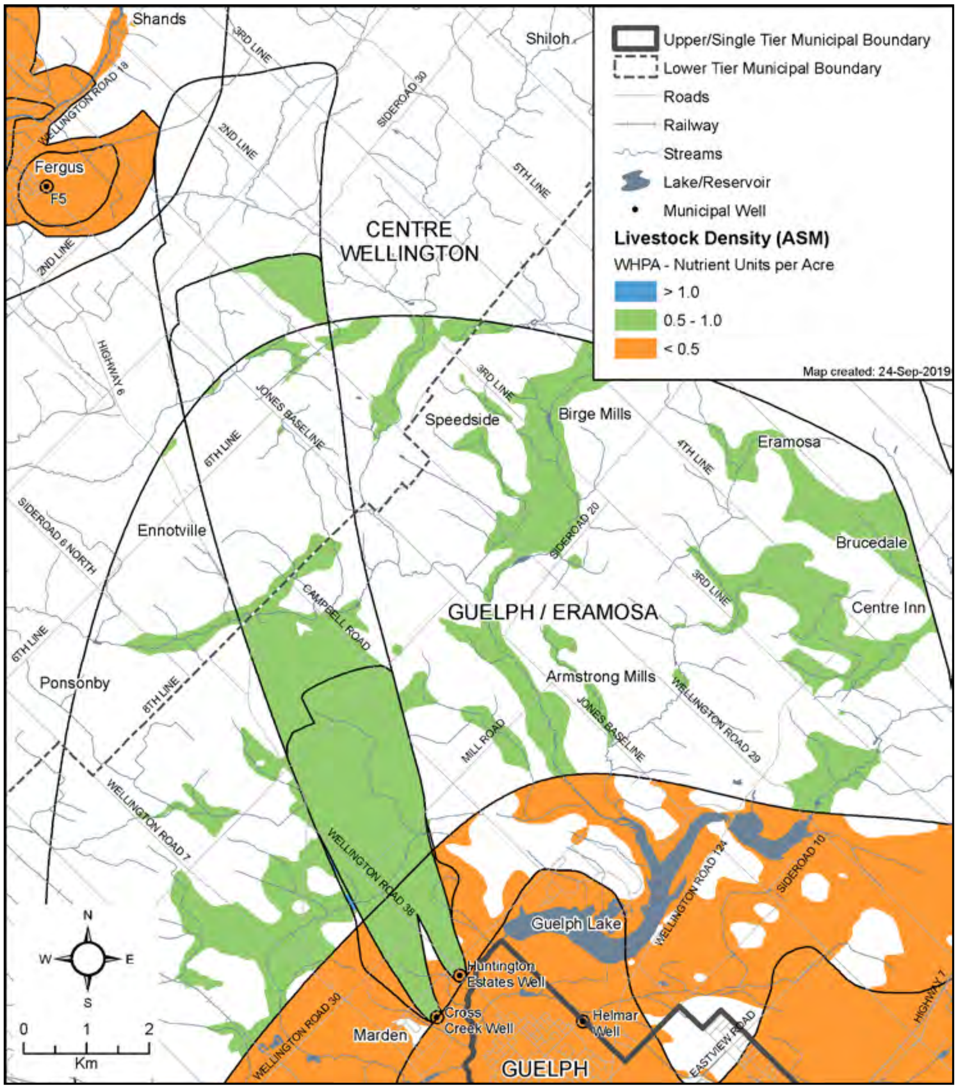
**Map 6-49: Hamilton Drive Water Supply Percent Managed Lands**



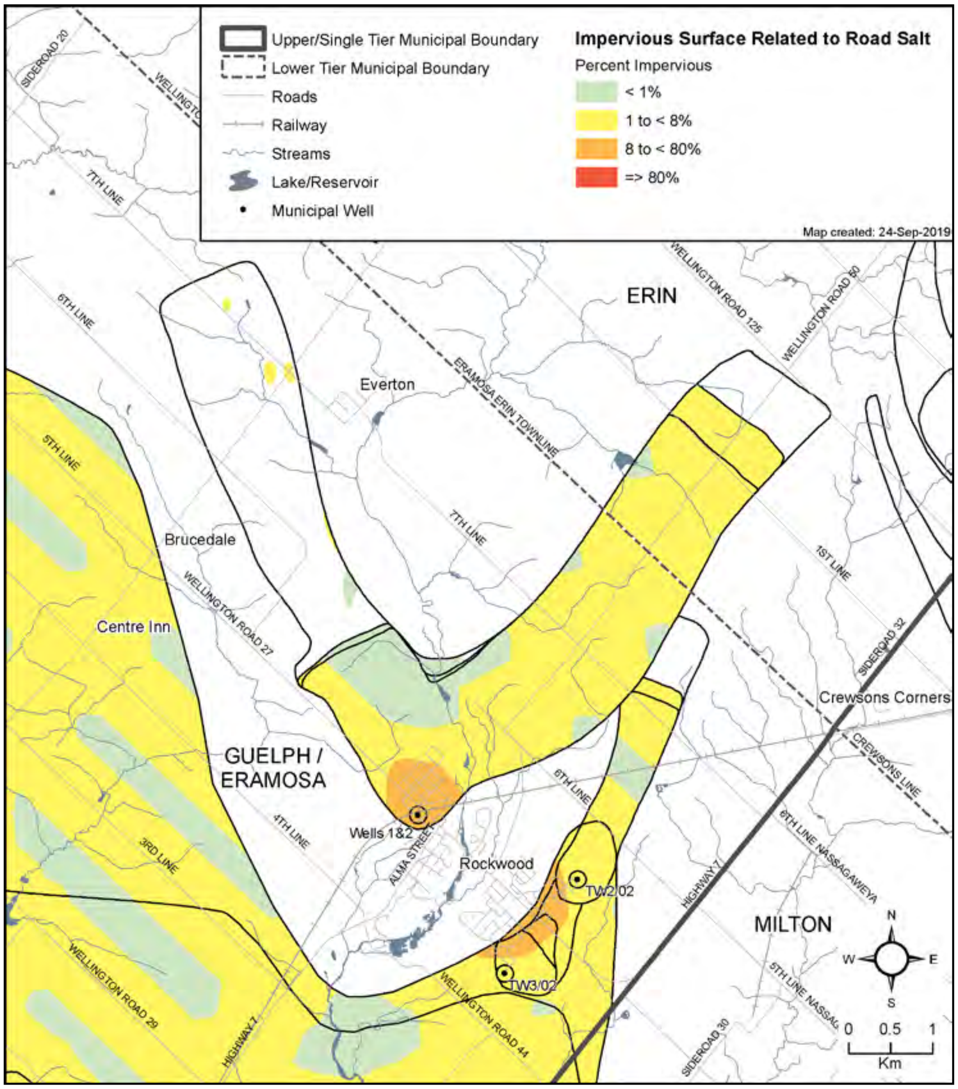
**Map 6-50: Rockwood Water Supply Livestock Density**



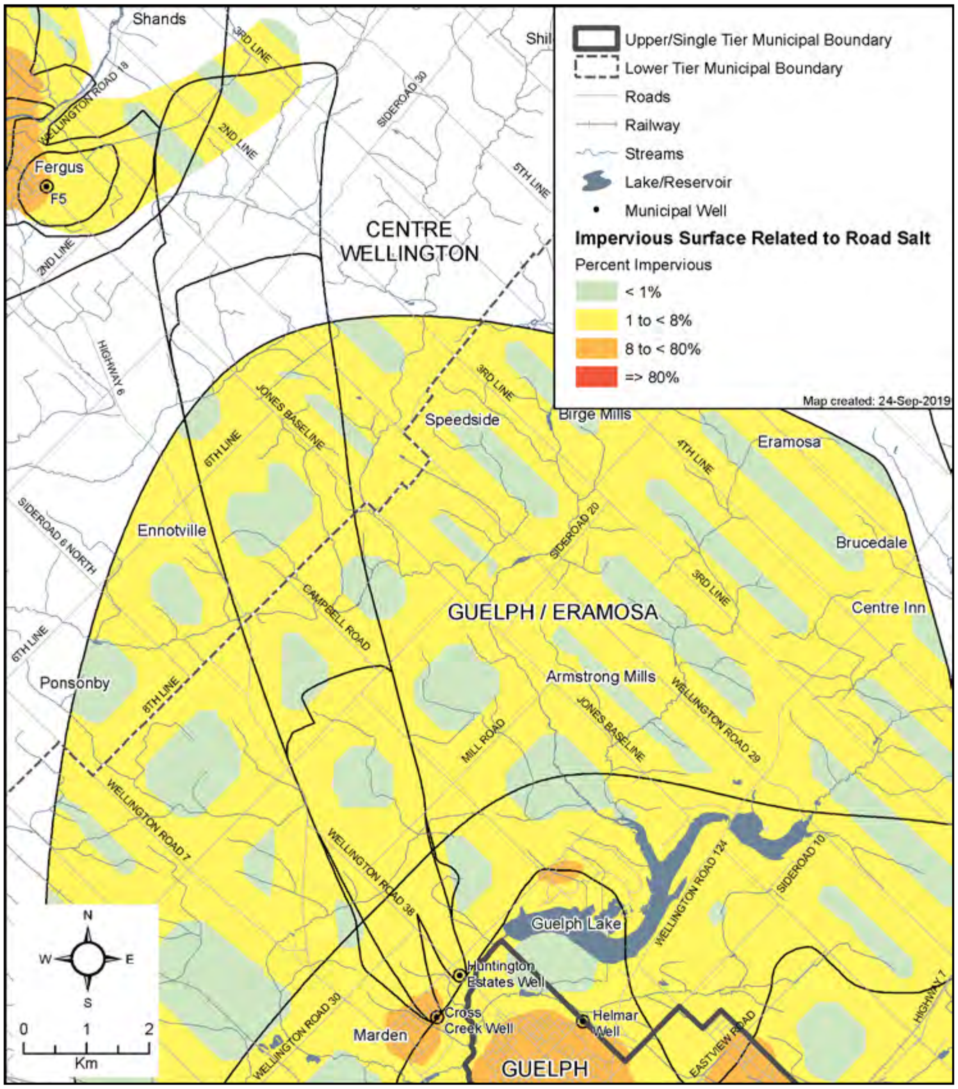
**Map 6-51: Hamilton Drive Water Supply Livestock Density**



**Map 6-52: Rockwood Percent of Impervious Surfaces**



**Map 6-53: Hamilton Drive Percent of Impervious Surfaces**



### 6.4.4 Drinking Water Threats Assessment

The Ontario Clean Water Act, 2006, defines a Drinking Water Threat as "an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, and includes an activity or condition that is prescribed by the regulation as a drinking water threat." A Prescribed Drinking Water Threats table in Chapter 3 of this Assessment Report lists all possible drinking water threats.

***Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Rockwood and Hamilton Drive Water Supply Systems***

The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. ~~For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**.~~ The information above can be used with the vulnerability scores shown in **Map 6-43 and Map 6-47** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

**Table 6-37** provides a summary of the threat levels possible in the Rockwood and Hamilton Drive Well Supplies for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), and Pathogens. A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in the maps.

**Table 6-39: Identification of Drinking Water Quality Threats in the Rockwood and Hamilton Drive Wellhead Protection Areas**

| Threat Type | Vulnerable Area | Vulnerability Score | Threat Classification Level | | |
|---|---|---|---|---|---|
| | | | Significant 80+ | Moderate 60 to <80 | Low >40 to <60 |
| Chemicals | WHPA-A/B | 10 | ✔ | ✔ | ✔ |
| | WHPA-B/C | 8 | ✔ | ✔ | ✔ |
| | WHPA-C/D | 6 | | ✔ | ✔ |
| | WHPA-D | 2 & 4 | | | |
| Handling / Storage of DNAPLs | WHPA-A/B/C | Any Score | ✔ | | |
| | WHPA-D | 6 | | ✔ | ✔ |
| | WHPA-D | 2 & 4 | | | |
| Pathogens | WHPA-A/B | 10 | ✔ | ✔ | |
| | WHPA-B | 8 | | ✔ | ✔ |
| | ~~WHPA-C/D~~ | ~~Any Score~~ | | | |

### 6.4.5 Conditions Evaluation

Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the Technical Rules (MOECC, 2017), lists criteria for drinking water sources, which is outlined in Chapter 3 of this Assessment Report.~~Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126~~

of the CWA Technical Rules (MOE, 2009b), lists the following two criteria for groundwater sources:

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.
- The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.

The above listed criteria were used to evaluate potentially contaminated sites within the Rockwood and Hamilton Drive WHPAs to determine if such a Condition was present at a given site.

The criteria were used to evaluate potentially contaminated sites within the Rockwood and Hamilton Drive WHPAs to determine if such a Condition was present at a given site.

***Conditions Evaluation for the Rockwood and Hamilton Drive Water Supply Systems***

A review of available data regarding potential contamination within the Wellhead Protection Areas was completed. Data available included databases from the Ecolog ERIS results such as Record of Site Condition, MECP Spills Database and Occurrence Reporting Information System.

**Table 6-38** provides a summary of potential conditions identified through the Ecolog ERIS search. This search of available databases does not provide evidence of a condition such as water quality results or monitoring report results.

**Table 6-40: Summary of Potential Conditions within the Rockwood Wellhead Protection Areas**

| Source Database | Description | Vulnerable Area Location | Details |
|---|---|---|---|
| ORIS | Heating oil spill | Rockwood 1/2 WHPA-B | 275 L spill to ground in 2002, possible impact |
| ORIS | Furnace oil spill | Rockwood 1/2 WHPA-B | Unknown amount spilled to municipal sewer, 1997 |
| ORIS | Furnace oil spill | Rockwood 1/2 WHPA-B | 160L spill to ground, impact confirmed, 1992 |
| WDSH/ANDR | Old village dump | 100 m outside Rockwood 1/2 WHPA-B | Landfill closed 1964, classified as no potential environmental and health impacts. |
| ORIS | PCP/oil mixture spill | Cross Creek WHPA-D | 68L spill to ground in 1996, impact confirmed, cleaned up. |

In addition to the condition site assessment presented above and in the Approved Grand River Assessment Report (August 2012), additional information whas been obtained from municipal files and some responsible parties pertaining to condition sites within the Township of Guelph / Eramosa. This information was reviewed in 2015 and two (2) sites were identified as condition sites but not as significant drinking water threat condition sites. In 2019, these sites were reviewed and based on changes to the Director's Technical Rules, the two (2) sites are no longer condition sites. ~~As a result, the available documents, reports and data pertaining to an additional, two (2) potential condition sites were reviewed to determine whether any of the sites met the technical rules as a condition or significant drinking water threat condition site.~~

Based on the documentation available ~~at this time~~in 2019, the additional, two (2) sites within Rockwood 1 / 2, WHPA A are not considered condition sites under Technical Rule 126.~~,~~ ~~however, there is not sufficient evidence to identify the sites as significant drinking water threat condition sites under technical rule 140.~~

~~Based on available data there were two Conditions identified under Rule 126 in the Rockwood or Hamilton Drive Wellhead Protection Areas, however, no Significant Drinking Water Threat Conditions sites were identified under technical Rule 140.~~

### 6.4.6 Drinking Water Quality Issues Evaluation

The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring ~~well~~ location would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)). Elevated concentrations of selected parameters that are naturally occurring or where effective treatment is in place are not considered drinking water Issues.

Once a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the Issue within an Issue Contributing Area and manage these threats appropriately. If at this time the Issue Contributing Area can not be identified or the Issue can not be linked to threats then a work plan must be provided to assess the possible link.

If an Issue is identified for an intake, well or monitoring location~~well~~, then all threats related to a particular Issue within the Issue Contributing Areas are as significant drinking water threats, regardless of the vulnerability.

Methodology for the Drinking Water Quality Issues Evaluation

A review of the available water quality data to assess whether any contaminants are impacting or have the potential to impact or interfere with the Township of Guelph-Eramosa drinking water sources was completed.~~ (Burnside, 2010).~~ This included the following steps:

- Collection of water quality data
- Comparison of water quality data to the ODWQS to see if any parameters were in exceedance
- Concentrations of parameters of consideration over time were plotted to evaluate if there were any increasing trends.

***Drinking Water Issues Evaluation for the Rockwood Water Supply System***

Historical water quality data for the Rockwood wells indicate that the water is traditionally very hard and hardness often exceeds the ODWQS standards (Rockwood Annual Drinking Water Report 2008 to 2018~~Burnside, 2002b~~). A hardness concentration of 480~~65~~ mg/L was recorded for Well 1 and 2 in 2018~~02~~. This is above the Operational Guideline of the ODWQS range of 80-100 mg/L ~~(Burnside, 2002b).~~ . This level is typical of drinking water obtained from a dolostone bedrock source and is not considered a condition that threatens the groundwater as a safe drinking water source.

~~MOE Annual Reports~~Water quality data for ~~2003 and 2005 to 2008~~up to August 2019 were reviewed. Sampling is completed at the supply systems weekly for microbiological parameters and once every 36 months for chemical parameters. Since 2018, sampling for sodium and chloride has been completed monthly at Station Street Wells 1 and 2. One exceedance of total coliforms (2 cfu/100 mL) was reported in June 2015. ~~All parameters analyzed met the ODWQS except for fluoride at Rockwood Well TW3/02.~~

~~The criteria were used to evaluate potentially contaminated sites within the Elora and Fergus WHPAs to determine if such a Condition was present at a given site.~~

In 2005, and exceedance of f~~F~~luoride ~~concentrations~~at Rockwood Well 3 was noted of 1.65 mg/L (MAC of 1.5 mg/L). ~~in 2005 and 1.7 mg/L in 2009 are recorded for Rockwood Well TW3/02~~No further exceedances for fluoride have been recorded since 2005.~~.~~ ~~Both concentrations exceed the Maximum Allowable Concentration (MAC) Ontario Drinking Water Standard (ODWS) of 1.5 mg/L.~~ Adverse effects of fluoride between 1.5 mg/L and 2.4 mg/L are considered to be only cosmetic in nature (dental mottling in a small portion of the population). The MECP~~OE~~ recommends that public awareness concerning other fluoride sources is raised when naturally occurring fluoride levels are between 1.5 mg/L and 2.4 mg/L. Since fluoride is naturally occurring and a non-health related parameter it is not considered an Issue under Technical Rule 114.

Elevated sodium concentrations have been recorded in Rockwood Wells 1 and 2 with levels ~~ranging from 62.5 to 97 mg/L~~reaching 180 mg/L in 2018 (Figure 2). The Ontario Drinking Water Standards MAC for sodium is 200 mg/L, however the local Medical Officer of Health should be notified when sodium concentrations exceed 20 mg/L. ~~-~~There has been a ~~n slightly~~ sharp increasing trend at~~for~~ Rockwood Wells 1 and 2 during 2018 and 2019.~~; however, this trend is based on only a few data points ranging over several years and recent sampling (2010) shows a decrease in concentration. The concentrations have yet to reach the MAC/2 (100 mg/L), which triggers increased sampling frequency under the Safe Drinking Water Act for municipal water systems.~~. ~~Sodium concentrations at Rockwood Well 3 have been increasing slightly from 3 mg/L in 2005 to 17 mg/L in 2019. Sodium concentrations at Rockwood Well 3 are below the Indicator of Adverse Quality (20 mg/L).~~ In February 2018, chloride concentrations at Rockwood Wells 1 and 2 are at the Maximum Acceptable Concentration of 250 mg/L with five exceedances in 2019 (Figure 3). Chloride concentrations range from 180 to 260 mg/L (2018 and 2019) at Rockwood Wells 1 and and 2.

Sodium concentrations at Rockwood Well 3 have been increasing slightly from 3 mg/L in 2005 to 17 mg/L in 2019. Sodium concentrations at Rockwood Well 3 are below the Indicator of Adverse Quality (20 mg/L). Chloride concentrations show a stable trend in Rockwood Well 3 with concentrations ranging from 33 to 37 mg/L (2018 and 2019).

Elevated sodium and chloride concentrations at Rockwood Wells 1 and 2 may be an indication of impacts from the application of road salt., however, have not been ~~and may be~~ higher during the winter and spring months when runoff from roads is recharging the aquifer. ~~The higher values in 2009 are from samples collected in February and March while the lower values in 2002 and 2003 were from samples collected in May and August. Therefore, the difference in values may be a result of seasonal variations of sodium concentrations within the aquifer. More frequent sampling would be required to confirm if a trend exists~~. An increase in sampling frequency during 2018 and

2019 did not show a seasonal trend, but rather a sharp increasing trend. The municipality is further assessing the potential sources, trends, timing and fate / transport mechanisms for sodium and chloride at the Station Street Wells 1 and 2.

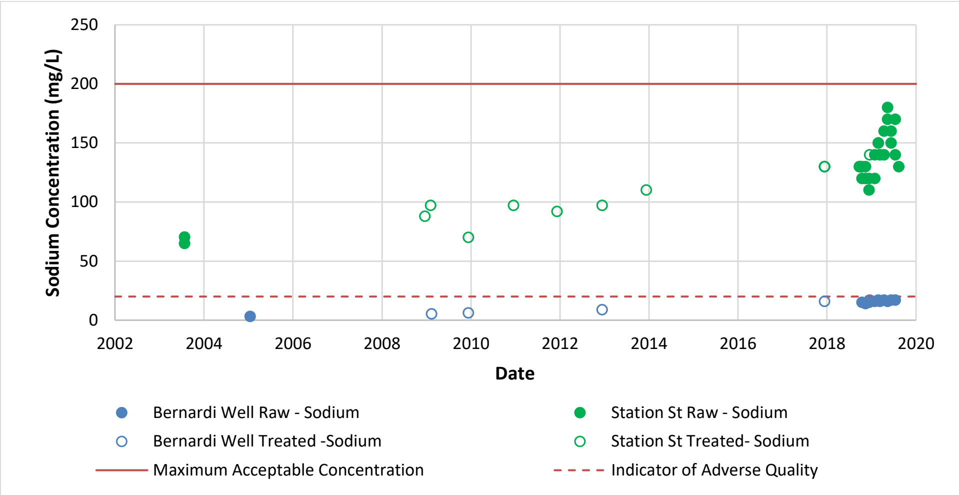



**Figure 2: Sodium Concentrations at Rockwood Wells (Bernardi (3) and Station St. (1and 2))**

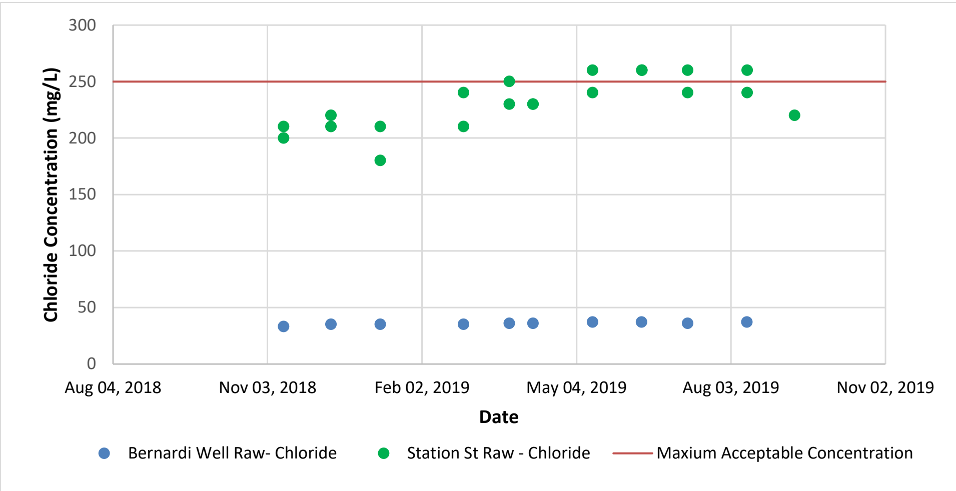



**Figure 3: Chloride Concentrations at Rockwood Wells (Bernardi (3) and Station St. (1and 2))**

A Microbial Contamination Control Plan for Wells 1 and 2 was prepared in September 2008 to comply with the Certificate of Approval 3052-5RBP8E. As part of this report, particle counting was completed at the well. The results from the report indicate there are no microbial water quality Issues for the Rockwood Water Supply (Burnside, 2008).

***Summary of Water Quality Issues Evaluation for the Rockwood Water Supply System***

It is recommended that the sodium and chloride concentrations at Station Street Wells 1 and 2 be described a drinking water issue per Technical Rule 115.1 under Section 15(2) (f) of the *Clean Water Act, 2006.* Under this Technical Rule, an Issues Contributing Areas is not delineated and therefore there can be no significant threat activities identified associated with this issue. The only applicable policies would relate to the monitoring of the sodium and chloride issue. Since in-depth sampling has only been ongoing since 2018 and since it is unclear whether the source is naturally occurring, this issue approach allows the Township time to complete further sampling and study into the trends, timing and fate / transport mechanisms for sodium and chloride at the Station Street Wells 1 and 2.

~~Sodium is identified as a parameter of concern due to higher concentrations at Rockwood Wells 1 and 2, but there is not enough data, nor is there an obvious increasing trend, to identify~~. ~~S~~sodium has not been identified ~~as an Issue under Technical Rule 114.~~

There are currently no Issues concerning drinking water quality ~~for~~ and requiring an Issues Contributing Area for the Rockwood Water Supply.

***Drinking Water Issues Evaluation for the Hamilton Drive Water Supply System***

Historical water quality analysis results of raw water samples from the Cross Creek Well and Huntington Well indicate exceedences of the ODWQS for hardness in both wells with values ~~ranging from 275 to 291~~of 300 mg/L in 2019.~~(Burnside, 2001b).~~ This level is typical of drinking water obtained from a dolostone bedrock source and is not considered an Issue that threatens the groundwater as a safe drinking water source.

~~MOE Annual Reports for 2005-2008~~Water quality data for up to 2019 were reviewed~~ with no exceedences identified~~. Microbiological data reported exceedences in August 2015, June 2017, July 2017, and October 2017of ~~from 2002 to 2009 showed no concerns with~~ total coliforms. One exceedance of~~or~~ *E.coli* was reported for July 2017.

Fluoride concentrations range from 0.14 to 0.16 mg/L at the Hamilton Drive Wells. A review of fluoride concentrations to 2019 reported no exceedences of the Maximum Allowable Concentration (MAC) Ontario Drinking Water Standard (ODWS) of 1.5 mg/L.

Sodium concentrations range from 9.8 to 29 mg/L at the Hamilton Drive Wells. A review of sodium concentrations at the Huntington Well reported exceedences of the Indicator of Adverse Quality of 20 mg/L; however the Aesthetic Objective of 200 mg/L was not exceeded. There were no exeedences of sodium at the Cross Creek Well. Chloride concentrations range from 9.2 to 47 mg/L at the Hamilton Drive Wells. The chloride concentrations at Hamilton Drive are below the MAC ODWS for chloride of 250 mg/L.

***Summary of Drinking Water Issues Evaluation for the Hamilton Drive Water Supply System***

There are currently no Issues concerning drinking water quality for the Hamilton Drive Water Supply.

***Limitations and Uncertainty for the Drinking Water Issues Evaluation***
The water quality data reviewed covered a period from 2001 to ~~2009~~2019; however sampling frequency did no increase until 2018~~.~~ This is a limited time span with frequent sampling making it difficult to ~~identify~~ confirm trends~~, especially when not all parameters were sampled during each year~~. It is also noted that there is no monitoring well water quality data available. Monitoring wells are only monitored for water levels as part of the PTTW requirements.

### 6.4.7 Enumeration of Significant Drinking Water Quality Threats

The Technical Rules (MOECC, ~~2009b~~2017) require an estimation of the number of locations at which an Activity is a significant drinking water threat and the number of locations at which a Condition resulting from past activity is a significant drinking water threat.

6.4.7.1 Initial Enumeration of Significant Drinking Water Threats

For the initial enumeration in the 2012 Assessment Report, numerous data sources were used to identify threats on properties within the Wellhead Protection Areas.

***Data Sources for the Enumeration of Significant Drinking Water Quality Threats***
EcoLog Environmental Risk Information Services Ltd. (EcoLog ERIS) is a national database service, which provides specific environmental and real estate information for locations across Canada. A review of all available provincial, federal and private environmental databases was requested for the areas within a radius around the wells that included the outer edge of the WHPA. As a result, the search included data to the west of the WHPAs. The search included the following databases:

*Federal Government Source Databases*

- National PCB Inventory 1988 – June 2004
- National Pollutant Release Inventory 1994 – 2004
- Environmental Issues Inventory System 1992 – 2001
- Federal Convictions 1988 – January 2002
- Contaminated Sites on Federal Land June 2000 – 2005
- Environmental Effects Monitoring 1992 – 2004
- Fisheries & Oceans Fuel Tanks 1964 – September 2003
- Indian & Northern Affairs Fuel Tanks 1950 – August 2003
- National Analysis of Trends in Emergencies System (NATES) 1974 – 1994
- National Defense & Canadian Forces Fuel Tanks Up to May 2001
- National Defense & Canadian Forces Spills March 1999 – February 2005
- National Defense & Canadian Forces Waste Disposal Sites 2001,2003
- National Environmental Emergencies System (NEES) 1974 – 2003
- Parks Canada Fuel Storage Tanks 1920 – January 2005
- Transport Canada Fuel Storage Tanks 1970 – May 2003.

*Provincial Government Source Databases*

- Certificates of Approval 1985 – September 2002
- Ontario Regulation 347 Waste Generators Summary 1986 – 2004
- Ontario Regulation 347 Waste Receivers Summary 1986 – 2004
- Private Fuel Storage Tanks 1989 – 1996

- Ontario Inventory of PCB Storage Sites 1987 – April 2003
- Compliance and Convictions 1989 – 2002
- Waste Disposal Sites – MOE CA Inventory 1970 – September 2002
- Waste Disposal Sites – MOE 1991 Historical Approval Inventory Up to October 1990
- Occurrence Reporting Information System (ORIS) 1988 – 2002
- Pesticide Register 1988 – August 2003
- Wastewater Discharger Registration Database 1990 – 1998
- Coal Gasification Plants 1987, 1988
- Non-Compliance Reports 1992(water only), 1994 – 2003
- Ministry Orders 1995 – 1996
- Aggregate Inventory Up to May 2005
- Abandoned Aggregate Inventory Up to September 2002
- Abandoned Mines Inventory System 1800 – 2005
- Record of Site Condition 1997 – September 2001
- Ontario Oil and Gas Wells (1999 – Oct 2004; 1800 – May 2004 available for 14 select counties)
- Drill Holes 1886 – 2005
- Mineral Occurrences 1846 – October 2004
- Environmental Registry 1994 – July 2003

*Private Sources Databases*
- Retail Fuel Storage Tanks 1989 – June 2005
- Canadian Pulp and Paper 1999, 2002, 2004, 2005
- Andersen's Waste Disposal Sites 1930 – 2004
- Scott's Manufacturing Directory 1992 – 2005
- Chemical Register 1992,1999 – June 2005
- Canadian Mine Locations 1998 – 2005
- Oil and Gas Wells October 2001 – 2005
- Automobile Wrecking & Supplies 2001 – June 2005
- Anderson's Storage Tanks 1915 – 1953
- ERIS Historical Searches, March 1999 – 2005.

The database search identified numerous items within the search radius around the various Wellhead Protection Areas, which were later confirmed through field site reconnaissance. All potential contaminant sources identified have been mapped and compiled into the project database.

Historical and current aerial photographs were reviewed to identify land use changes and potential high-risk activities such as waste disposal sites within the Wellhead Protection Areas. While the resolution of the photographs limits the detail that can be observed of the surface conditions, the following is a summary of what can be discerned:

- **1978 Aerial Photography:** Within Rockwood Well 1 and 2 Wellhead Protection Area, the southern portion is dominated by the Eramosa River and its associated forested buffer area. Residential development is visible to the north of the wells along three streets directly adjacent to Main Street North. The northern part of the WHPA contains agricultural land uses with some rural residences. Agricultural land uses are prominent within the Wellhead Protection Areas of Rockwood Wells 3 and 4. Some residential and commercial buildings exist along Main Street South (Highway 7) within the Village of Rockwood. A small active gravel pit/quarry located between the two Wellhead Protection Areas, north of the Village and east of Eramosa was noted. Several surface water features at the pit are visible in the photograph. No waste disposal sites or potential brownfield sites were identified. Within the Cross Creek and Huntington Wellhead Protection Areas, land is generally agricultural and wetlands. The subdivisions of Cross Creek and Huntington are not present in the photograph.

- **2000 Aerial Photography:** The photographs from 2000 revealed that land use within the Rockwood Wellhead Protection Areas has remained relatively unchanged with the Eramosa River and its associated forested buffer dominating the western portion of the areas and agricultural land uses dominating the eastern portions of the area. Some development has occurred south of Main Street South (Highway 7), in the vicinity of Well TW3/02, and north of Main Street North, in the vicinity of Wells 1 and 2. The pit/quarry noted in the 1978 photograph is visible although appears to be no longer in use. Surface water features visible in the 1978 aerial photography appear to remain generally unchanged in the 2000 photography. A junk and scrap yard was identified within WHPA-D at 6th Line and Sideroad 10. Within the Cross Creek and Huntington Wells Wellhead Protection Area, some development of houses and small subdivisions has taken place since the 1978 air photograph.

A drive-by roadside inspection of the Wellhead Protection Areas was completed on July 27, 2006 to verify and complement the dataset compiled during the records review portion of the assessment. The inspection consisted of a fence line/roadside documentation of the properties and their land uses included in the Wellhead Protection Area.

Within the Rockwood Well 1 and 2 Wellhead Protection Areas, one cemetery, a gravel pit and an automotive repair shop were identified. Land uses within Rockwood Well TW3/02 and Well TW2/02 Wellhead Protection Areas include residential lands, natural areas and agricultural lands. Rockwood Well TW3/02 is located on the edge of a developing subdivision in the Village of Rockwood. At the time of the site visit, construction of new houses within the subdivision was taking place. Agricultural fields are located south of the well. Several livestock farms were identified in the Wellhead Protection Areas.

Land uses within the Cross Creek and Huntington Wellhead Protection Areas include residential and agriculture. One cemetery was identified in the Cross Creek Wellhead Protection Area.

***Land Use Activity Assumptions for the Purpose of Enumerating Significant Drinking Water Quality Threats***

A standardized set of assumptions were made for each land use type and activity. The assumptions are summarized in **Table 6-39.**

**Table 6-41: Land Use Activity Assumptions for the Purpose of Enumerating Significant Drinking Water Quality Threats in the Rockwood and Hamilton Drive Water Supply Systems**

| Scenario | Assumption |
|---|---|
| Agricultural property with residence and outbuildings | • Storage and handling of pesticides, fuel, commercial fertilizer, agricultural source material, septic system.<br>• Application of pesticide, commercial fertilizer, agricultural source material. |

**Table 6-41: Land Use Activity Assumptions for the Purpose of Enumerating Significant Drinking Water Quality Threats in the Rockwood and Hamilton Drive Water Supply Systems**

| Scenario | Assumption |
|---|---|
| Agricultural property with residence and outbuilding – buildings not in WHPA | • Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied. |
| Agricultural property without farm buildings and structures | • Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied. |
| Residence with no gas line | • Oil furnace |
| Organic solvent | • Storage below grade in a quantity that would make it a significant threat |
| No sanitary sewer infrastructure | • Septic system |
| Presence of any chemical | • Storage is below grade |
| Multiple PINs associated with one Assessment Roll number | • One threat point assigned to the entire assessed property. |
| Where an assessment line transects a property, but has one PIN | • One threat point assigned to the entire property. |
| Lawn/turf | • Potential application of commercial fertilizer (ID dependent on the percent of managed land and the application of NU to the surrounding properties) |
| Municipal well sites | • Commercial fertilizer not applied unless the well is within a municipal park, in which case there is potential that fertilizer is applied. |
| All properties | • If buildings and structures are located outside the vulnerable area – circumstance IDs associated with storage and handling are not applied |
| Septic system | • In serviced villages where sanitary services are being phased in, but have not yet reached the mandatory connection date, it is assumed private septic systems are still present. |
| Sanitary sewers | • A sanitary sewer is a linear feature. For the purposes of enumeration of threats, where a sanitary sewer is present one threat point is assigned to represent the sanitary sewer in each WHPA. |
| Storm sewer piping | • Storm sewer piping is not considered to be part of a storm water management facility. |

To complete the threats classification the data fields within the database were populated using the following methods and assumptions.

Land use activities were assigned based on the tables provided in the MOE Lookup Table Database v. 7.1.2 (WRIP, 2009). They were assigned a land use category and a land use activity name based on best fit with the actual land use activity.

Threats were assigned based on the land use activities and the threats listed for those activities in the ~~MOE~~ MECP Lookup Tables. All threats were assumed to be present except in the following circumstances:

- Playing fields were assigned the land use activity name Spectator Sports. The threat application of commercial fertilizer was manually added.
- Cemeteries were assigned the land use of Religious Organizations. The threat application of commercial fertilizer was manually added.
- For agricultural land uses, if the parcel did not have any farm buildings located on it, any threats related to storage (i.e. fuel, fertilizer, pesticides) were removed.
- The threat, "Waste Disposal Site – Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste" was only applied to properties with a Certificate of Approval and/or are a registered waste generator or waste receiver.
- Threat points were placed in the area on the parcel with the highest vulnerability score except for residential fuel tank and septic systems threats which were placed within a reasonable distance of the associated building.
- All residential properties have been assumed to have fuel storage tanks for heating except for houses built in Rockwood after 2000. A threat has been assigned to each parcel within the WHPA. Homes built after 2000 are assume to be heated by natural gas, electrical or propane.

### 6.7.4.2 Enumeration of Significant Drinking Water Threats for 2019 Assessment Report

Since the initial enumeration of significant drinking water threats for the 2012 Assessment Report, a substantial amount of work has been completed by municipal Risk Management staff and consultants to verify threats at a site level. This work has included additional air photo analysis, site visits, windshield surveys, review of databases and site specific files / reports. The focus of this work is to compete verification of significant drinking water threats and where warranted negotiate risk management plans and to conduct inspections. This work has been focused within the wellhead protection areas delineated in the 2012 and 2015 Assessment Reports. New wellhead protection areas have now been delineated, however, there is overlap between the 2015 and the new wellhead protection areas.

For purposes of updating significant drinking water quality threats in the newly delineated wellhead protection areas, a review is being conducted of the existing database of verified threats, municipal servicing data and air photos. Results will be updated in the Assessment Report prior to public consultation.

***Significant Drinking Water Threats for the Rockwood Water Supply***

As per the Technical Rules (MOE~~CC~~, 20~~17~~09b), the enumeration of significant threats is required for the completion of the Assessment Report. **Table 6-40** summarizes the significant threats identified in the Rockwood Wellhead Protection Areas in the Township of Guelph-Eramosa.

**Table 6-42: Significant Drinking Water Quality Threats in the Rockwood Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 7 | WHPA-A<br>WHPA-B |
| 2 | Sewage System or Sewage Works- ~~Septic~~ Onsite Sewage Systems | 34 | WHPA-B |

**Table 6-42: Significant Drinking Water Quality Threats in the Rockwood Wellhead Protection Areas**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| | Sewage System or Sewage Works- Sanitary Sewers and related pipes | 1 | WHPA-A WHPA-B |
| | Sewage System or Sewage Works- Discharge of Untreated Stormwater from a Stormwater Retention Pond | 2 | ~~WHPA-A~~ WHPA-B |
| 3 | Application of Agricultural Source Material to Land | 21 | WHPA-A WHPA-B |
| 4 | Handling and Storage of Agricultural Source Material | 8 | WHPA-B |
| 8 | Application of Commercial Fertilizer | 17 | WHPA-B |
| 9 | Handling and Storage of Commercial Fertilizer | 8 | WHPA-B |
| 10 | Application of Pesticides to Land | 21 | WHPA-A WHPA-B |
| 11 | Handling and Storage of Pesticides | 8 | WHPA-B |
| 16 | Handling and Storage of Dense Non-Aqueous Phase Liquids | 9 | WHPA-A WHPA-B WHPA-C |
| 17 | Handling and Storage of Organic Solvents | 7 | WHPA-A WHPA-B |
| 21 | Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation (Grazing and pasturing) | 8 | WHPA-B |
| **Total Number of Activities** | | **151** | |
| **Total Number of Properties** | | **52** | |

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Residential handling and storage of fuel threats were not enumerated as significant threats due to Natural gas service being provided to the Township of Guelph-Eramosa in 2000. Further, polices must be created in order to address potential fuel storage tanks remaining on residential properties.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

***Significant Drinking Water Threats for the Hamilton Drive Water Supply***

As per the Technical Rules (MOECC, ~~2009b~~2017), the enumeration of significant threats is required for the completion of the Assessment Report. **Table 6-41** summarizes the significant threats identified in the Hamilton Drive Wellhead Protection Areas.

**Table 6-43: Significant Drinking Water Quality Threats for the Hamilton Drive Water Supply System**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 1 | Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites | 2 | WHPA-A |

**Table 6-43: Significant Drinking Water Quality Threats for the Hamilton Drive Water Supply System**

| PDWT[1] # | Threat Subcategory[2] | Number of Activities | Vulnerable Area |
|---|---|---|---|
| 2 | Sewage System or Sewage Works- ~~Septic~~ Onsite Sewage Systems | 23 | WHPA-A WHPA-B |
| 3 | Application of Agricultural Source Material to Land | 1 | WHPA-B |
| 8 | Application of Commercial Fertilizer | 1 | WHPA-B |
| 10 | Application of Pesticides to Land | 1 | WHPA-B |
| 16 | Handling and Storage of Dense Non-Aqueous Phase Liquids | 3 | WHPA-A WHPA-B |
| 17 | Handling and Storage of Organic Solvents | 2 | WHPA-A |
| **Total Number of Activities** | | **33** | |
| **Total Number of Properties** | | **27** | |

*1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*

*Note: Residential handling and storage of fuel threats were not enumerated as significant threats due to Natural gas service being provided to the Township of Guelph-Eramosa 2000. Further, polices must be created in order to address potential fuel storage tanks remaining on residential properties.*

*2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

*Note: Storm sewer piping is not considered to be part of a storm water management facility.*

***Limitations and Uncertainty for the Enumeration of Significant Drinking Water Quality Threats for the Rockwood and Hamilton Drive Well Supply***

In this study a number of databases were used to create the threats enumeration. All databases have an error associated with them, whether it applies to the spatial or attribute information. The accuracy of the databases used depends on the source, the age of the information and the scale at which the spatial information was recorded. To decrease some of the error in the database information a field reconnaissance was completed to confirm the data when possible. Therefore, the uncertainty associated with the location of threats is predominantly low since most were field verified.

**Commented [KD2]:** This section should be moved to the initial enumeration section once the new enumeration is completed and a new limitations section is added. In the new enumeration section, we need to add a limitation about the vulnerability assessment not being updated to match the new understanding in the Tier 3 model.

The determination of land use activities used a series of assumptions which have an uncertainty associated to them. For this enumeration, it was assumed that any possible threats associated with an activity were present and that all potential chemicals were present. The circumstances and quantity for each threat were assigned based on available knowledge such as typical storage practices, typical chemical quantities and typical waste disposal practices for that particular land use activity.

Based on the uncertainty involved in the assumptions and data used, the uncertainty for the threats enumeration has been classified as high. This level of uncertainty is expected in a desk top study. It is anticipated that additional information that is collected over time will allow for the uncertainty related to the hazard rating to be reduced.

**Table 6-42** summarizes the uncertainty assessment for the enumeration of significant drinking water quality threats in the Rockwoods and Hamilton Drive Water Supply Systems.

**Table 6-44: Uncertainty Assessment for Enumeration of Significant Drinking Water Quality Threats in the Rockwood and Hamilton Drive Water Supply Systems**

| | Uncertainty Type | WHPA-A | WHPA-B | WHPA-C | WHPA-D |
|---|---|---|---|---|---|
| Rockwood Threats Uncertainty | Location of Threats | Low | Low | High | High |
| | Circumstances of threats | High | High | High | High |
| | Overall – Threats Uncertainty | High | High | High | High |
| Hamilton Drive Threats Uncertainty | Location of Threats | Low | Low | Low | Low |
| | Circumstances of threats | Low | High | High | High |
| | Overall – Threats Uncertainty | Low | High | High | High |