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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).

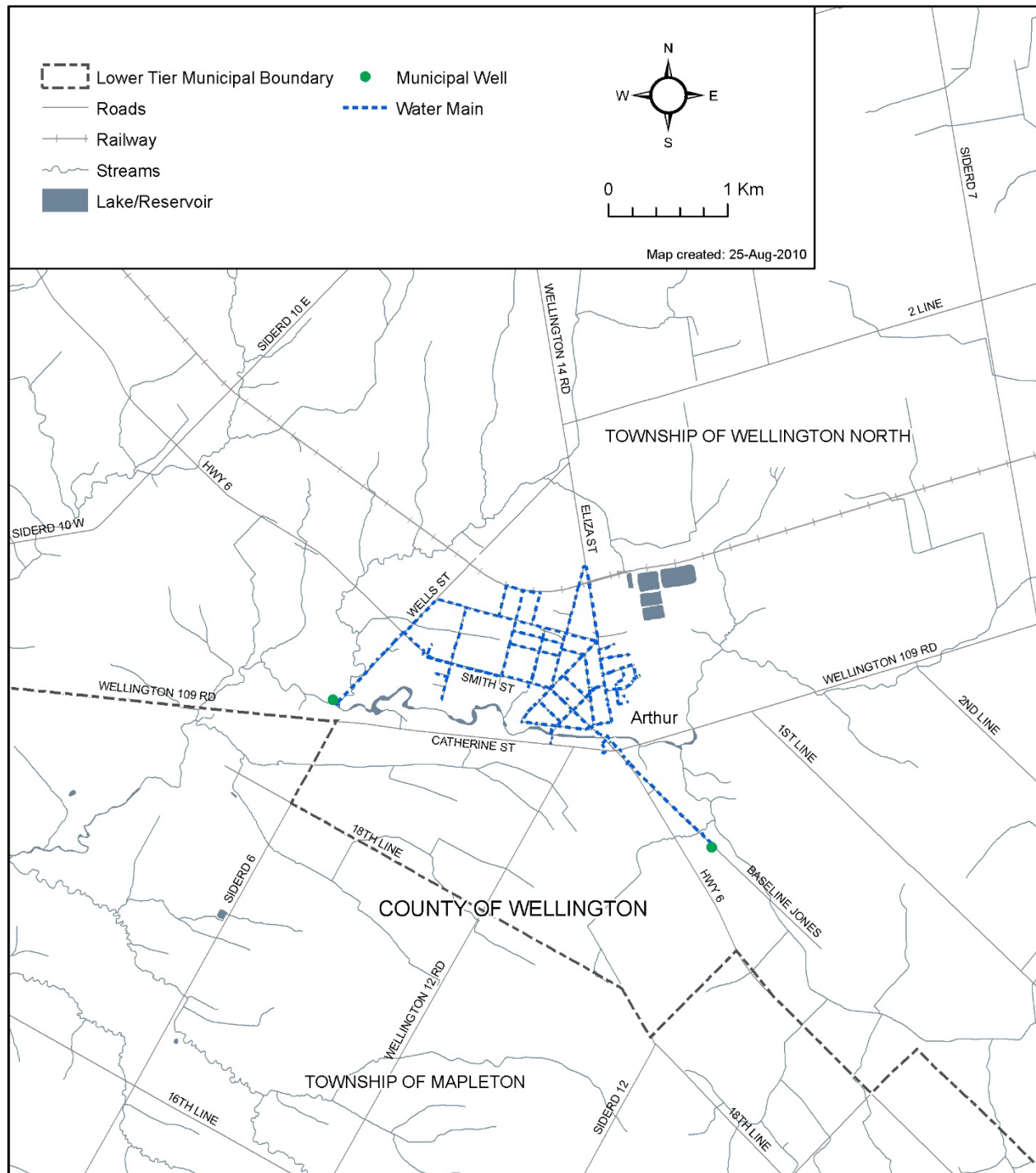
The Town of Arthur is currently serviced by three municipal production wells: 7B, 8A, and 8B. The wells are completed in a deep overburden aquifer at approximately 46 m below ground surface. The upper surficial Quaternary geology is mapped as a clayey silt to silt till (Tavistock Till) which covers a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

Well 7B is located to the west of Arthur along Highway 109; Wells 8A and 8B are located to the south of Arthur in a rural setting as shown on **Map 6-2**. The following tables, **Table 6-1** and **Table 6-2** provide a summary of Arthur's 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 Classification¹	Number of Users served²
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 <i>Safe Drinking Water Act, 2002</i> .					
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. Taking¹ (m³/d)	Monthly Average Taking¹ (m³/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 Arthur municipal water supply represent the areas within the aquifer that contribute groundwater to the municipal wells over a specific time period. Four WHPAs have been mapped for the Arthur wells, one is a proximity zone and the others are time-related capture zones:

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

A WHPA-E and WHPA-F were not delineated for the Arthur municipal wells as they are not considered to be under the direct influence of surface water (GUDI).

Arthur Wellhead Protection Areas

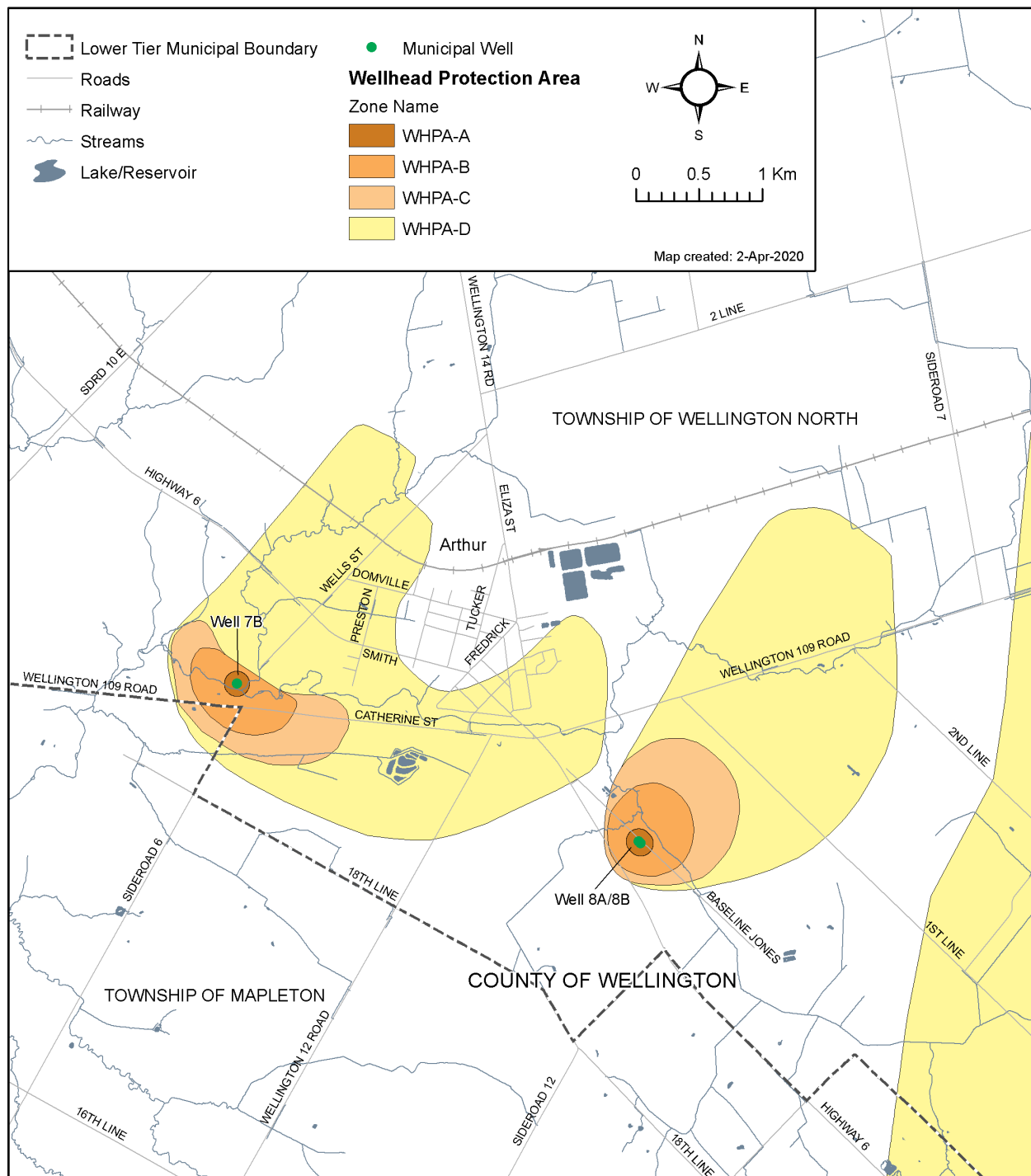
The current WHPAs for the Township of Wellington North were developed by Golder Associates in 2009 through the development of a numerical groundwater flow model. The WHPAs for the Arthur Well Supply are presented on **Map 6-2**.

There are two distinct WHPAs for the Arthur 7B and Arthur 8A/B wells. The WHPA-D for Well 7B extends northeast encircling the urban footprint of Arthur, which is serviced by municipal sanitary sewers, and has a total land area of approximately 6.16 km². The land with the Well 7B's WHPA-D 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 WHPA-D 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 WHPAs, and are approximately 50 m from Well 7B and 200 m from Wells 8A/B. Land use within the WHPAs is primarily rural agricultural, although Well 7B's WHPA-D encroaches into the urban area. A few private septic systems and storm water infiltration features were identified within the WHPA-B, and several water wells are mapped throughout the WHPAs. Two historic waste disposal sites were also identified in Well 7B's WHPA-D.

Projected pumping rates for Arthur Wells 8A/B are approximately 350 m³/day greater than for Arthur Well 7B. However, due to the nature of the groundwater flow paths, Wells 8A/8B's WHPA-D has a total land area of approximately 4.74 km², which is slightly less than the Well 7B's WHPA-D.

Map 6-2: Arthur Well Supply Wellhead Protection Areas



Modelling Approach for the Arthur Well Supply

WHPAs for Arthur's municipal wells were delineated using numerical groundwater flow models. This involved the refinement of a time of travel analysis completed as part of the 2001 MOE Groundwater Studies Initiative (Conestoga Rovers and Associates, 2007 and 2009).

With the exception of WHPA-A, which was based solely on the proximity to the well or well field, the shape of the time of travel capture zones used to delineate the WHPAs were 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 initially mapped in 2005 were refined in 2009 using surveyed well locations, updated operational schedules (current to 2009), and updated forecasted pumping rates that accounted for future growth within each WHPA. 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.

The Aquifer Vulnerability Index (AVI) was used to categorize areas of intrinsic groundwater vulnerability as high, medium, or low on a regional scale. The AVI method 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 are regionally-derived products based largely on water well records, local geology and other hydrogeological data.

Vulnerability Scoring for the Arthur Wellhead Protection Areas

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

Each WHPA 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 WHPA, providing a relative indication of the intrinsic susceptibility of the underlying aquifer to contamination from drinking water quality threats. The intrinsic vulnerability is shown on **Map 6-3**.

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 the current study were used as a starting point to identify transport pathways within each WHPA. Available water well record databases, provincial and municipal mapping, aerial photography, and other source mapping data were reviewed to determine the location of these features. Additional databases were also used to identify transport pathways including: 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-

served 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 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 identified within the Arthur WHPAs are shown on **Map 6-4**.

Adjusted Vulnerability Scoring for the Arthur Wellhead Protection Areas

Four factors are 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 provided a general indication of the aerial extent across which the vulnerability modifier should be applied, while the density of the constructed pathways provided 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.

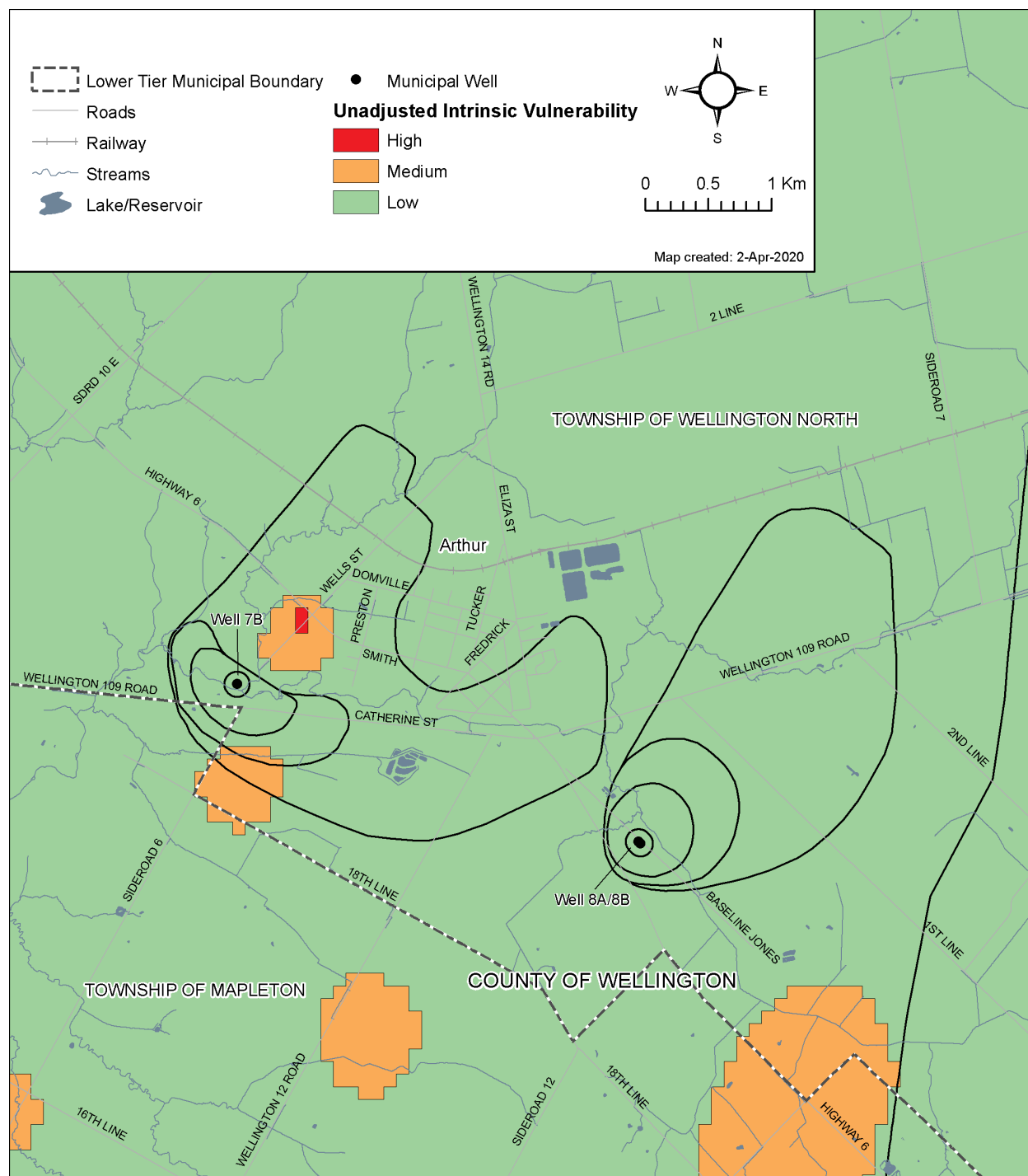
Since septic and sanitary sewer systems and infrastructure were only identified within the WHPA-B, only those areas within the WHPA-B with an initial vulnerability score of less than 10 were selected for a transport pathway score adjustment. The transport pathway areas of influence are shown on **Map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

Adjusted Vulnerability Scoring for the Arthur Wellhead Protection Areas

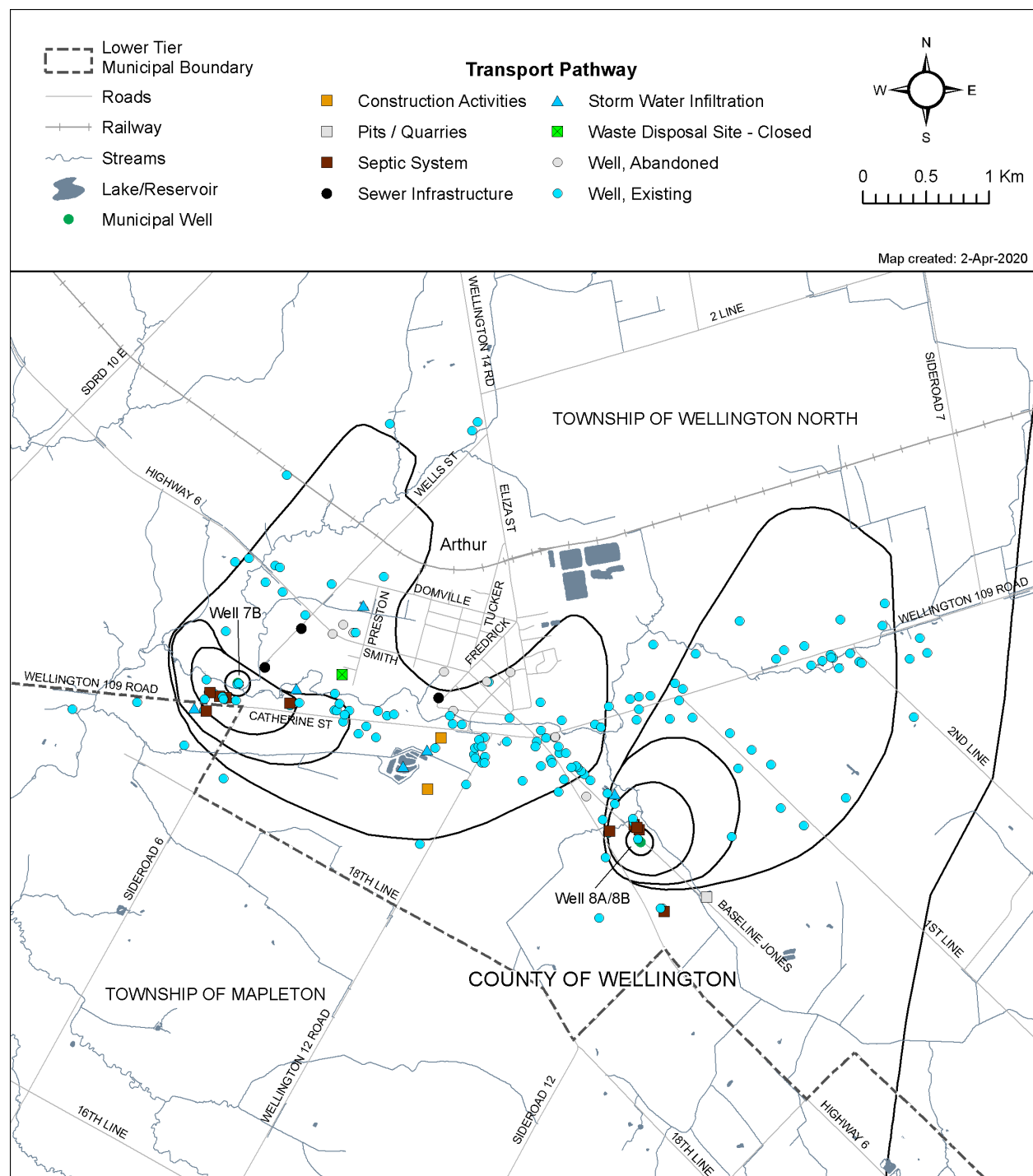
Uncertainty in the Wellhead Protection Area Delineation and the Vulnerability Scoring for the Arthur Well Supply

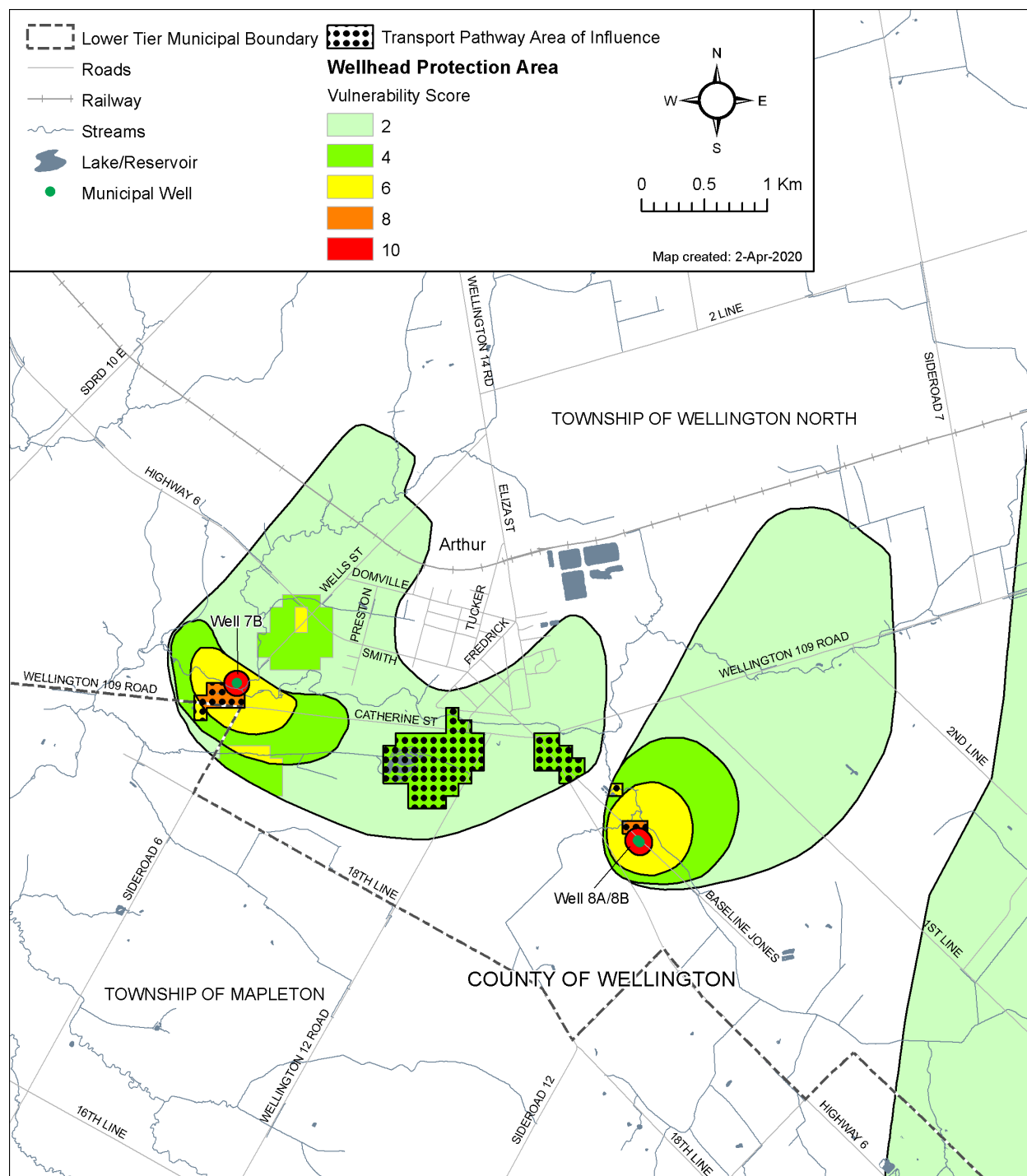
Data errors and data gaps are likely present in the information collected and thus the level of certainty is limited by the quality and completeness of the information available at the time the work was performed. Uncertainty associated with the regional aquifer vulnerability index mapping as part of 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.

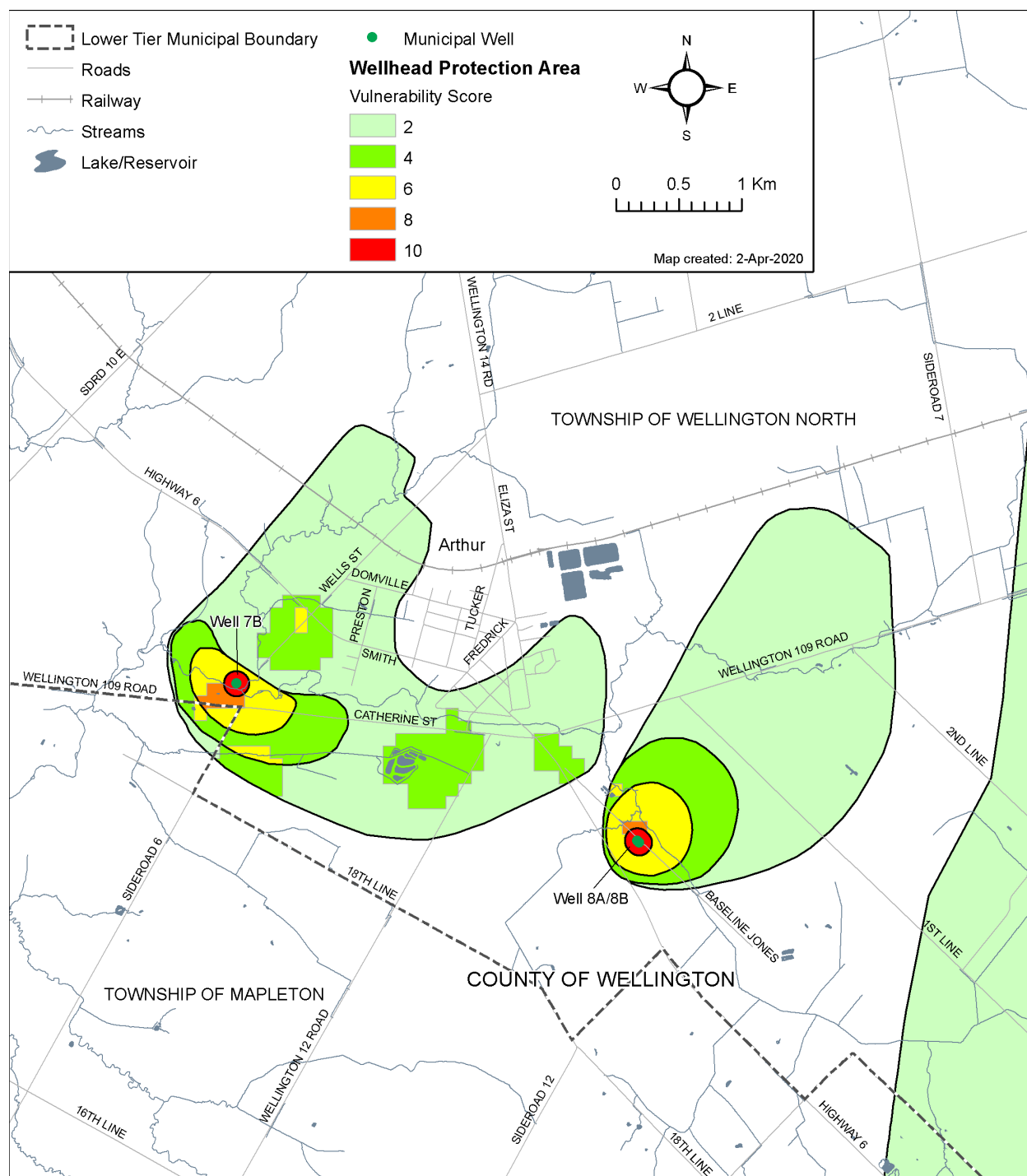
Map 6-3 Arthur Well Supply Unadjusted Intrinsic Vulnerability



Map 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: 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) (MOECC, 2017) with details outlined in Chapter 3 of this Assessment Report. The percentage of managed lands was only calculated where the vulnerability score in each WHPA was 6 or greater.

The results of the calculations for managed lands are provided in **Table 6-3** and **Map 6-7**, 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	18.88%	47.72%	83.12%	50.64%
		8A/8B	79.39%	96.11%	4.87%	N/A

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.

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

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	0	0
		8A/8B	2.59	0.801	0	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

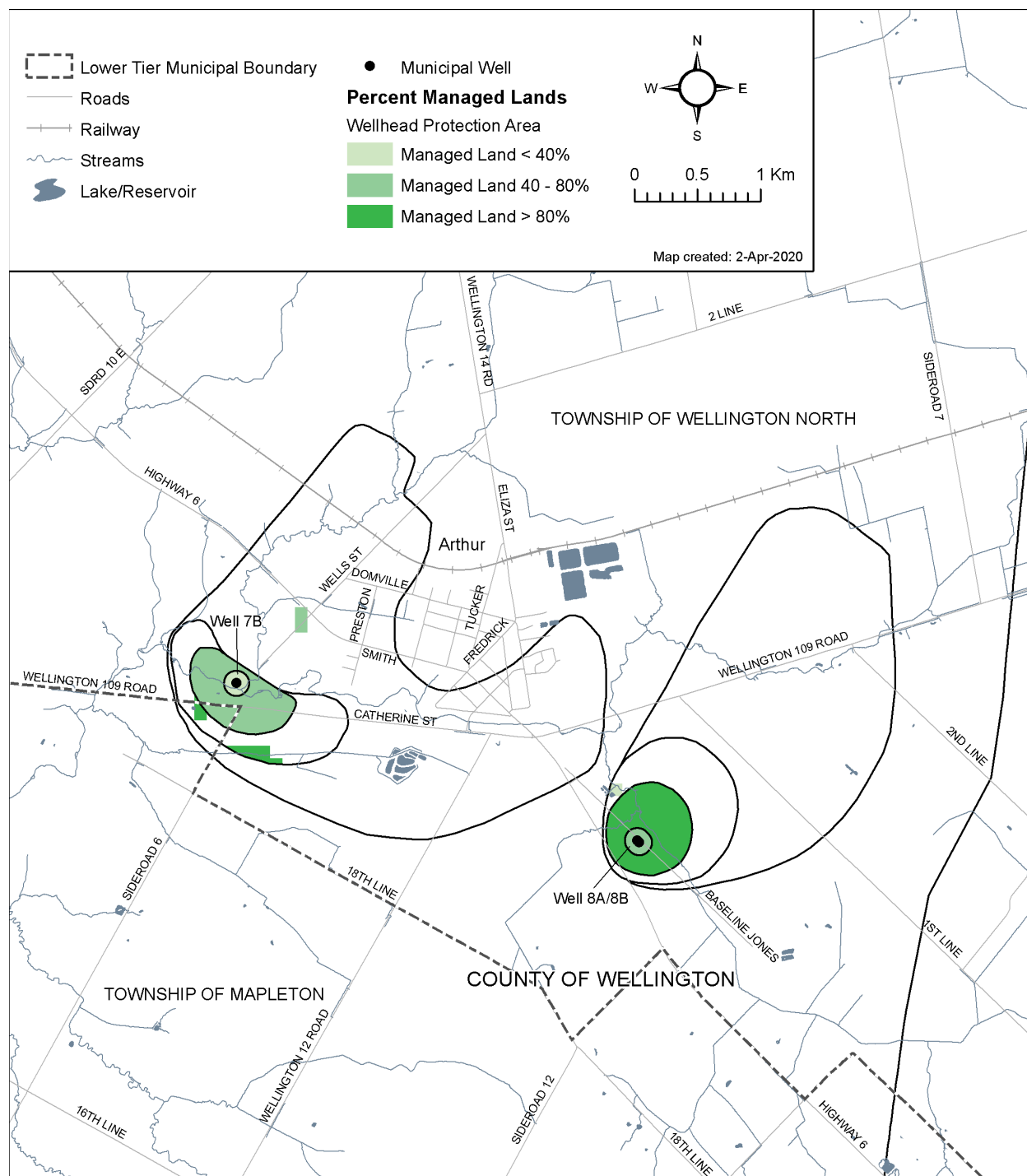
Some default values were used for estimating NAML based on the air photo interpretations and for ease of calculating. Roads generally had right-of-ways that were about 50% of the parcel size

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.

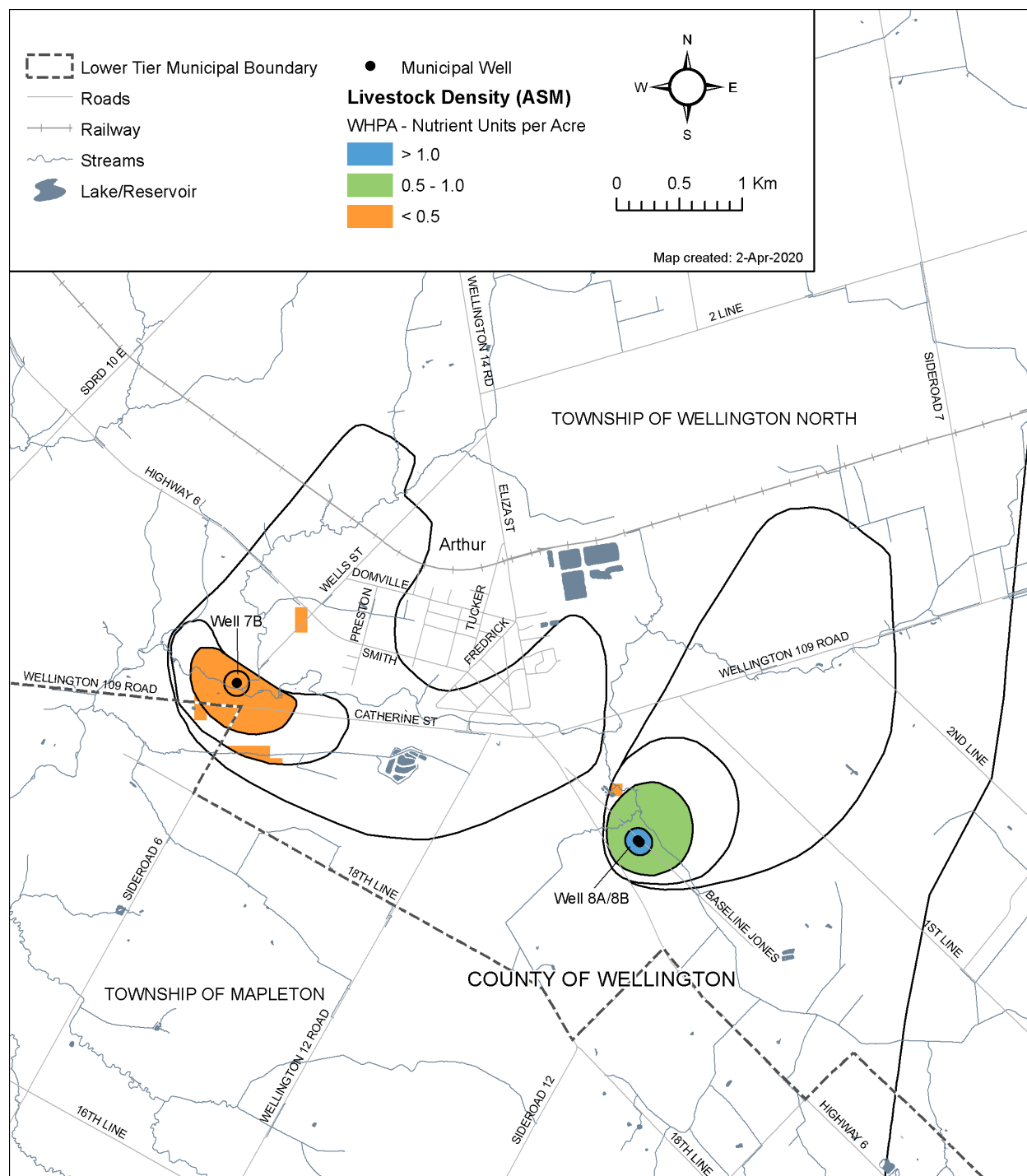
Percent Impervious Surface Area within the Arthur Wellhead Protection Areas

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

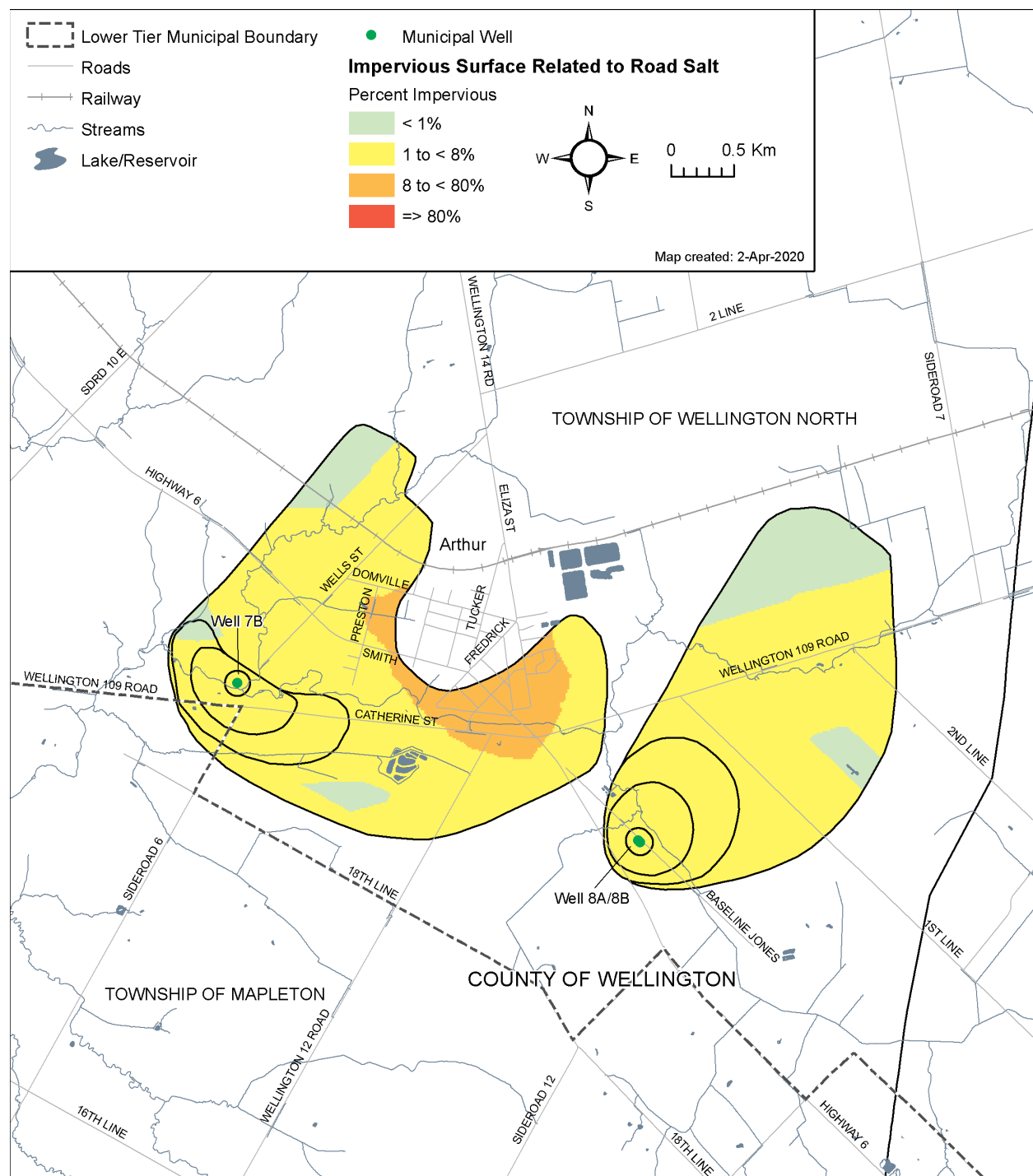
Map 6-7 : Arthur Well Supply Percent Managed Lands



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 determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 6-5 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 6-5: 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 WHPA that have the potential to contaminate 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 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 6-6**. 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 6-6: 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 (MOECC, 2017).

Summary of Water Quality Issues Evaluation for the Arthur Well Supply

A total of four parameters listed in **Table 6-6** (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 WHPAs included the following: windshield surveys; government databases; assessment information; aerial photography; discussions with municipal representatives; ERIS; and MPAC property codes.

Significant Drinking Water Quality Threats in the Arthur Wellhead Protection Areas

Table 6-7 summarizes the total number of significant pathogen, chemical, and DNAPL threats identified within each vulnerable area.

Table 6-7: Significant Drinking Water Quality Threats in the Arthur Wellhead Protection Areas			
PDWT¹ #	Threat Subcategory²	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- 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
1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).			

Table 6-7: Significant Drinking Water Quality Threats in the Arthur Wellhead Protection Areas

PDWT ¹ #	Threat Subcategory ²	Number of Activities	Vulnerable Area
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 are treated 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 m³/min and the daily amount is not to exceed 3,927 m³/day. As required by the PTTW 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 treated 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 m³/day (Burnside, 2009b). As part of the PTTW, a monitoring program has been established and results are reported annually to the MECP. Two monitoring wells known as the Yard Well and Lounabury Well are included in this program.

Map 6-10: Township of Mapleton Serviced Areas

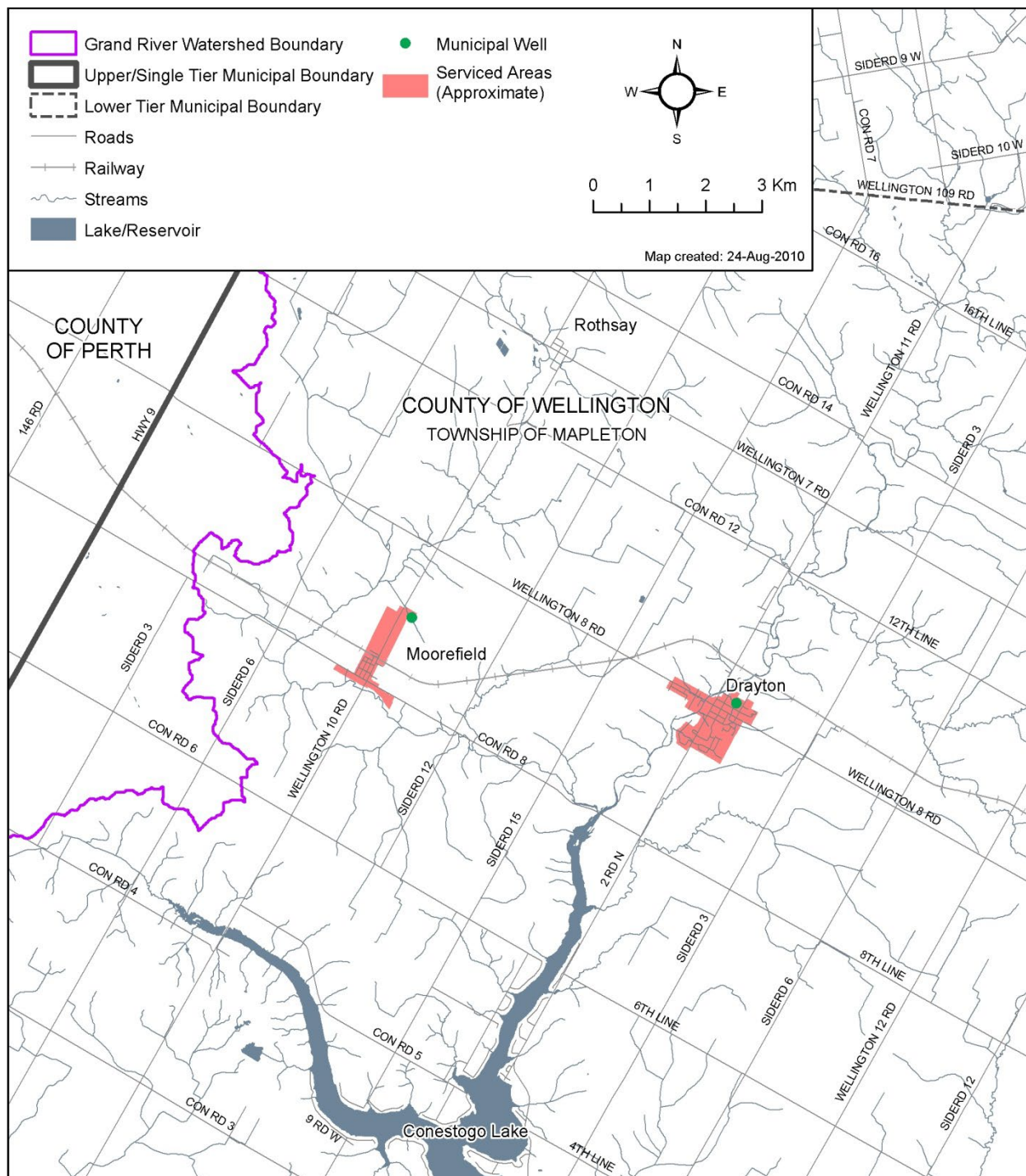


Table 6-8, Table 6-9 and Table 6-10 summarize the municipal groundwater systems and pumping rates for both the Drayton and Moorefield Well Supply systems within the Township of Mapleton.

Table 6-8: 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 6-9: 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 Classification¹	Number of Users Served²
220004064	Drayton Well Supply	OCWA	GW	Large Municipal Residential System	1,550
260069732	Moorefield Well Supply	OCWA	GW	Large Municipal Residential System	550
¹ as defined by O. Reg. 170/03 (Drinking Water Systems) made under the <i>Safe Drinking Water Act</i> , 2002.					
² Drayton and Moorefield 2009 Annual Reports (O.Reg 170/03)					

Table 6-10: Annual and Monthly Average Pumping Rates for Mapleton Municipal Residential Drinking Water Systems in the Grand River Region													
Well or Intake	Annual Avg. Taking¹ (m³/d)	Monthly Average Taking¹ (m³/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 (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 WHPAs are mapped; one is a proximity zone and the others are 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 WHPAs as part of their previous groundwater management study (Golder, 2006a). The WHPAs 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 6-11**.

Table 6-11: 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 Moorefield Wellhead Protection Areas

As the Moorefield and Drayton municipal wells are not classified GUDI, 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

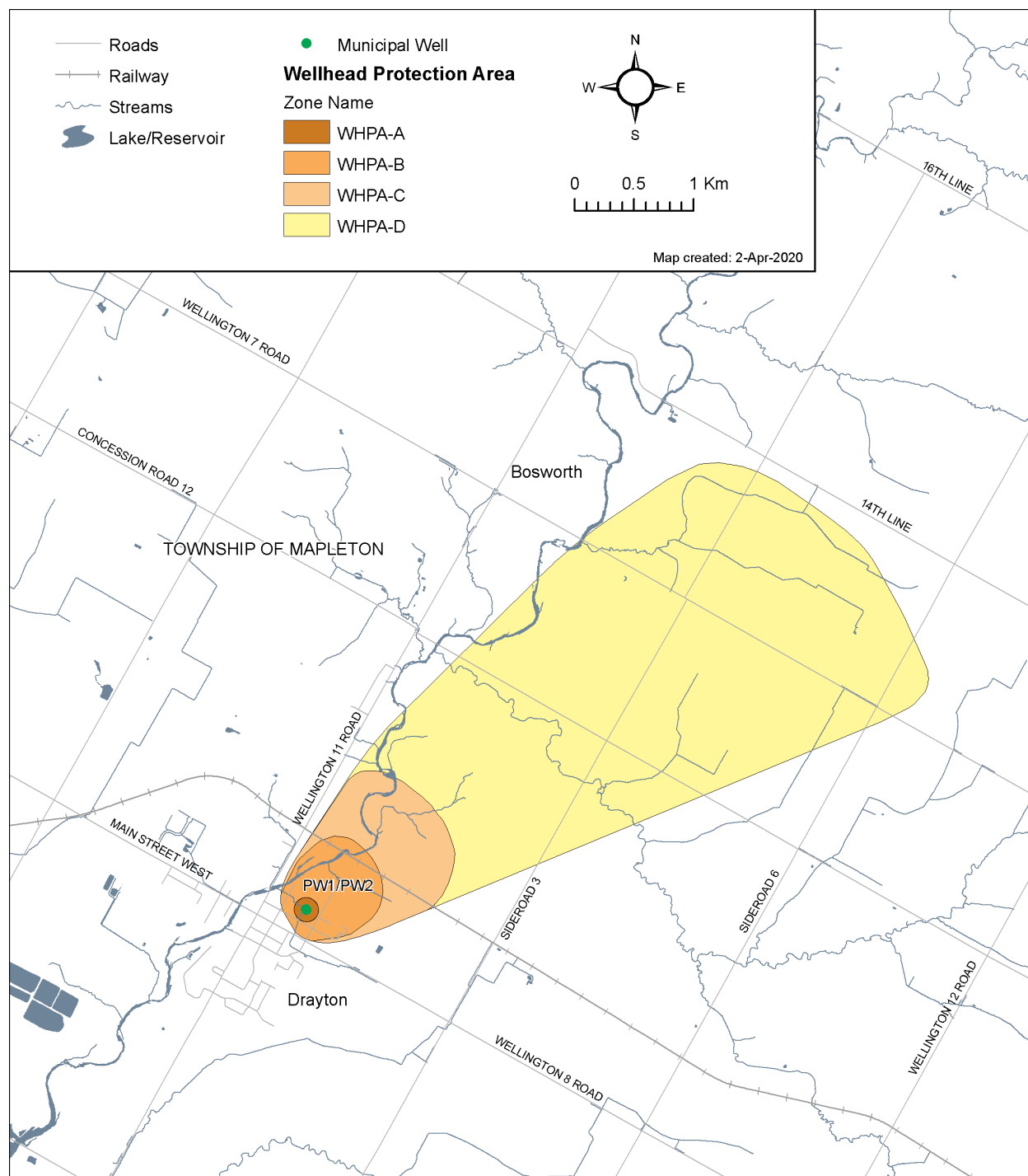
The delineation of the WHPAs for the Drayton and Moorefield municipal wells was completed as a part of the Wellington County Groundwater Protection Study, 2006 through the use of a MODFLOW groundwater model. The model was based on a number of simplifying assumptions that incorporate some level of uncertainty 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.

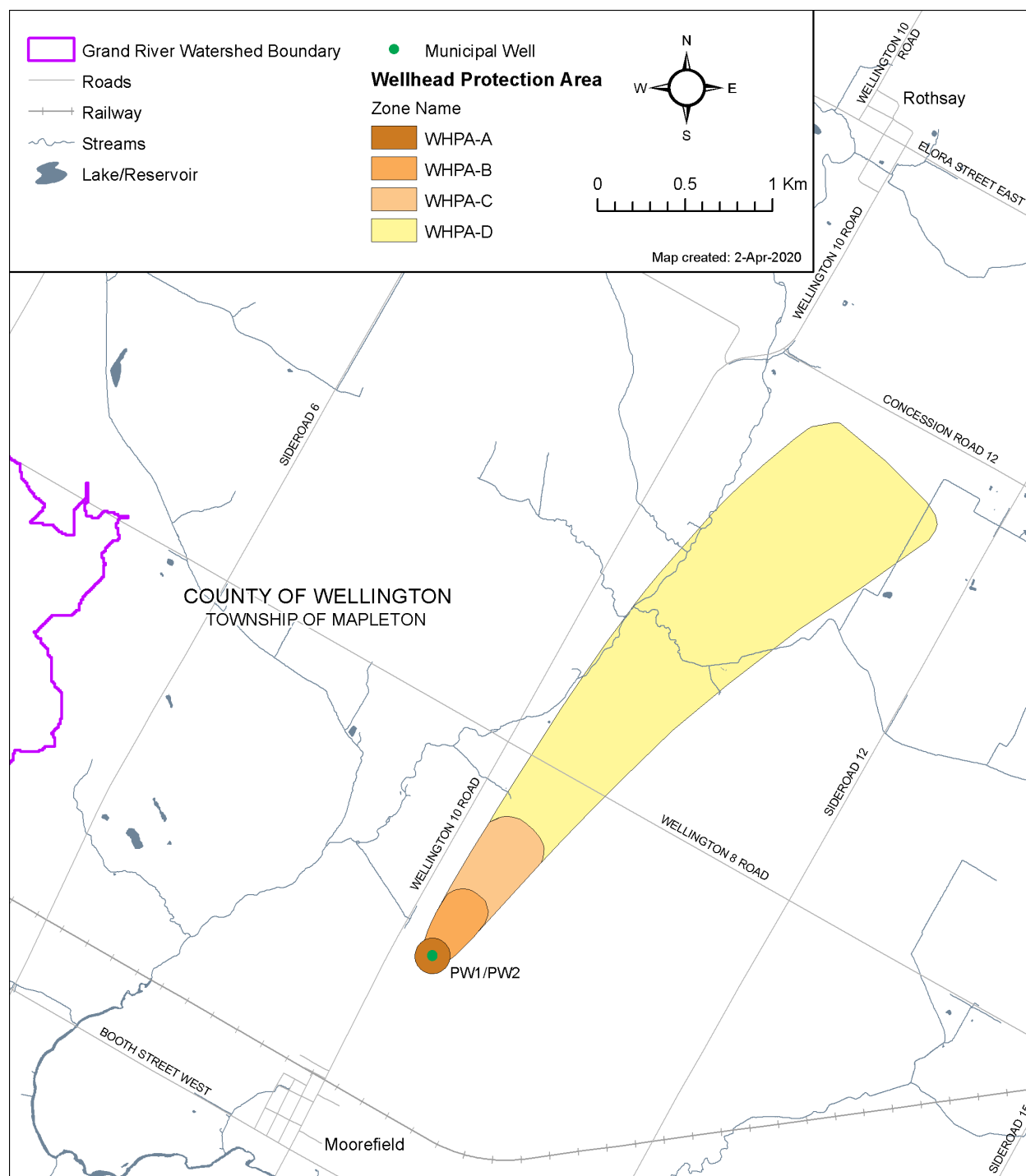
Uncertainties within the model were associated with limitations in the availability of subsurface information and could be related to projected variability in the aquifer properties (e.g. hydraulic conductivity; porosity) or uncertainties with the conceptual model (e.g. groundwater-surface water interactions; location of flow boundaries; recharge rates; continuity in aquitards; direction of regional groundwater flow). To account for some of these uncertainties, a 'factor of safety' was applied to the WHPAs in terms of the capture zones' width and length. Capture zone length was 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 to increase the width of the capture zones at increasing distances from the pumping well. This reflected 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 WHPAs the uncertainty of the delineations was 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

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.

Vulnerability mapping using the SAAT method was completed for most of the Grand River watershed (Earthfx, 2008). The regional mapping was reviewed on a local scale in the vicinity of the municipal 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 intrinsic vulnerability for Drayton and Moorefield are shown on **Map 6-13 and Map 6-15**.

Within WHPAs, the vulnerability score was determined based on overlaying the aquifer vulnerability classification (high, medium, low) with the defined WHPAs. The vulnerability scoring was completed in accordance with Rule 82 of the Technical Rules. Vulnerability scores ranged from 10 for areas with the highest vulnerability to 2 for areas with low vulnerability. A summary of the process used to define vulnerability scores is outlined in Chapter 3 of this Assessment Report.

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 Moorefield Well Supply Systems

The vulnerability assessment was completed using the SAAT method. The SAAT calculation was based on a number of empirical formulae provided in past guidance documents from the MECP. 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 comprised of two components; the unsaturated zone advection time (UZAT) and the water table to aquifer advection time (WAAT). Both components were computed based on simplifying assumptions included in MECP provided formulae. It was noted that the UZAT was computed based on estimates for groundwater recharge derived from a GAWSER model. 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 indicated that there was 95.5 % certainty that the UZAT time calculated was within +/-42 years of the actual time at any well. This indicated that the variability of the UZAT value (margin of error) was 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 indicated 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 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 (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 in the Drayton and Moorefield Wellhead Protection Areas

A review of water well records from the MECP 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 32 water wells within the Drayton WHPAs and classified 18 of the wells as high risk wells. Five water wells were identified in the Moorefield WHPAs 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 is 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 WHPAs. There were no aggregate operations located within the WHPAs.

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

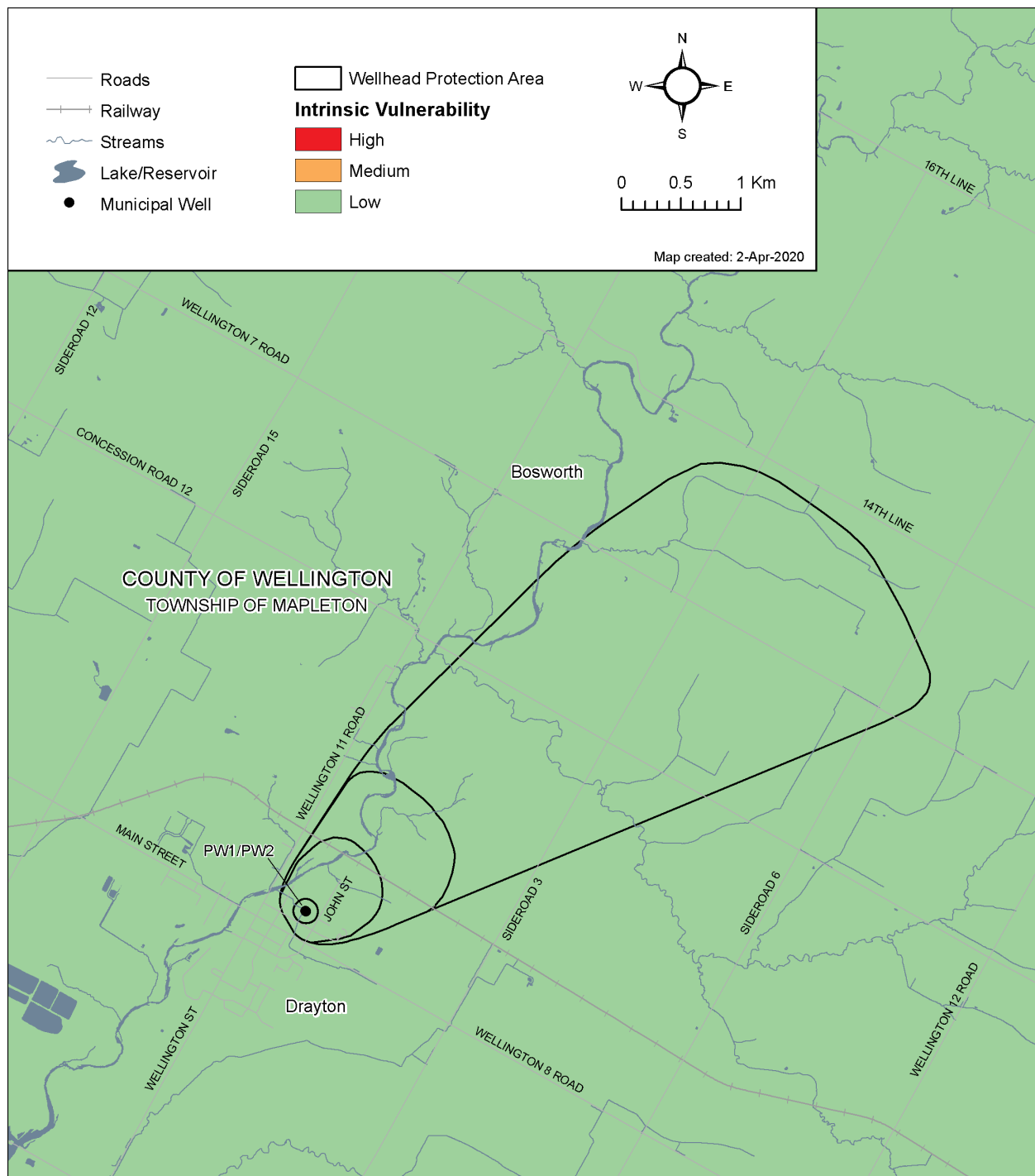
In the Drayton and Moorefield WHPAs the aquifer vulnerability was modified to consider increases in vulnerability due to transport pathways. In this area only well locations were considered to increase the vulnerability of an area. To decrease the uncertainty in the location and risk of the wells mapped, a field verification survey was completed. This survey sought to verify the location of wells included in the various WHPAs 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 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 was 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 of the Wellhead Protection Area (WPA) for the Municipal Well in Drayton, Ontario.

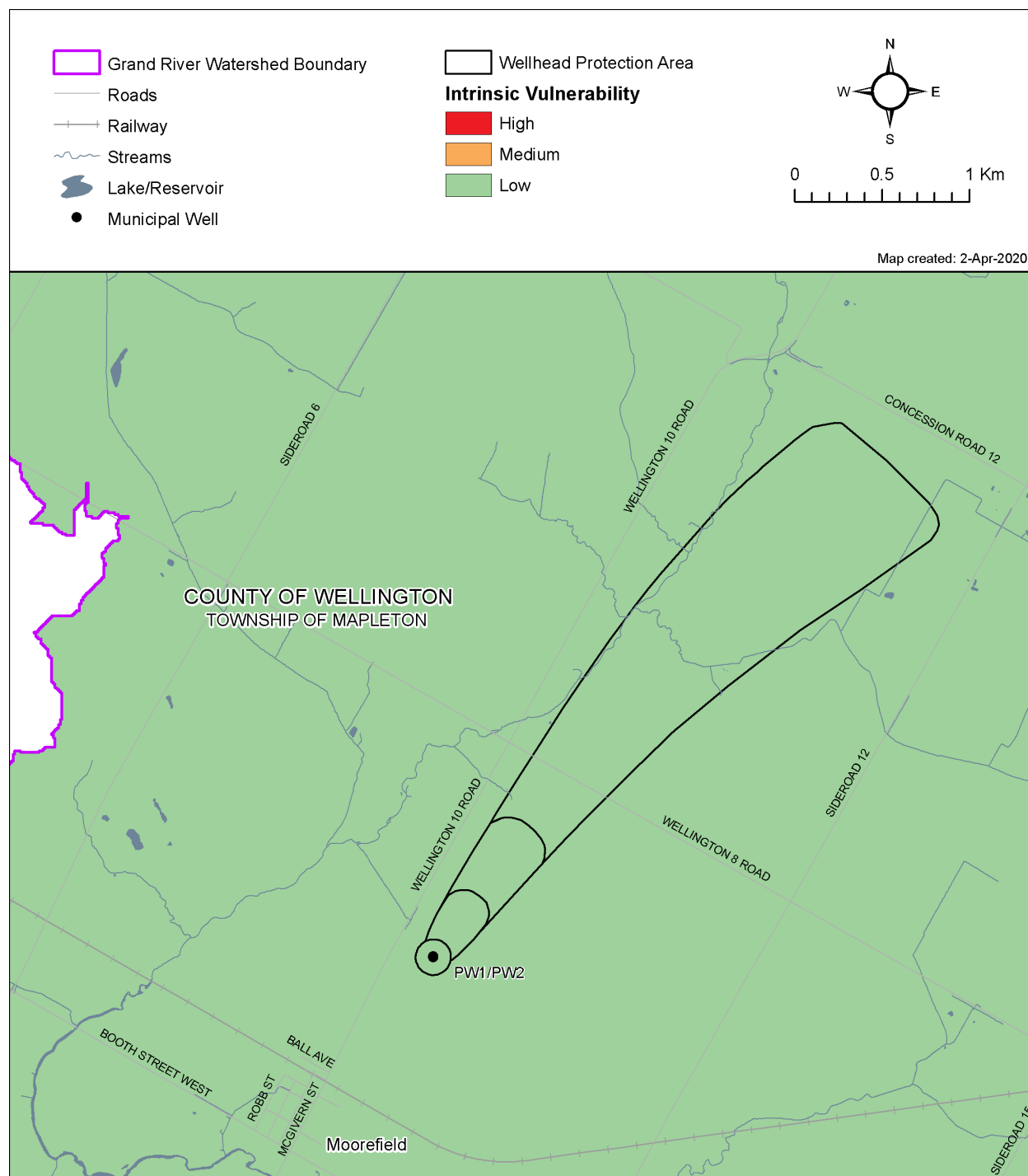
Legend:

- Roads
- Railway
- Streams
- Lake/Reservoir
- Municipal Well
- Wellhead Protection Area**
- Vulnerability Score**
 - 2
 - 4
 - 6
 - 8
 - 10

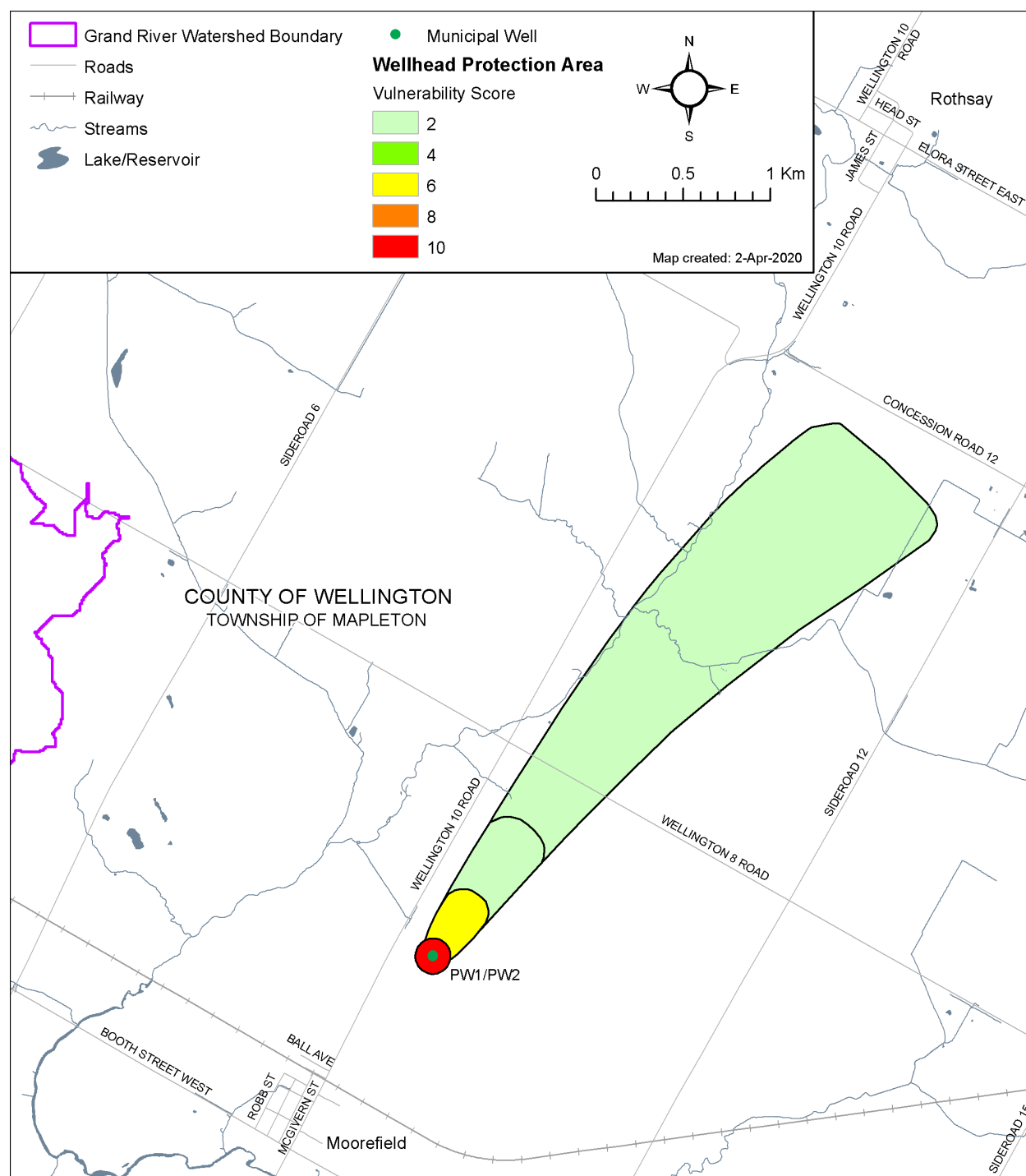
Map created: 2-Apr-2020

The map shows the WPA boundary, which is a large, irregularly shaped area shaded in light green. The WPA is centered on the Municipal Well, which is marked with a red dot and labeled 'PW1/PW2'. The map includes a legend for roads, railways, streams, lakes/reservoirs, and the WPA. It also features a north arrow and a scale bar (0 to 1 km). The map is titled 'Map created: 2-Apr-2020'.

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.

Calculation of the percentage of managed lands was done in accordance with Technical Rule 16(9) (MOECC, 2017) with details outlined in Chapter 3.

The results of the calculations for managed lands are provided in **Table 6-12**, **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 6-12: 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 of this Assessment Report.

The results of the calculations for livestock densities are provided in **Table 6-13**, **Map 6-19**, and **Map 6-20**, for the Drayton and Moorefield Wellhead Protection Areas.

Table 6-13: 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.

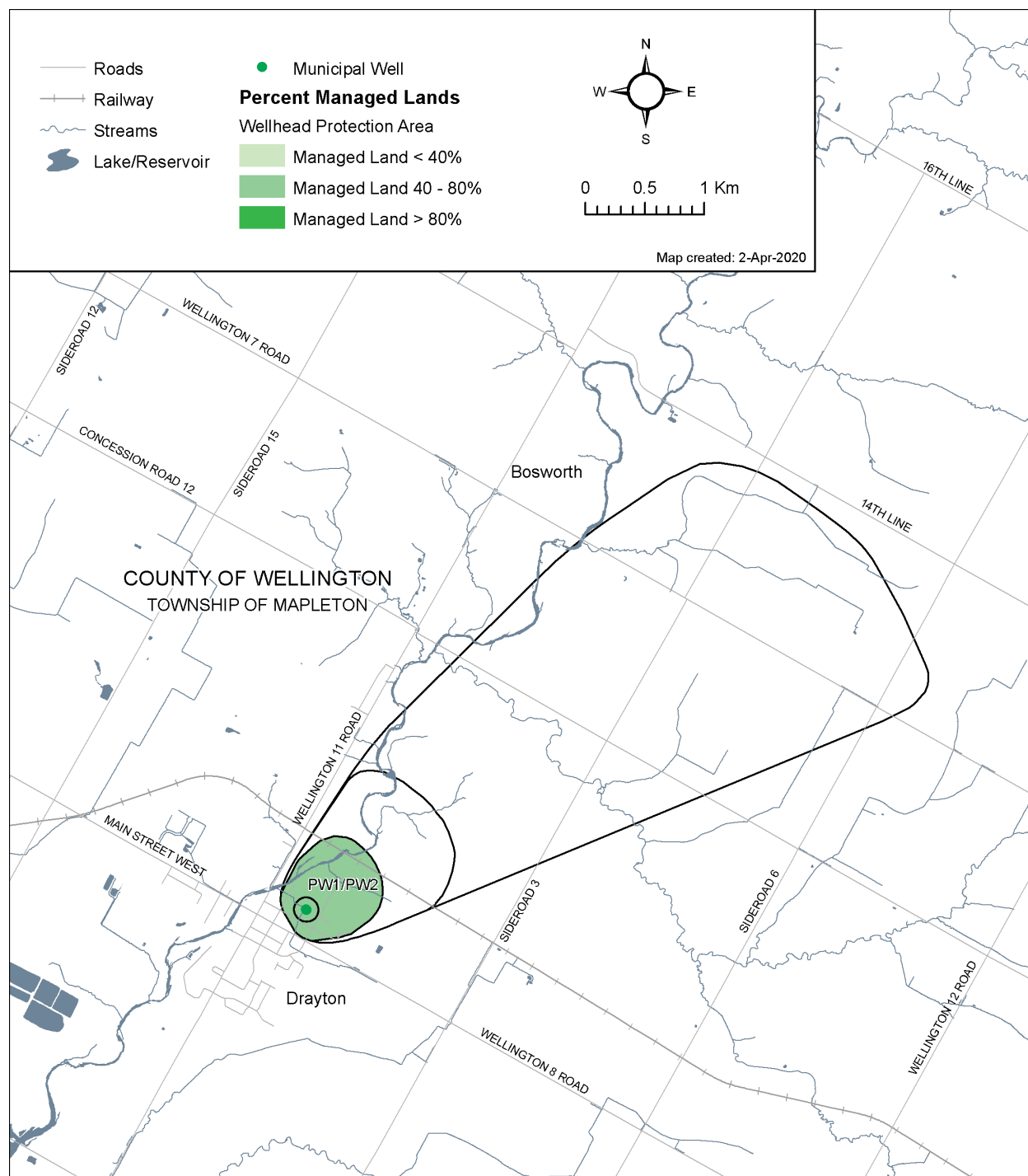
Percent Impervious Surface Area in Wellhead Protection Areas

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.

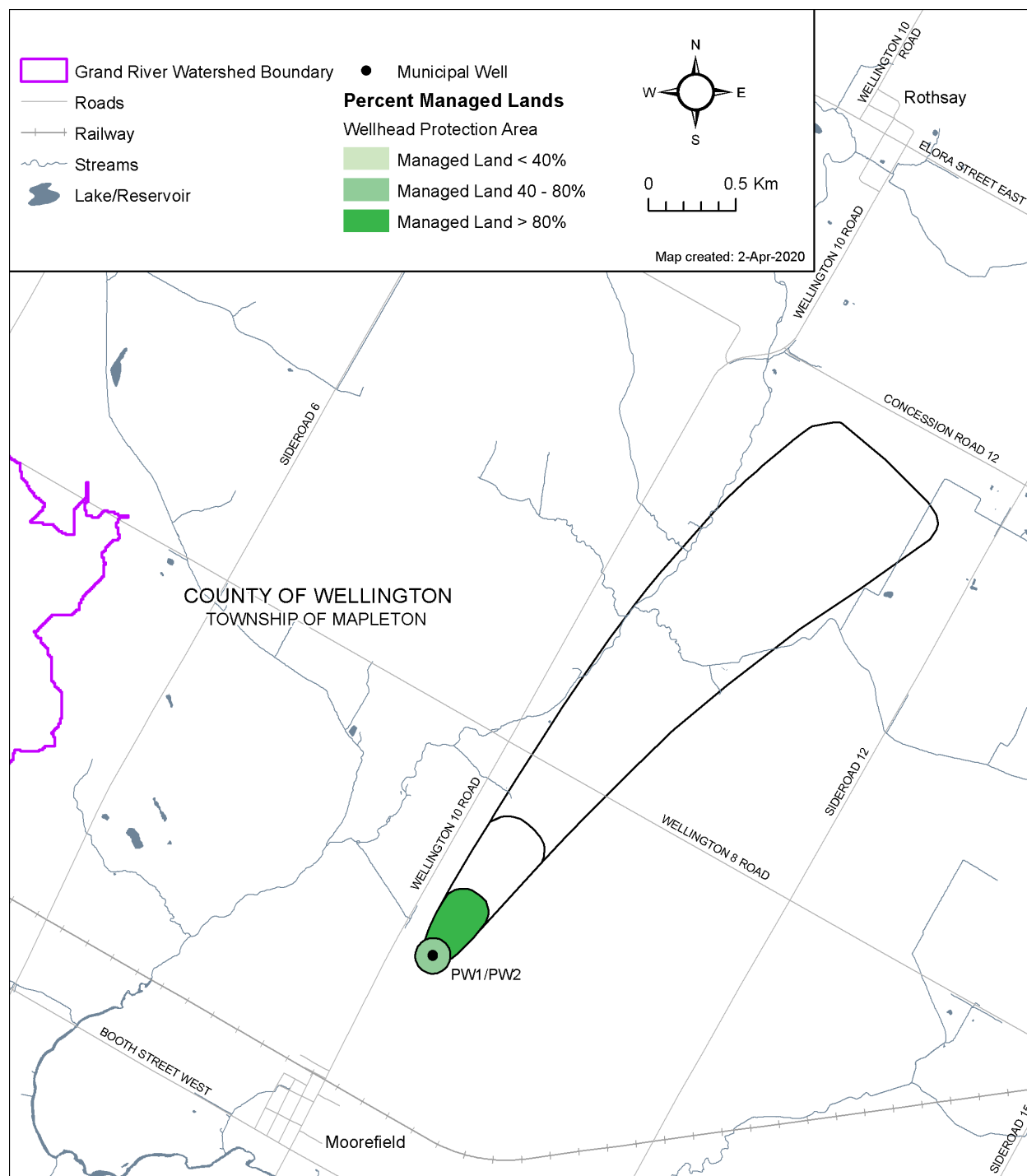
The 1 km x 1km grid method, described in Chapter 3 was used for Moorefield and Drayton wellfields. The application of road salt can only be a threat in areas with a vulnerability score of 6 or greater under the threats-based approach; therefore the percent impervious calculation was only completed in areas with a score of 6 or greater.

The 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**).

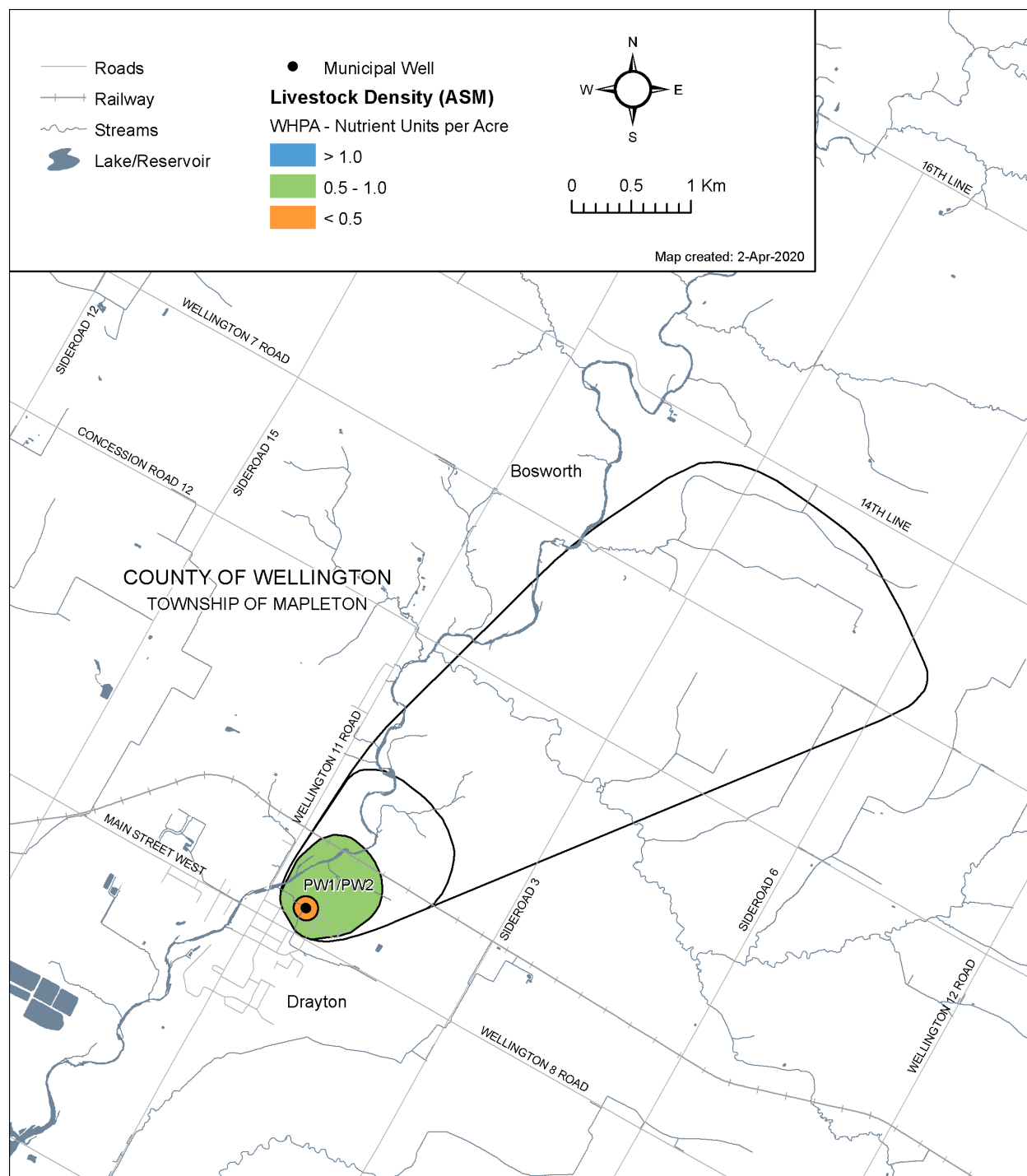
Map 6-17: Drayton Well Supply Percent Managed Lands



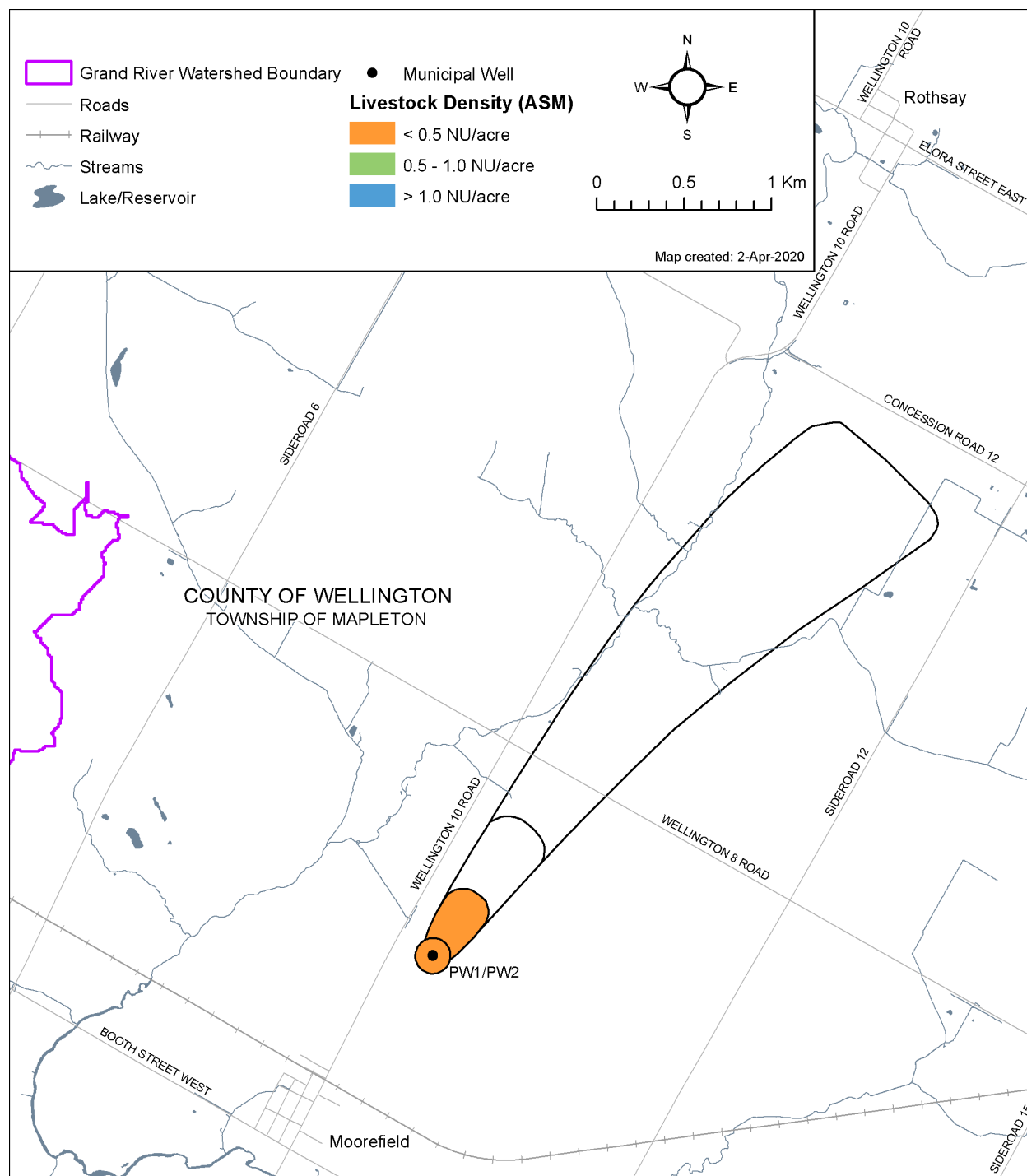
Map 6-18: Moorefield Well Supply Percent Manged Lands



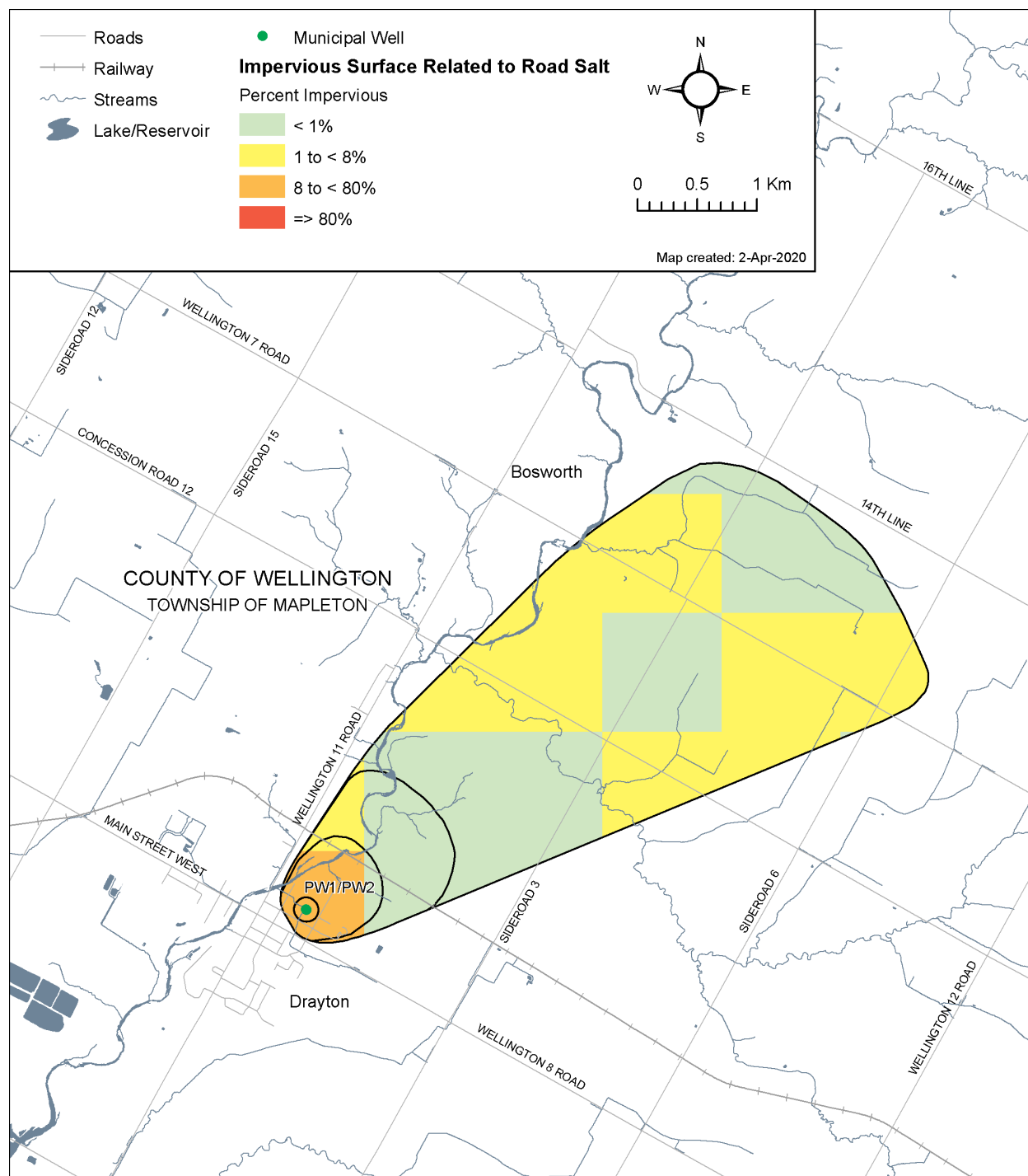
Map 6-19: Drayton Well Supply Livestock Density



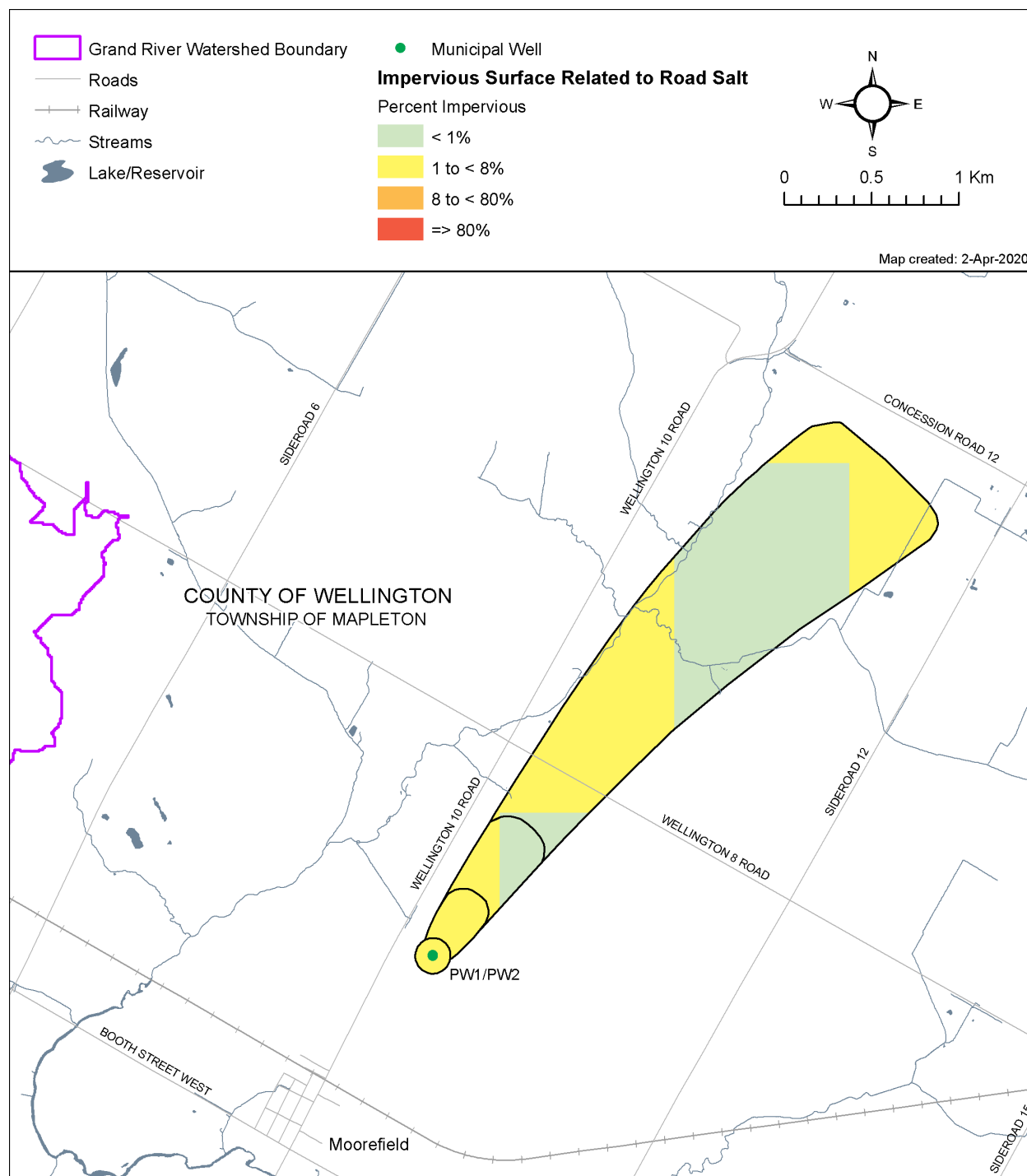
Map 6-20: Moorefield Well Supply Livestock Density



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 6-14 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 6-14: 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), 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 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 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 (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 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.

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 WHPAs 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 WHPAs.

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 m³/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 WHPAs are located on John Street, Wood Street, Robin Drive, Elm Street and Main Street (MOE, 2008a). There are no sanitary sewers within the Moorefield WHPAs. The sewage pumping station and lagoons are located outside of both of the Wellhead Protection Areas.

Septic Systems

Within the WHPAs, 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 WHPAs are generally used 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 WHPA 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 WHPAs during the site inspection. The Bosworth landfill is located within the WHPA-D but is no longer in operation.

Table 6-15 summarizes the significant drinking water quality threats identified in the Drayton Wellhead Protection Areas in Drayton.

Table 6-15: Significant Drinking Water Threats in the Drayton Wellhead Protection Areas			
PDWT¹ #	Threat Subcategory²	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- 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 WHPA-B
17	Handling and Storage of Organic Solvents	4	WHPA-A
Total Number of Activities		18	
Total Number of Properties		7	
<p>1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).</p> <p>2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.</p> <p>Note: Storm sewer piping is not considered to be part of a storm water management facility.</p>			

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 WHPAs 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 WHPAs, there are a total of five residential and/or farm properties.

Table 6-16 summarizes the significant threats identified in the Moorefield WHPAs in the Township of Mapleton.

Table 6-16: Significant Drinking Water Threats in the Moorefield Wellhead Protection Areas			
PDWT¹ #	Threat Subcategory²	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	
Total Number of Properties		3	
<p>1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).</p> <p>2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.</p> <p>Note: Storm sewer piping is not considered to be part of a storm water management facility.</p>			

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

The Township of Centre Wellington owns and operates the Centre Wellington Drinking Water System, as presented in **Table 6-17**. The system is entirely supplied by groundwater. The serviced area, which includes the communities of Fergus and Elora, is shown on **Map 6-23**. Approximately 20,600 residents utilize municipal water.

Table 6-17: 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 Classification¹	Number of Users served²
220000086	Centre Wellington Well Supply	Township of Centre Wellington	GW	Large Municipal Residential	20,600
¹ as defined by O. Reg. 170/03 (Drinking Water Systems) made under the <i>Safe Drinking Water Act, 2002</i> .					
² Centre Wellington Well Supply 2018 Annual System Reports (O.Reg 170/03)					

Elora Municipal Wells

Three bedrock wells, E1, E3, and E4, are located in Elora (**Table 6-18**).

Table 6-18: Municipal Production Wells in Elora					
Well	Well Field	Depth of Well (m)	Depth of Casing (m)	Purpose	Status
E1	Elora	130	19.8	Production	In Regular Use
E3	Elora	122	29.2	Production	In Regular Use
E4	Elora	128	25	Production	In Regular Use

The permitted water takings for each well are regulated by Permit to Take Water No. 2823-7QEH3C. A summary of the permitted taking and the rates used to delineate WHPAs for wells E1, E3, and E4 are summarized in **Table 6-19**.

Table 6-19: Municipal Production Wells Pumping in Elora		
Well	Permit to Take Water (L/day)	Rate Used to Delineate WHPA (L/day)
E1	1,740,960	1,500,000

E3	1,963,000	900,000
E4	1,227,000	1,200,000

Fergus Municipal Wells

Six bedrock wells, F1, F2, F4, F5, F6 and F7 (**Table 6-20**) are located in the vicinity of Fergus.

Table 6-20: Municipal Production Wells in Fergus					
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
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 is classified as GUDI (Groundwater Under the Direct Influence of surface water) as there is a potential for surface water from the Grand River to migrate to the well. Well F2 has not been used for municipal supply since June 2003 because 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).

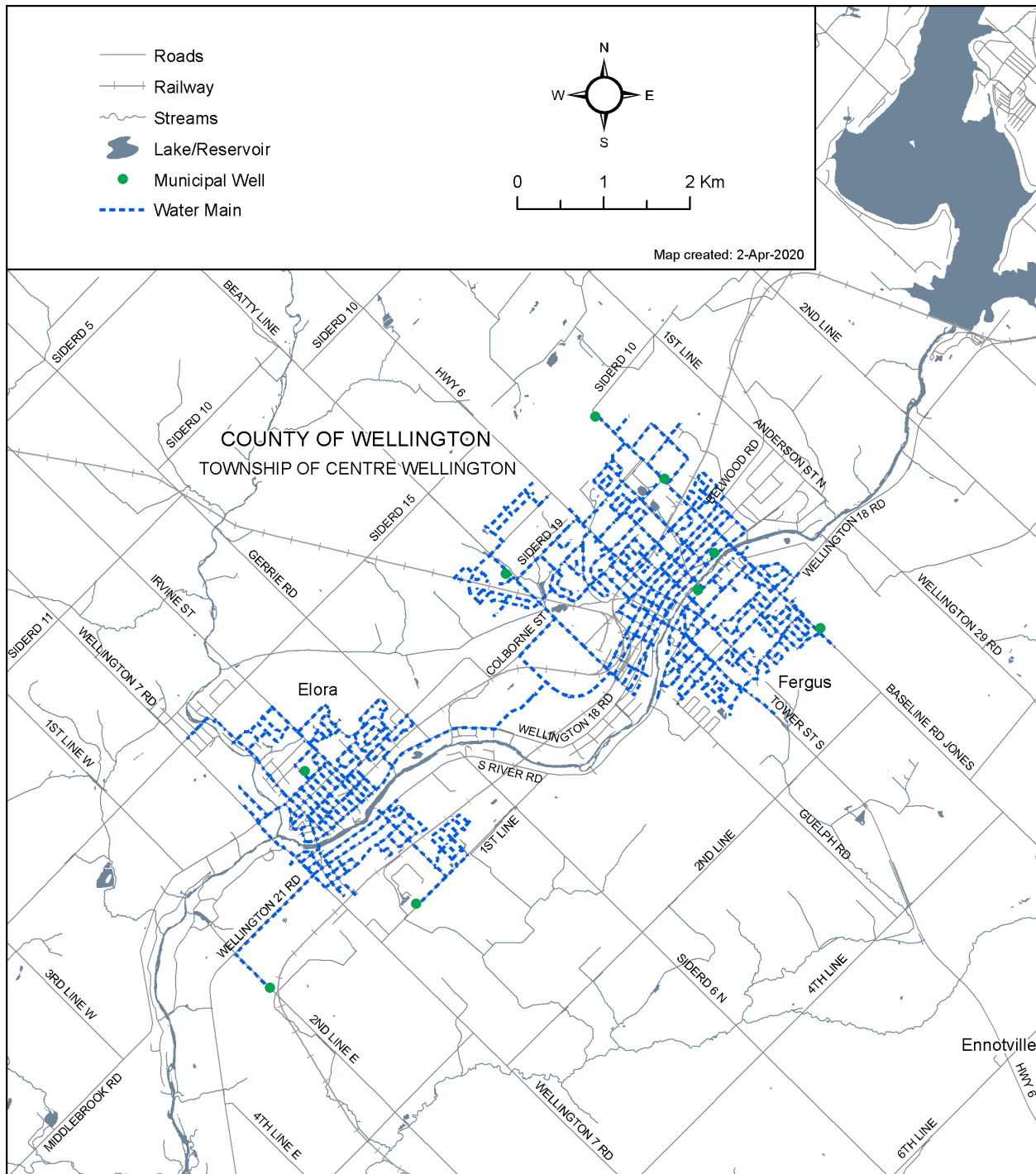
The permitted water taking for each well is regulated by Permit to Take Water No. 2823-7QEH3C. A summary of the permitted taking and the rates used to delineate WHPAs for wells in the Fergus area are summarized in **Table 6-21**.

Table 6-21: Municipal Production Wells Pumping in Fergus		
Well	Permit to Take Water (L/day)	Rate Used to Delineate Wellhead Protection Area (L/day)
F1	1,832,947	1,300,000
F2	490,140	400,000
F4	1,963,911	1,200,000
F5	1,963,872	1,000,000
F6	1,963,872	1,300,000
F7	1,962,000	1,600,000

Table 6-22 summarizes the 2018 average annual and 2018 monthly pumping rates for all wells in the Centre Wellington Well Supply.

Table 6-22: Annual and Monthly Average Pumping Rates for Centre Wellington Well Supply													
Well or Intake	Annual Taking¹ (m³)	Monthly Total Taking¹ (m³)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elora Well System													
E1	316,707	33,828	32,236	27,459	20,506	24,730	22,942	25,802	30,920	26,544	23,278	23,096	25,366
E3	264,474	22,198	26,743	24,926	21,064	20,888	21,442	24,732	22,859	21,929	19,285	20,413	17,995
E4	92,092	8,916	99	7,333	7,670	11,490	13,313	10,957	7,220	6,798	7,360	2,984	7,953
Fergus Well System													
F1	266,322	18,694	20,757	24,769	27,160	33,234	32,371	26,925	17,703	17,318	16,198	13,754	17,439
F4	373,135	27,601	25,944	27,219	19,652	20,615	26,522	34,055	35,520	39,203	40,491	38,014	38,300
F5	135,800	10,044	7,280	5,571	11,481	11,134	15,598	18,165	14,998	13,720	9,956	5,390	12,464
F6	188,777	28,193	18,668	18,487	8,143	8,014	19,689	10,881	21,615	11,271	10,406	17,780	15,629
F7	224,916	16,323	14,547	17,617	21,600	24,899	15,650	25,740	20,913	25,272	17,456	17,420	7,449
¹ source: Centre Wellington annual summary reports, based on 2018 monitoring data													

Map 6-23: Centre Wellington Well Supply Serviced Areas



6.3.2 Vulnerability Analysis

Modelling Approach for the Centre Wellington Well Supply

Centre Wellington WHPAs were mapped based on particle tracking results using the calibrated numerical groundwater flow model developed for the Centre Wellington Tier 3 Assessment (Matrix 2018a). At the time of the WHPA delineations, the Tier 3 model was considered the best tool available to complete this task.

The Tier 3 model version used to delineate the WHPAs incorporated estimated current pumping for non-municipal wells, existing land use, and long term average groundwater recharge. In the Fergus/Elora area of Centre Wellington, the Tier 3 model was calibrated to long-term average water levels, one baseflow estimate at Irvine Creek, and transient conditions recorded during a shutdown/pumping test over a period of 6 weeks in 2012.

The WHPAs delineated for the Centre Wellington municipal wells represent a composite of capture zones developed from a Base Case scenario and three sensitivity scenarios. The sensitivity analysis was completed by adjusting the calibrated Base Case model parameters and evaluating the change in particle tracking results used to delineate the capture zones.

Base Case Scenario

The calibrated Centre Wellington Tier 3 model is referred to as the Base Case scenario. The municipal pumping rates utilized for the WHPA delineations are consistent with the wellfield capacity estimates developed for Centre Wellington's Water Supply Master Plan (AECOM, 2018). The pumping rates applied in the Base Case scenario are provided in **Table 6-19** and **Table 6-21**. Effective porosity values of 0.2 for the overburden, 0.03 for bedrock aquifers and 0.01 for bedrock aquitards were applied. 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 evaluate the effects of model parameter uncertainty on the size and shape of the predicted capture zones while still maintaining a calibrated model. The sensitivity analysis adjusted selected parameters from the calibrated Base Case model and evaluated 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 Goat Island and Gasport formations (bedrock production aquifer) from 3% to 1%. A reduction in porosity leads to greater groundwater velocities and longer pathlines and time-of-travel capture zones. An effective porosity of 1% was applied as it represented the lowest value of effective porosity applied to the bedrock within the neighbouring City of Guelph and Township of Guelph/Eramosa Tier 3 model (Matrix 2017a). Estimates of bedrock effective porosity for the Tier 3 model were derived from field observations in Cambridge, Ontario in addition to estimates made by other professionals practicing in the Guelph area. The effective porosity estimated or applied in these studies ranged from 0.07% to 11%.

Sensitivity Scenario 2 included the lower porosity of Scenario 1 and included increasing the hydraulic conductivity values of the bedrock aquifers (Goat Island and Gasport formations) 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 Centre Wellington Tier 3 model (Matrix 2019). The final ranges of hydraulic conductivity for this scenario were close

to the original hydraulic conductivity values applied in the original calibrated Tier 3 model and largely within the range of field-derived hydraulic conductivity derived for various geologic units as part of the Tier 3 Assessment.

Sensitivity Scenario 3 included the lower porosity of Scenario 1 and decreased the hydraulic conductivity of the bedrock aquitards (Guelph Formation and Vinemount Member of the Eramosa Formation) by 20%. These units overlay the Goat Island and Gasport aquifer formations and are interpreted to have a relatively lower hydraulic conductivity. The magnitude of this decrease was considered appropriate to maintain a reasonable calibration, and the value was based on insights gained during the calibration process of the Tier 3 model (Matrix 2019). The values for the hydraulic conductivity for this scenario are lower than the range of field-derived hydraulic conductivity values for the Guelph Formation; however, many of the field-derived values that were obtained from hydraulic tests conducted within and outside the study area were targeting new water supplies (i.e., zones of enhanced transmissivity). Therefore, the available range of field-derived hydraulic conductivity values are expected to be on the high side. In addition, the model calibration exercise illustrated that the final hydraulic conductivity parameters resulted in the best match between observed and simulated water levels under average and transient (i.e., pumping test) conditions. As a result, the use of lower hydraulic conductivity values that maintained a reasonable calibration were considered appropriate for this scenario.

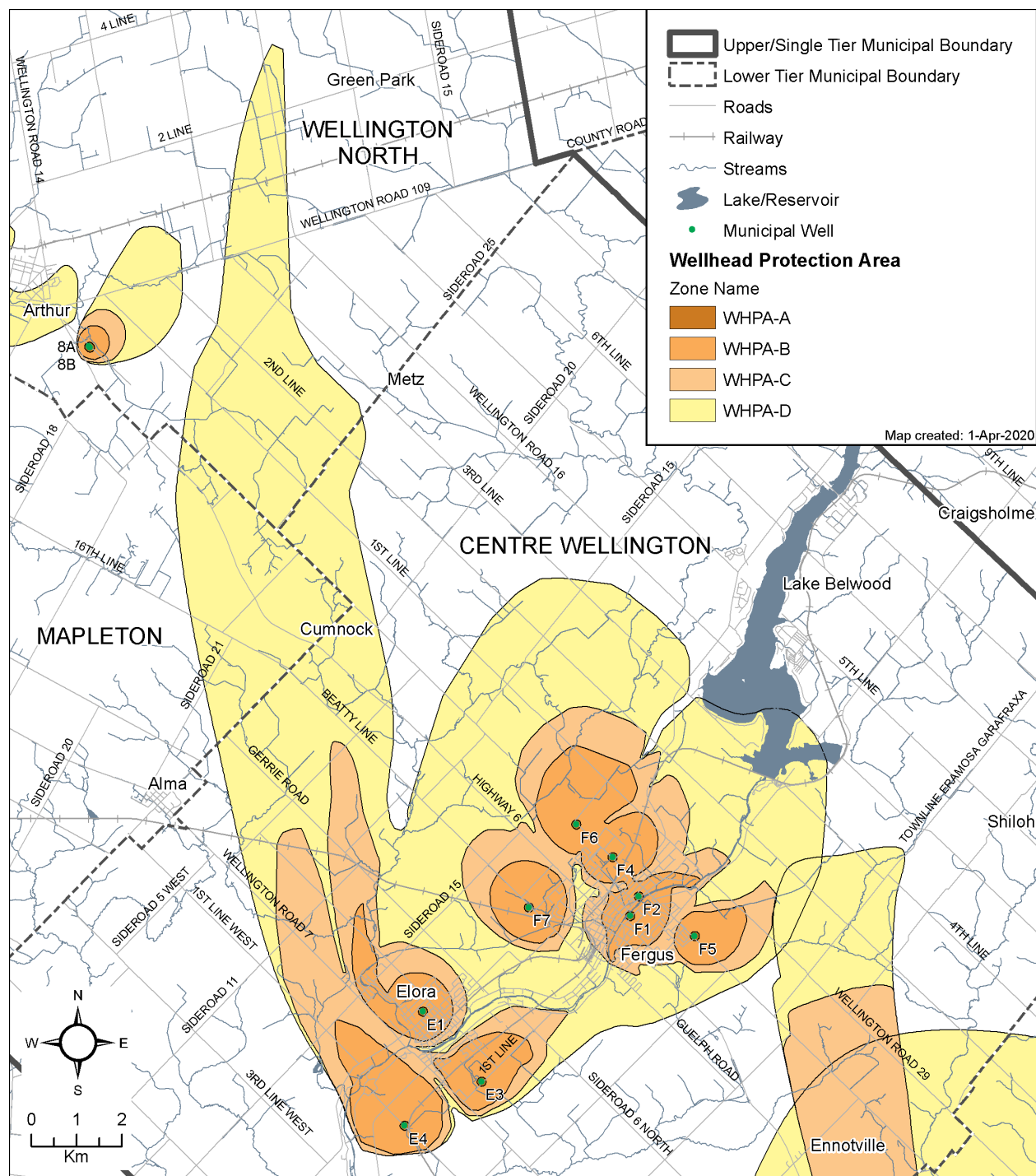
Virtual particles were released in the groundwater flow model at the municipal wells and tracked backward in time through the saturated subsurface for various time intervals. The computed pathlines travelled by these particles were projected to the ground surface and plotted on a plan view map. WHPAs were created by drawing polygons around the well and the particle pathlines for specific time intervals.

Delineation of Centre Wellington Wellhead Protection Areas

WHPA-A through WHPA-D were delineated for the nine Centre Wellington municipal wells as presented in **Map 6-24**.

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.

Map 6-24: Centre Wellington Wellhead Protection Areas



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

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

The WHPA-E delineation for Well F2 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, the 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 because 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 completed 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 95th percentile of flow. Experience has shown that 95th percentile flow and bankfull conditions are not substantially different for natural watercourses. The 95th percentile flow was estimated to be 32 m³/s.

A dye tracer study was carried out on April 28, 2009 at flows similar to the calculated 95th 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 95th percentile flow conditions. Under 95th 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 95th 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 Well F2 as there were no Issues identified for this well. 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 Centre Wellington wellfields was previously completed using the SAAT method (EarthFX, 2008). 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**.

Identification of Transport Pathways and Vulnerability Adjustment

Following a review of the intrinsic vulnerability scoring maps, an assessment of transport pathways was completed to determine whether adjustments to the vulnerability assessment were warranted. Technical Rules 39 through 41 (MOECC, 2017) provide guidance as to how transport pathways could 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 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.

Adjusted Vulnerability Scoring for the Centre Wellington Wellhead Protection Areas

Several data sources were reviewed to assess the relative risk of transport pathways to breach the natural protection afforded to the bedrock aquifers which provide water for Centre Wellington's municipal supply. 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 were overlain on the adjusted vulnerability mapping and scores were assigned. Final vulnerability scoring for the Centre Wellington wellfield is shown on **Map 6-29**.

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 6-23**.

Table 6-23: Uncertainty Analysis Factors and Ranking for WHPAs and Vulnerability Scores		
Uncertainty Assessment 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 Centre Wellington 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.

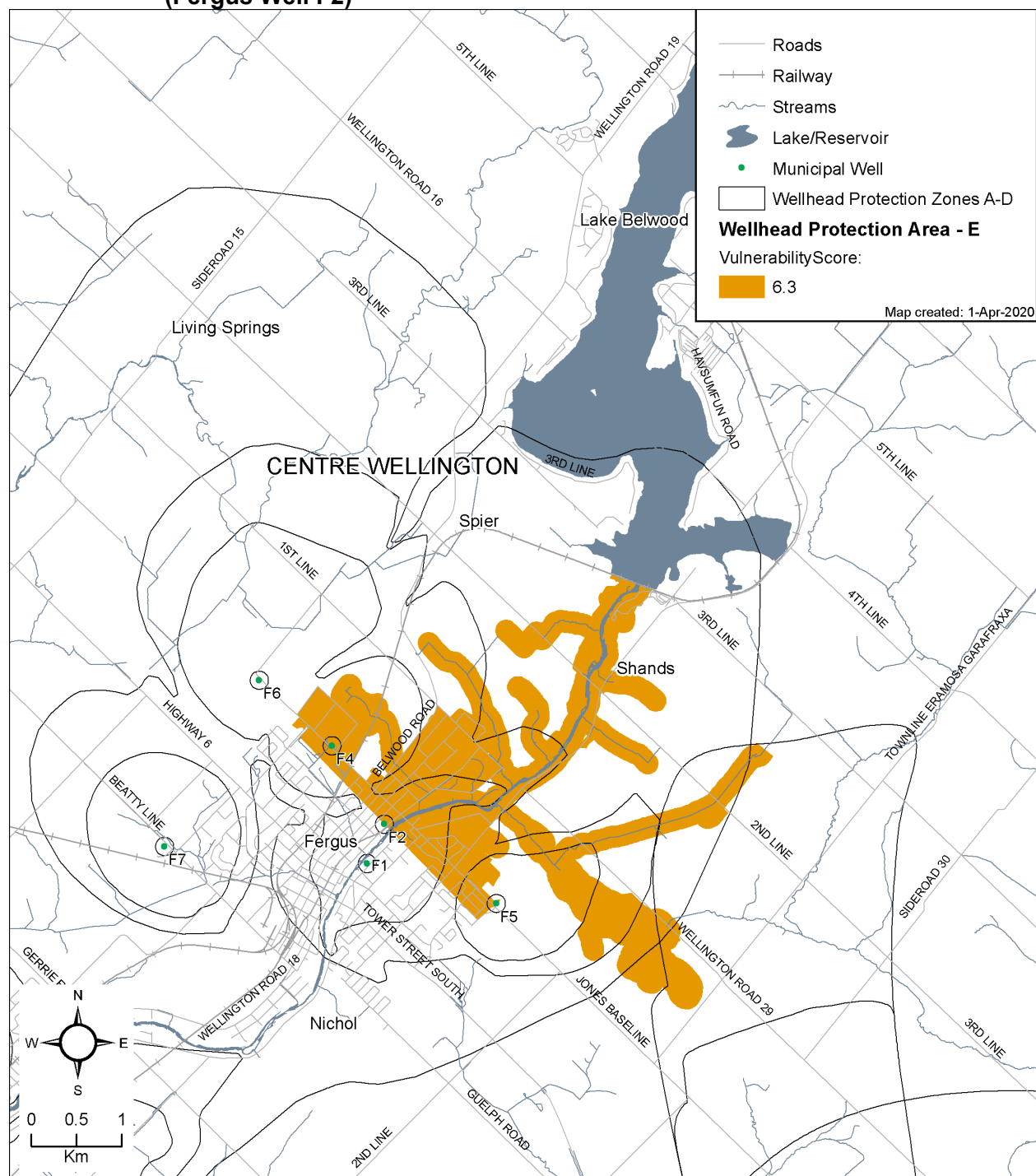
According to the Technical Rules, the source vulnerability factor for a surface water intake takes into consideration the depth of the intake from the water surface, the distance from land and historical water quality concerns. For a WHPA-E, the first two factors do not apply as there is no particular 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.

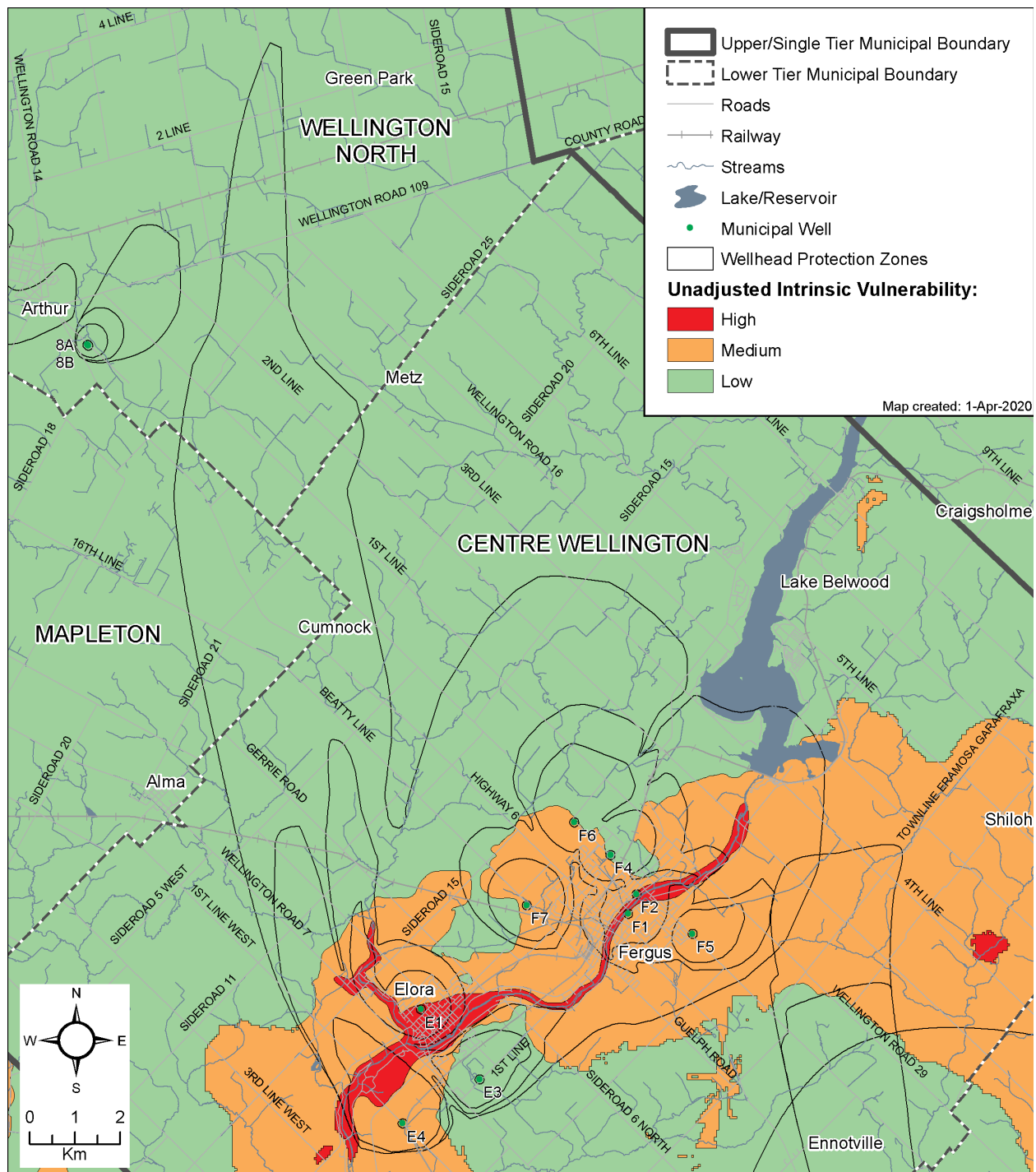
Combining the area and source vulnerability scores, the overall vulnerability score for the Well F2 WHPA-E is 6.3 (see **Table 6-24**).

Table 6-24: 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

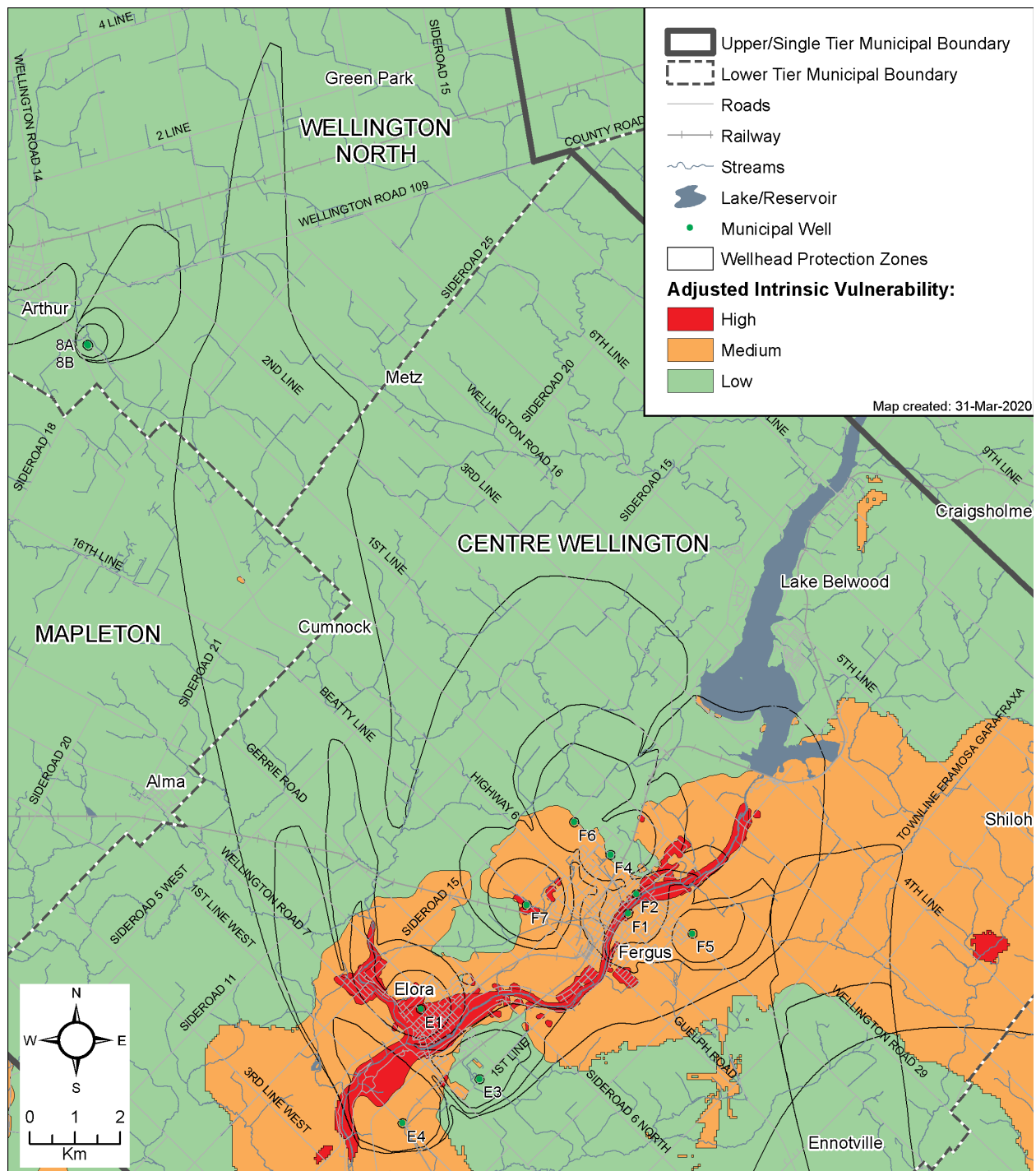
Map 6-25: Centre Wellington Well Supply Wellhead Protection Area E Delineation (Fergus Well F2)



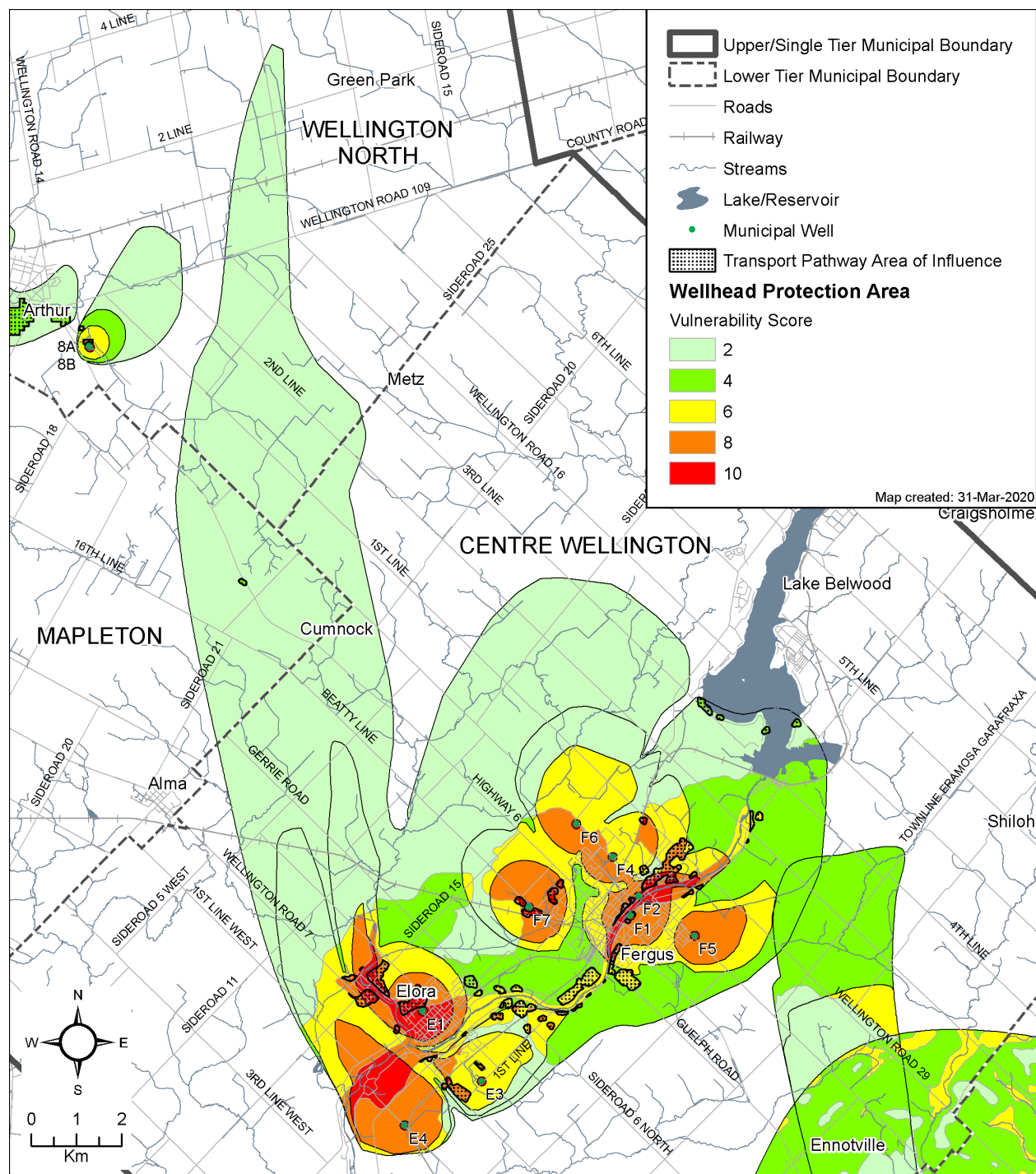
Map 6-26 Centre Wellington Well Supply Unadjusted Intrinsic Vulnerability



Map 6-27: Centre Wellington Well Supply Wellhead Protection Area Adjusted Intrinsic Vulnerability



Map 6-28 Centre Wellington Transport Pathways Area of Influence



Wellington North

Wellhead Protection Area

Vulnerability Score

1	2	3	4	5	6	7	8	9	10
Lightest Green	Light Green	Medium Green	Dark Green	Yellow-Green	Yellow	Orange-Yellow	Orange	Dark Orange	Red

Legend:

- Upper/Single Tier Municipal Boundary (Solid line)
- Lower Tier Municipal Boundary (Dashed line)
- Roads (Thin solid line)
- Railway (Line with cross-ticks)
- Streams (Wavy line)
- Lake/Reservoir (Blue area)
- Municipal Well (Green dot)

Map created: 1-Apr-2020

Geographical Labels: Green Park, Wellington North, Centre Wellington, Mapleton, Cumnock, Alma, Elora, Fergus, Ennotville, Lake Belwood, Craigsholme, Shiloh.

Wellhead Protection Areas (WPA) and Wells:

- WPA 1:** Surrounds well E1 (Elora).
- WPA 2:** Surrounds well E2 (Elora).
- WPA 3:** Surrounds well E3 (Elora).
- WPA 4:** Surrounds well E4 (Elora).
- WPA 5:** Surrounds well E5 (Elora).
- WPA 6:** Surrounds well F1 (Fergus).
- WPA 7:** Surrounds well F2 (Fergus).
- WPA 8:** Surrounds well F3 (Fergus).
- WPA 9:** Surrounds well F4 (Fergus).
- WPA 10:** Surrounds well F5 (Fergus).
- WPA 11:** Surrounds well F6 (Fergus).
- WPA 12:** Surrounds well F7 (Fergus).

Scale: 0 to 2 Km.

North Arrow: N, S, E, W.

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 m³/s, provide further confidence in the use of the 95% flow, determined through statistical analysis to be 32 m³/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 contain 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 6-25**.

Table 6-25: 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.

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 Elora and Fergus were completed in WHPA-A to WHPA-D where the vulnerability was 6 or higher. **Table 6-26** provides the results of the calculations and **Map 6-30** and **Map 6-33** show the ranges of managed lands percentage for the Centre Wellington WHPAs.

Table 6-26: Percent Managed Lands in the Centre Wellington Wellhead Protection Areas						
Township	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Centre Wellington	Elora	E1	57.69%	54.41%	59.69%	38.2%
		E3	49.20%	58.53%		
		E4	76.78%	57.01%		
	Fergus	F1	20.71%	47.99%	58.49%	
		F2	41.41%			
		F4	11.32%			
		F6	39.24%			
		F5	48.95%	68.76%		
		F7	60.47%	56.69%		

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 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 6.

Table 6-27 summarizes the livestock density results in nutrient units/acre (NU/acre) in the Centre Wellington WHPAs. **Map 6-31** shows the livestock density results for the Centre Wellington WHPAs.

Table 6-27: Livestock Density (NU/acre) in the Centre Wellington Wellhead Protection Areas						
Township	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Centre Wellington	Elora	E1	0.00	0.16	1.16	0.11
		E3	0.24	0.04		
		E4	0.15	0.48		
	Fergus	F1	0.00	0.28	0.31	
		F2	0.00			
		F4	0.00			
		F6	0.55			
		F5	0.44	0.46		
		F7	0.00	0.01		

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 6-34**. 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 MECP's Table of Drinking Water Threats.

Uncertainty of the Livestock Density within the Wellhead Protection Areas

The MECP 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

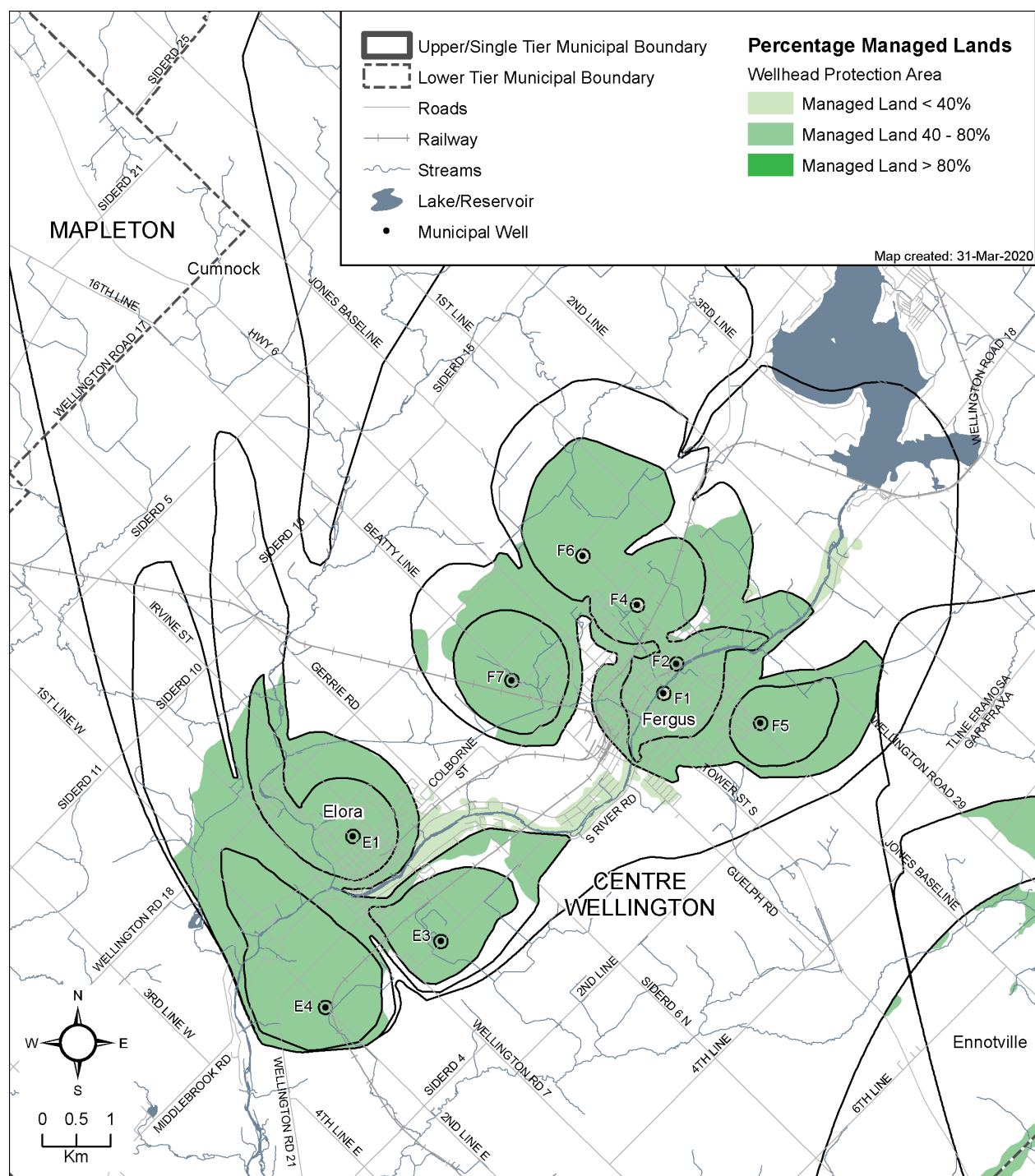
To determine whether the application of road salt poses a threat in the Centre Wellington WHPAs, the percentage of impervious surface where road salt can be applied per square kilometre was calculated as per Technical Rules 16(11) and 17. The moving window average technique, described in Chapter 3 was used for the Centre Wellington WHPAs. 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 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.

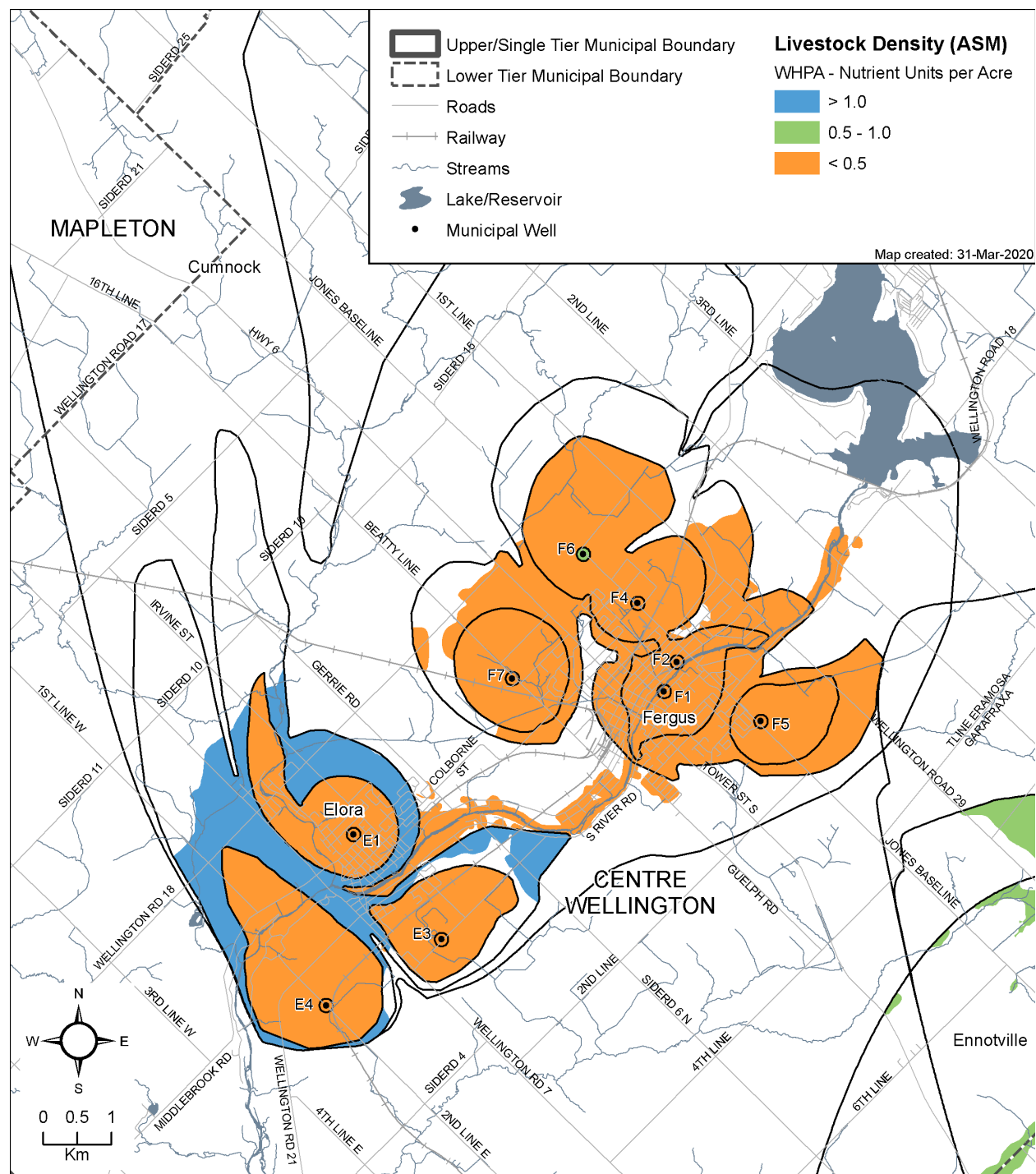
Map 6-32 shows the summary of the percent imperviousness within the Centre Wellington WHPAs respectively.

The percentage of impervious surface area where road salt can be applied within the Fergus WHPA-E is shown on **Map 6-35**. 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 MECP's Table of Drinking Water Threats.

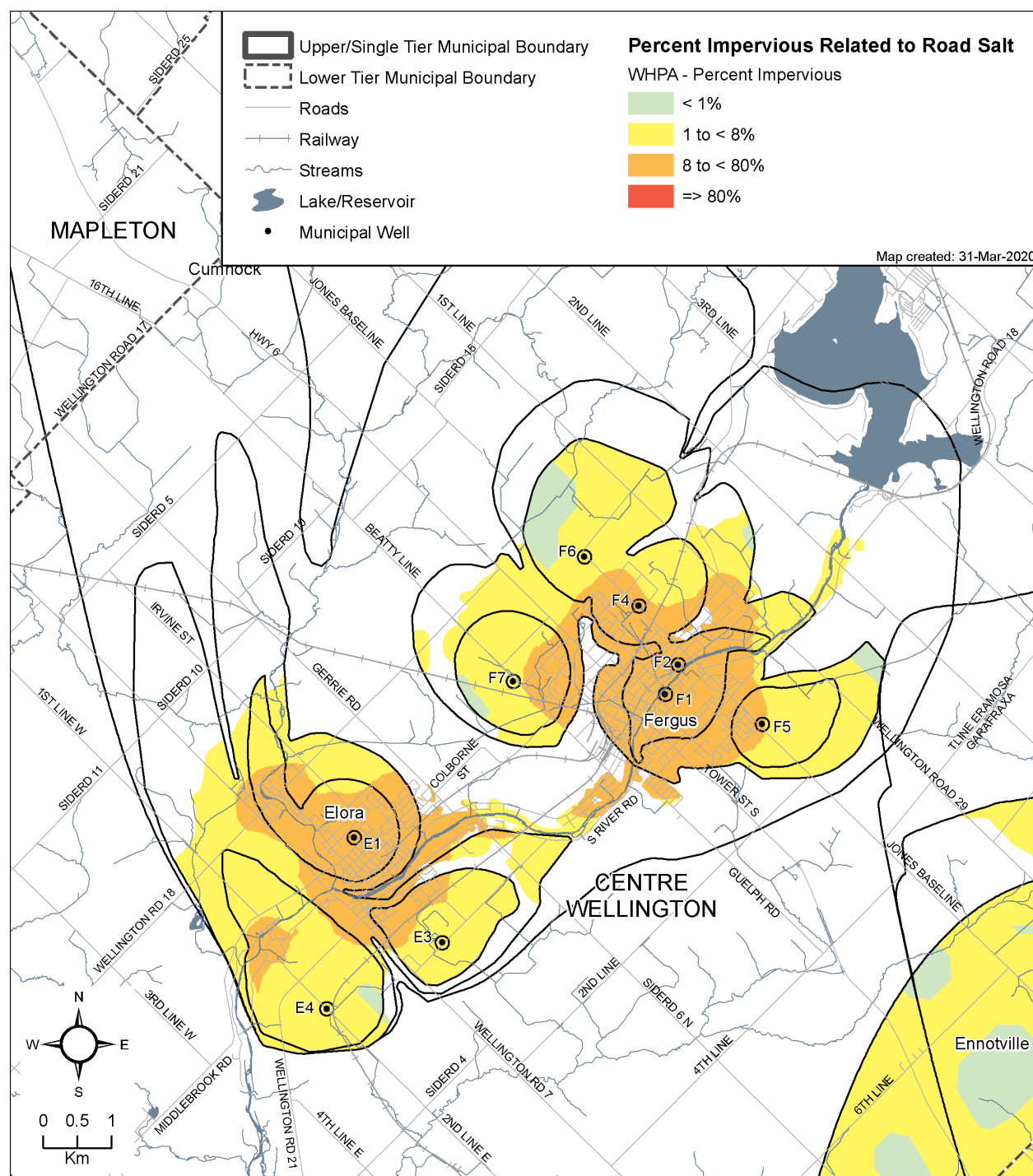
Map 6-30: Centre Wellington Well Supply Percent Managed Lands



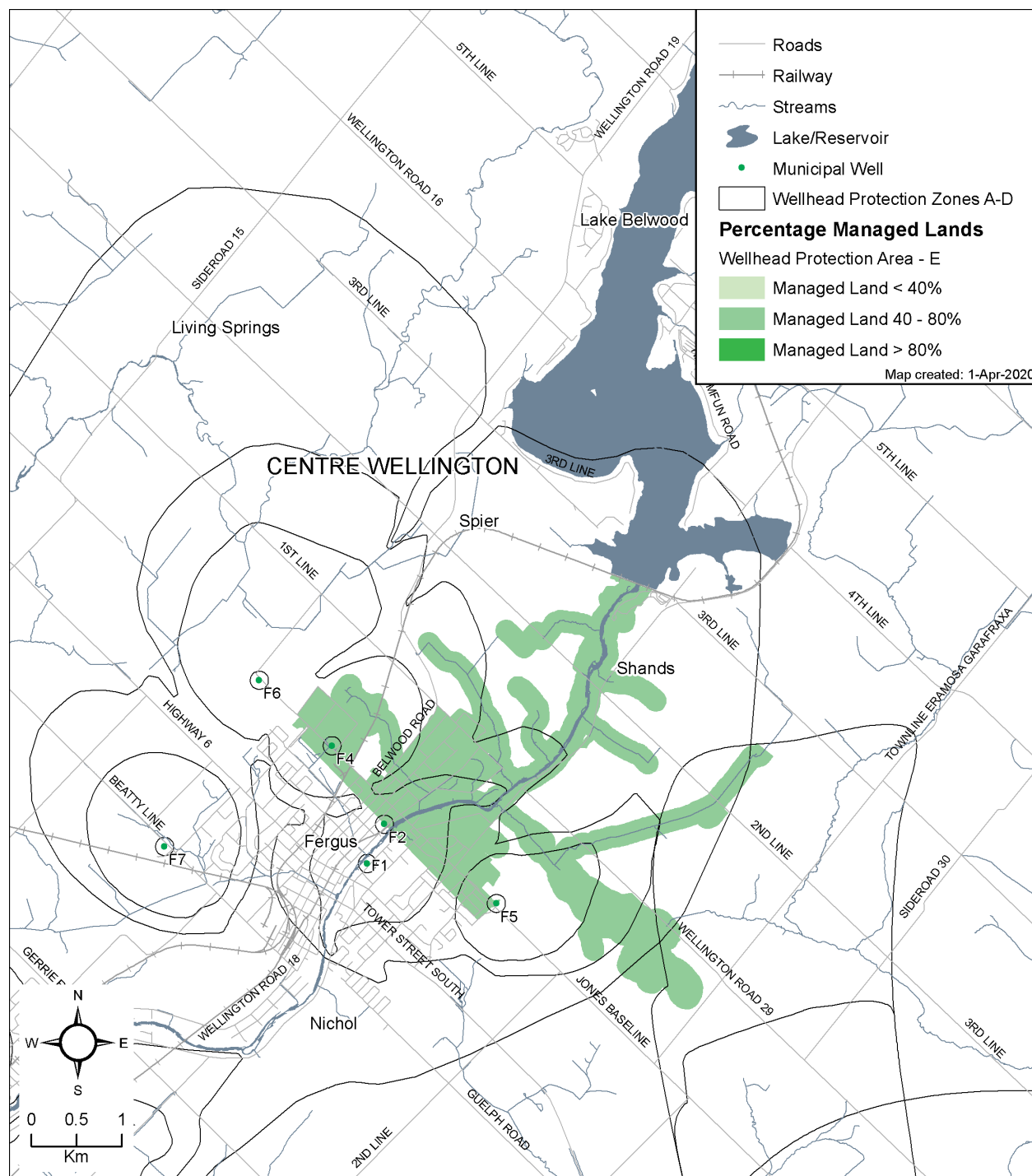
Map 6-31: Centre Wellington Well Supply Livestock Density



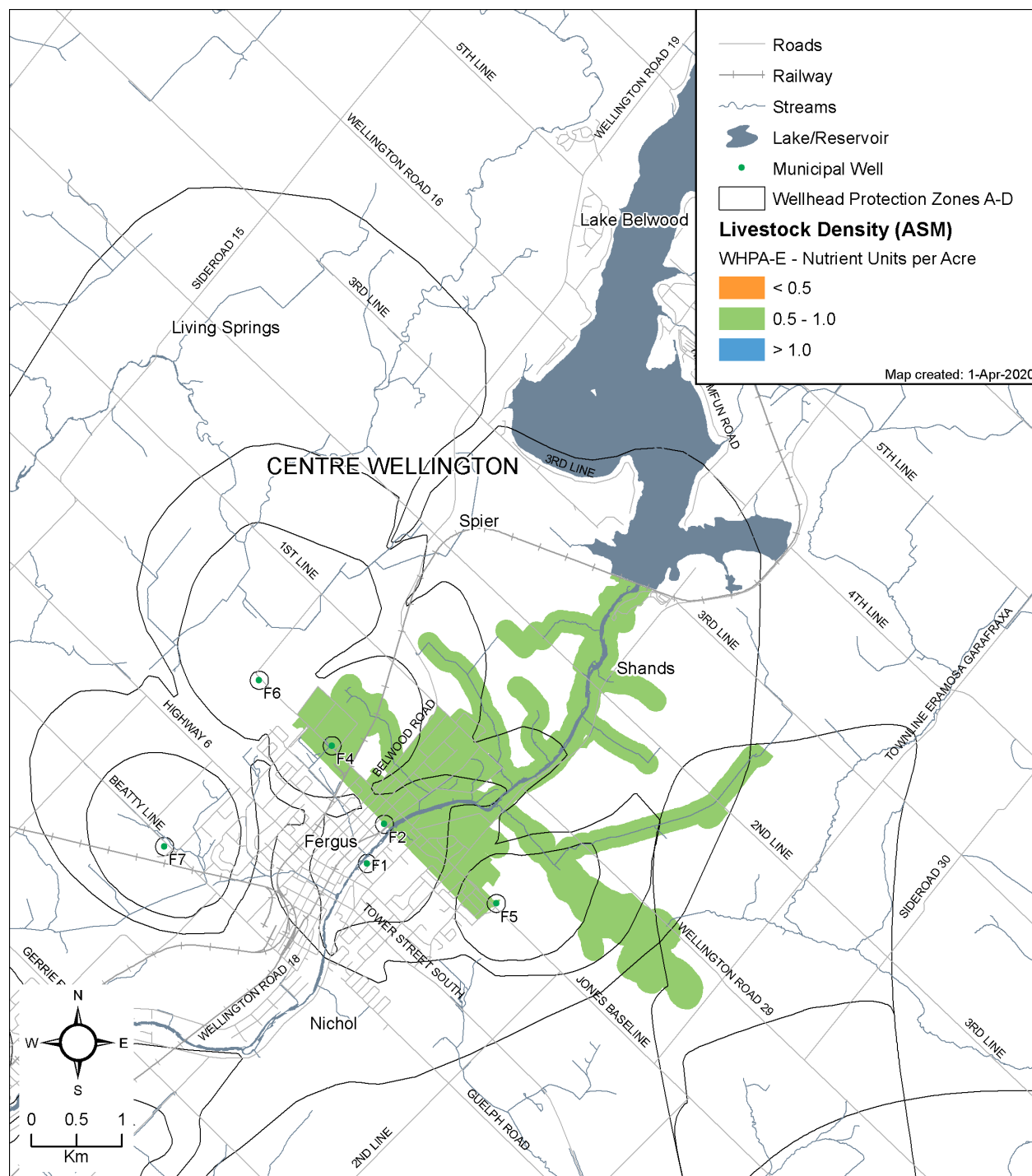
Map 6-32: Centre Wellington Well Supply Percent Impervious Surfaces



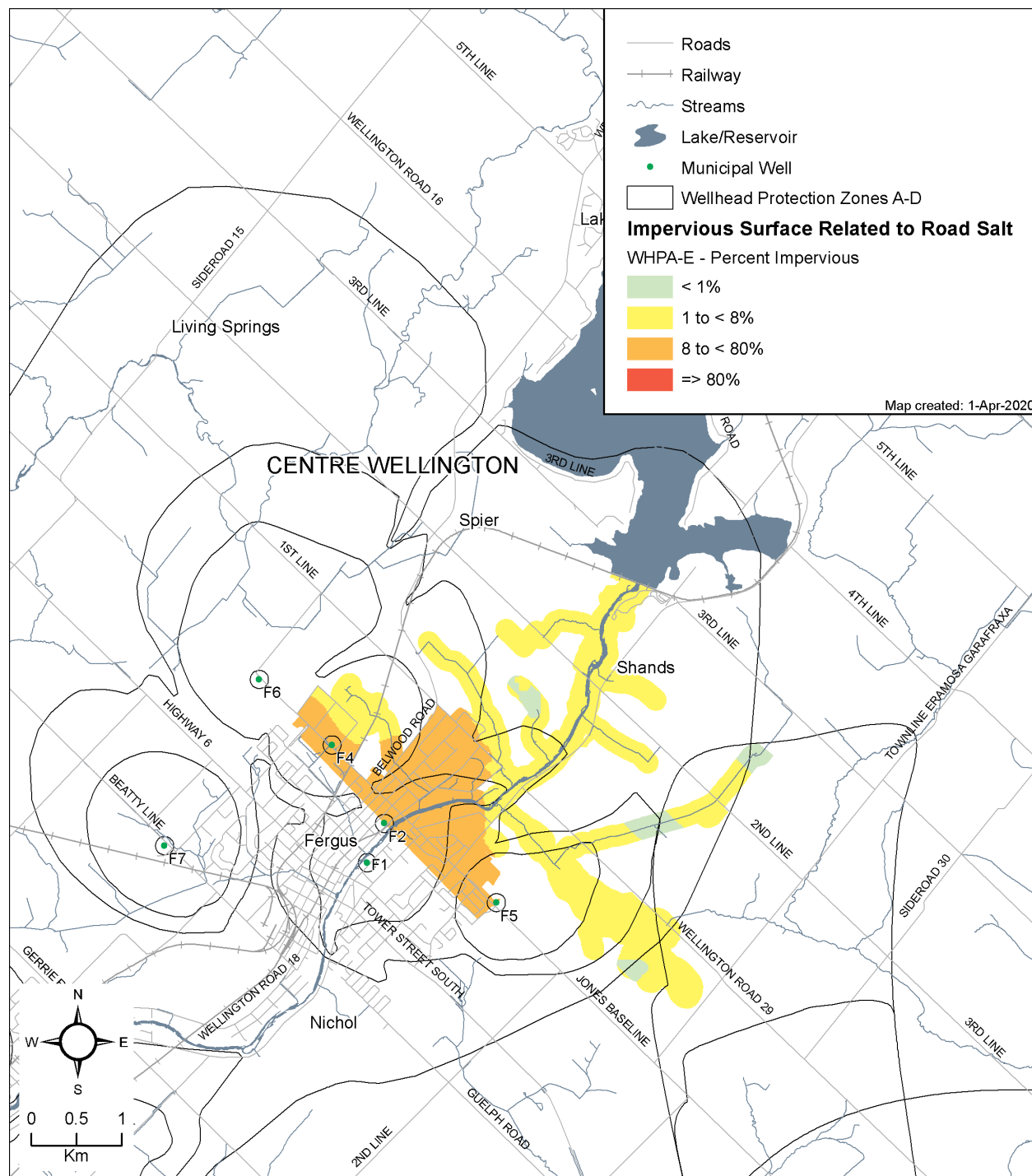
Map 6-33: Centre Wellington Well Supply WHPA-E Percent Managed Lands (Fergus, Well F2)



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>. 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 6-28 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 6-28: Identification of Drinking Water Quality Threats in the Centre Wellington 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-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, 2017), lists criteria for drinking water sources, which is outlined in Chapter 3 of this Assessment Report.

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

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 (2012) 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 in 2012.

Since the approval of the Assessment Report in 2012, additional information has been obtained from Ministry of Environment, Conservation and Parks 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 WHPAs.

During the 2019 review, nineteen (19) potential condition sites were reviewed; all were sites previously identified in 2015. No additional sites were identified. Three (3) of the nineteen (19) sites were not located within a municipal WHPA and therefore are not considered condition sites under Technical Rule 126. The remaining sixteen (16) sites were located within WHPAs. Ten (10) of the nineteen (19) sites did not meet the requirements for Technical Rule 126 because of a lack of information and were therefore not considered condition sites. Seven (7) of the nineteen (19) sites were not considered condition sites because of insufficient information but they were located in WHPAs. This data gap should be addressed and is referenced in the limitations section for the Township of Centre Wellington.

Six (6) of the nineteen (19) sites had sufficient information to be considered condition sites under Rule 126. Of these six sites, one (1) site in Fergus, related to petroleum hydrocarbon contamination, was a not significant drinking water threat condition site as the site's risk score was below the threshold of 80 because of the vulnerability scoring. This site has documented off-site contamination that is above the Table 2 potable groundwater standard as referenced in Technical Rule 126 (3). The site is located in a WHPA-C, vulnerability score 6 with a risk score of 60. This site was identified as a significant drinking water threat condition site in 2015, however, due to the changes in vulnerability score from a score of 8 to a score of 6, the site is now identified as a moderate condition site as the risk score is less than 80 and therefore meets Technical Rule 142.

Based on the documentation available at this time, there is sufficient evidence to identify five (5) of the nineteen (19) sites as significant drinking water threat condition sites under technical rule 140 or 141. Three significant drinking water threat condition sites are located in Fergus, one site is located in Salem and one site is located in Elora. The sites in Elora and Salem and two of the sites in Fergus are related to petroleum hydrocarbon contamination and there is evidence of off-site contamination. All of these sites meet Technical Rule 140. The remaining site located in Fergus is related to trichloroethylene contamination, there is evidence of off-site contamination, and it meets Technical Rule 141.

The site in Salem has documented off-site contamination that is above the Table 2 potable groundwater standard as referenced in Technical Rule 126 (3), and documented non-aqueous phase liquid in the groundwater as referenced in Technical Rule 126 (1). It is located in a WHPA-C, vulnerability score 8 with a risk score of 80.

The site in Elora has documented off-site contamination that is above the Table 2 potable groundwater standard as referenced in Technical Rule 126 (3), and documented non-aqueous phase liquid in the groundwater as referenced in Technical Rule 126 (1). It is located in a WHPA-C, vulnerability score 8 with a risk score of 80. Part of the site is also located in a WHPA-D, vulnerability score 6.

The two petroleum hydrocarbon significant drinking water threat sites in Fergus both have documented off-site contamination that are above the Table 2 potable groundwater standard as referenced in Technical Rule 126 (3). One of the two sites also has documented non-aqueous phase liquid in the groundwater as referenced in Technical Rule 126 (1) and is located in a WHPA-B, vulnerability score 10 with a risk score of 100. This site was also identified as a significant drinking water threat site in 2015. The second petroleum hydrocarbon Fergus site is located in a WHPA-B, vulnerability score 8 with a risk score of 80.

The third Fergus site has documented off-site, trichloroethylene contamination that is above the Table 2 potable groundwater standard as referenced in Technical Rule 126 (3), and documented non-aqueous phase liquid in the groundwater as referenced in Technical Rule 126 (1). It is located in an issue contributing area for trichloroethylene for Fergus well F1 and is located in WHPA-C, vulnerability score 6 and WHPA-D, vulnerability score 6. The risk score does not apply due to its location in an issue contributing area.

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.

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 Environmental Services from 2005, 2007, 2009 and 2011 to 2019 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 municipality also supplied nitrate concentrations from 2003 to 2019.

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), 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 (ODWQS) 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. 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 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, 2006* 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 the Centre Wellington wellfield to recommend what further action was required including whether there was sufficient evidence to identify a drinking water issue as per the Technical Rules under the *Clean Water Act, 2006*. 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. Hence, 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, in 2018, Golder Associates completed a study on chloride concentrations at the Centre Wellington wellfield 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 wells F1 and E3.

Centre Wellington Drinking Water Issues Evaluation

Well E1, in the north part of Elora, has sodium and chloride concentrations below 20 mg/L and nitrate concentrations less than 0.1 mg/L or non-detect. The ODWQS MAC for nitrate is 10 mg/L, and the aesthetic objectives for chloride, sulphate and iron are 250, 500 and 0.3 mg/L, respectively. Sulphate concentrations are below 300 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. All measurements of aluminum to 2019 were below the detection limit. Zinc concentrations were well below the aesthetic objective of 5 mg/L and in almost all cases were below the detection limit. The 2014 review confirmed the above findings related to sodium and chloride concentrations (Golder, 2014).

Well E3, in the south part of Elora, currently meets ODWQS for all health related parameters. Sodium concentrations range from 5 to 50 mg/L, nitrate concentrations are below 1.3 mg/L and sulphate concentrations range from 31 to 283 mg/L. Sulphate concentrations showed sharp peaks in 2011, 2015 and 2017 with values ranging from 278 to 283 mg/L, while sulphate concentrations from 2005 to 2009 and 2013 ranged from 30 to 34 mg/L. Sulphate concentrations increase with increased municipal pumping rates at E3 (Golder, 2018).

Chloride concentrations ranged from 0.5 to 165 mg/L for Well E3 and although variable, appeared to be increasing over time. A number of chloride concentrations from 2013 onward were greater than 50% of the Aesthetic Objective of 250 mg/L. As detailed in **Figure 6-1**, Well E3 chloride data shows an increasing trend where concentrations approach 50 percent of Ontario Drinking Water Aesthetic Objective of 250 mg/L for chloride (Golder, 2018).

According to Golder (2018), groundwater at Well E3 is derived mainly from the bedrock aquifer and receives chloride from surface (anthropogenic) sources. This results in decreased chloride concentrations when the well is pumped at a higher rate. Since the chloride at Well E3 is from an anthropogenic source, and concentrations have been greater than 50% of the AO and show an increasing trend, chloride has been identified as an Issue at Well E3 in accordance with Technical Rule 114.

An Issues Contributing Area was delineated for Well E3 and significant threat activities associated with the chloride Issue were identified. Chloride concentrations for Well E3 are shown on **Figure 6-1**.

Well E4, also located in the south part of Elora, currently meets the ODWQS for all health related parameters. There appears to be minimal 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 mg/L. Sulphate is naturally occurring in the area. Zinc and iron concentrations increased in 2009 compared to previous and current concentrations; however, both are below the aesthetic objective.

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 in 2008 and 2018 in Well E4 and Well E1, respectively. 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 WHPA is minimized or eliminated in accordance with the principles of source water protection.

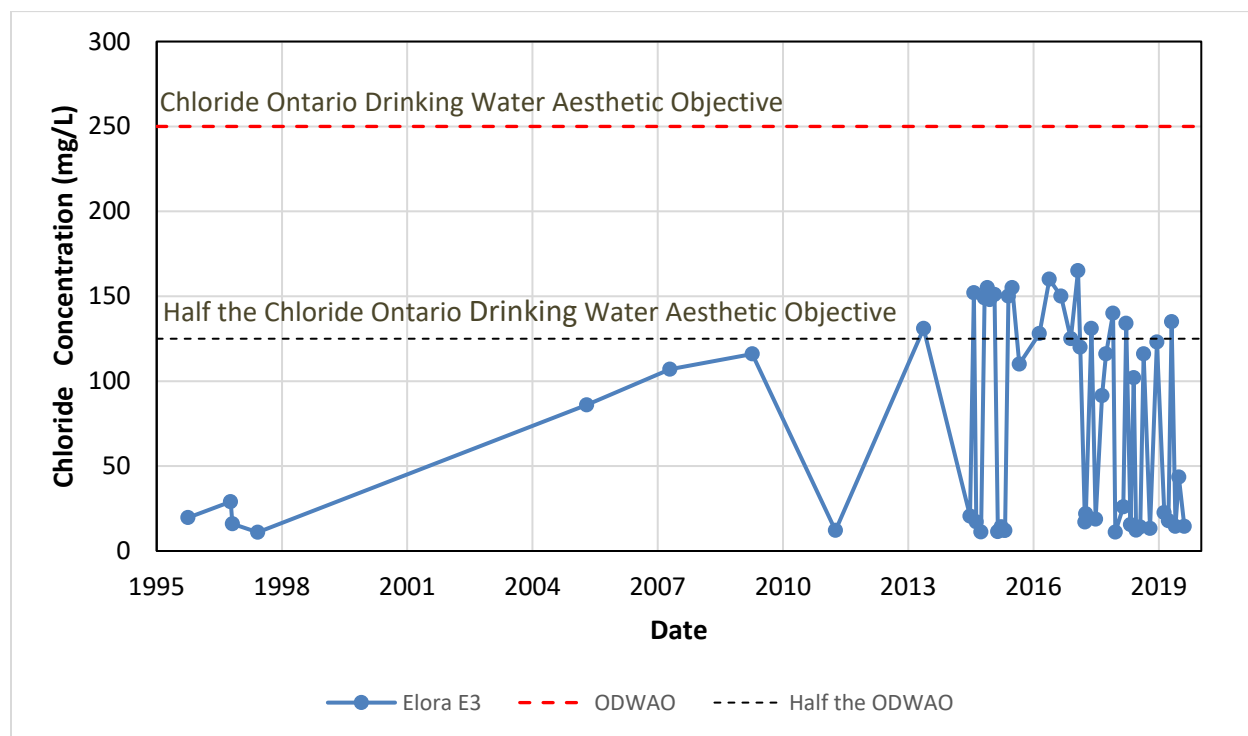


Figure 6-1: Chloride Concentrations at Well E3, Elora, Township of Centre Wellington.

Well F1 in Fergus has elevated chloride concentrations that range up to 160 mg/L (**Figure 6-2**). Sodium concentrations range up to 93 mg/L, nitrate concentrations are less than 1.5 mg/L and sulphate concentrations are elevated and range from 481 to 670 mg/L.

Golder (2018) indicated that chloride concentrations ranged from 21 to 128 mg/L for Well F1 and appear to be increasing, but show variation. The chloride concentrations measured during a sampling event in 2019 was greater than 50% of the Ontario Drinking Water Aesthetic Objective (AO) of 250 mg/L.

Groundwater at well F1 appears to be derived mainly from the overburden and shallow bedrock and receives chloride from surface (anthropogenic) sources, which results in increased chloride in the well when it is pumped at a high rate (Golder, 2018). With chloride originating from an anthropogenic source and concentrations at the well above 50% of the AO and potentially on an increasing trend, chloride has been identified as an Issue at well F1 in accordance with Technical Rule 114.

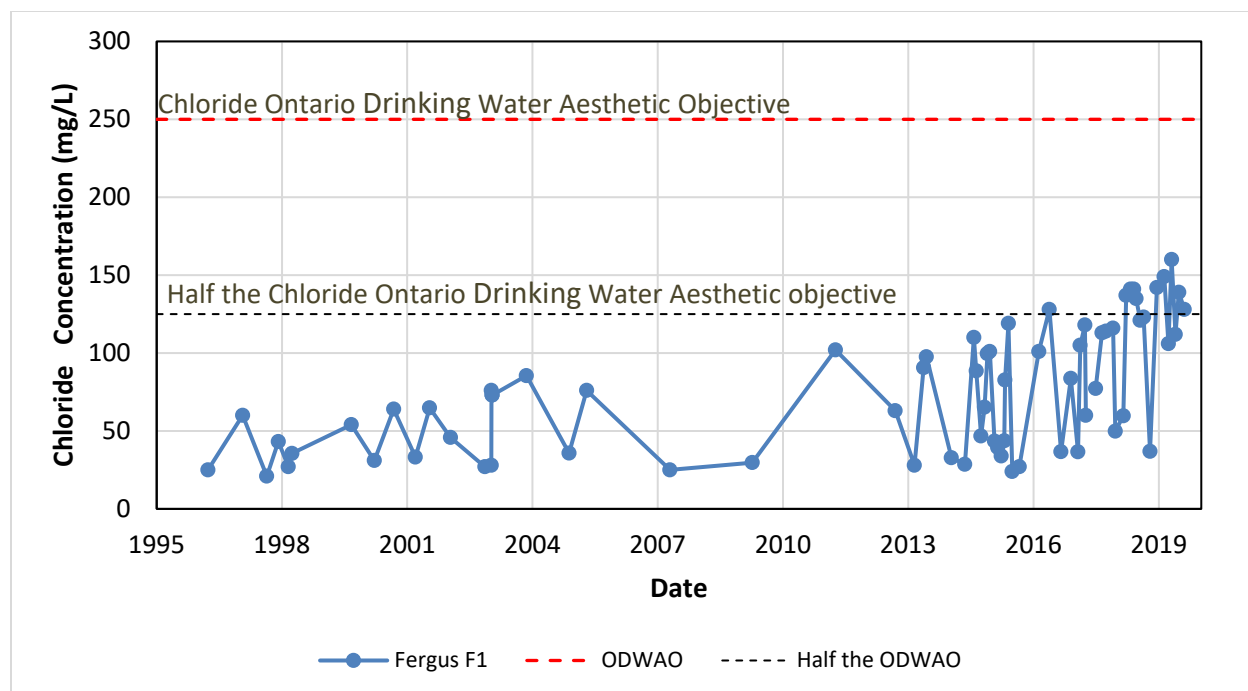


Figure 6-2: Chloride Concentrations at Well F1, Fergus, Township of Centre Wellington.

Well F1 has TCE concentrations in raw water that range up to 32 µg/L, although TCE concentrations have declined since the early 2000's (**Figure 6-3**). The ODWS MAC for TCE is 5 µg/L. Since 2012 (the approval date of the original Assessment Report), raw water TCE concentrations have been variable with concentrations fluctuating above and below the ODWS of 5 µg/L. In the past five years (2015 to 2020), 18 samples have exceeded the ODWS while 11 samples were below the ODWS. Overall, the trend of TCE concentrations in the raw water of municipal Well F1 exceeds the ODWS of 5 µg/L. With continued exceedances, the Township of Centre Wellington operates treatment for municipal Well F1 that reduces TCE concentrations in treated water to non-detectable levels. Since TCE continues to be present at concentrations in raw water, greater than the ODWS, which results in the need for treatment of raw water at municipal Well F1, TCE has been identified an Issue in well F1 in accordance with Technical Rule 114 (Wellington Source Water Protection, 2020a).

The occurrence of TCE at F1 was first 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 were in close proximity and it was assumed that pumping Well F1 would contain them. Blackport Hydrogeology Inc. (2002c) indicated that the source of TCE was not verified. Blackport Hydrogeology Inc. and Triton Engineering Services Limited (2008) concluded that the source of TCE was likely distant from Well F1 as the elevated TCE concentrations were found in a deeper zone of the open bedrock well.

Well F1 has been operating with an air stripper since 1991. A pump and treat system was added to two private bedrock wells in approximately 1993 with treated water discharged into a local storm water drain. The Township submits annual water quality and pumping reports to the MECP for Well F1 consistent with the Drinking Water Regulations.

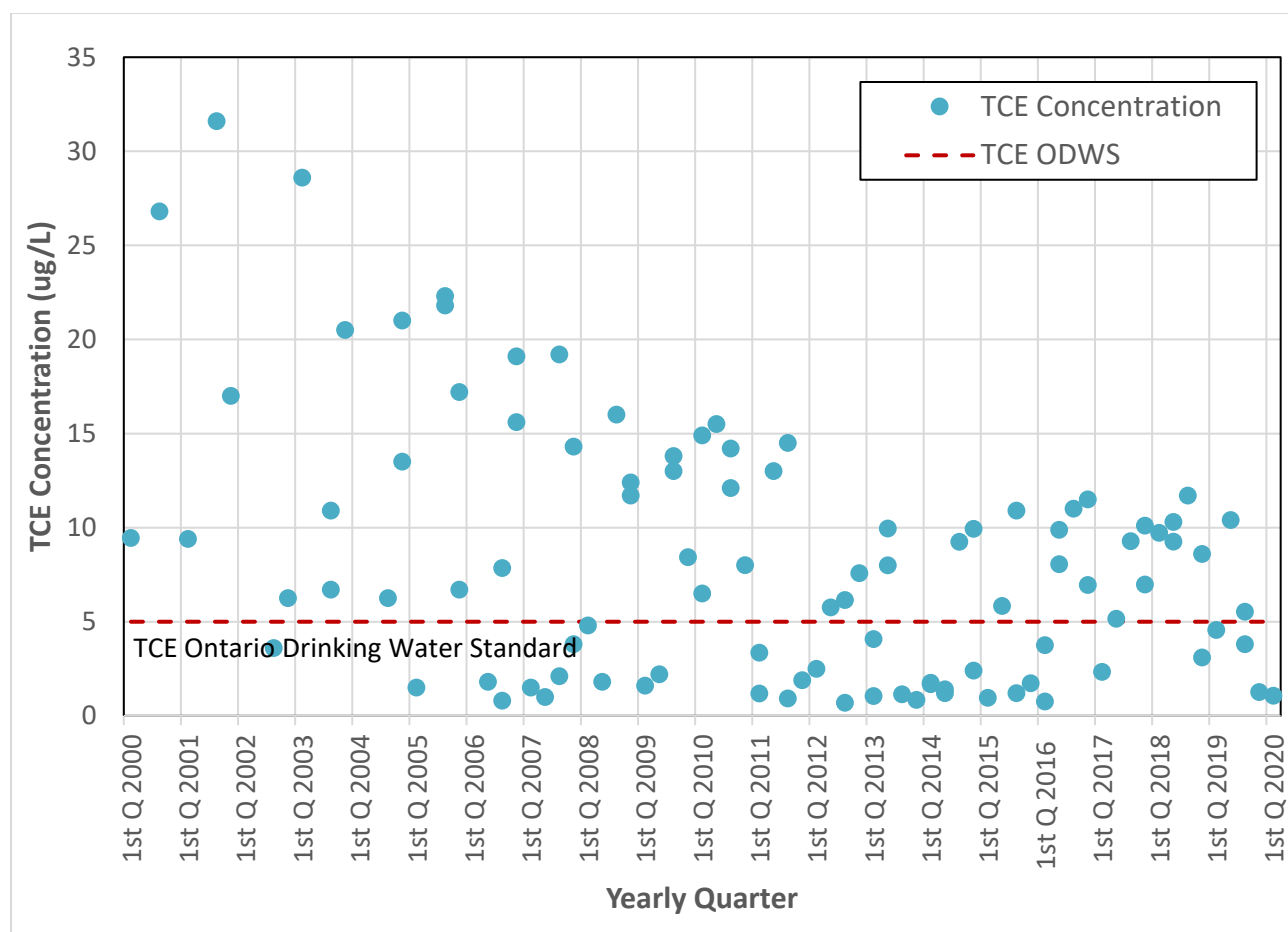


Figure 6-3: TCE Concentrations at Well F1, Fergus, Township of Centre Wellington

Well F4, located in the northern part of Fergus, 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.

Well F5 is located in the southern limits of Fergus. 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, aluminum concentrations were recorded at above the operational guideline of 0.1 mg/L, however concentrations have since been below the operational guideline.

Well F6, located north of Fergus contains sulphate concentrations 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. Sodium concentrations are slightly above 20 mg/L and nitrate concentrations have not been detected. Chloride concentrations were around 40 mg/L up to mid-2008. Since 2009, chloride concentrations have been variable, ranging from 10 to 88 mg/L. The concentrations are below 50% of the Ontario Drinking Water Aesthetic Objective of 250 mg/L. An investigation 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). Iron concentrations are variable and exceeded the Aesthetic Objective of 0.3 mg/L in 2009, 2011 and 2015. Iron is naturally occurring in the groundwater system.

Well F7 is located on the western side of Fergus. Sodium concentrations are occasionally slightly greater than 20 mg/L, nitrate has not been detected, and sulphate concentrations range from 45 mg/L to 317 mg/L. 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 Ontario Drinking Water Aesthetic Objective of 250 mg/L. An investigation 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 elevated 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 from 2015 to 2018. Total coliforms were detected a total of seven times from 2015 to 2018 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.

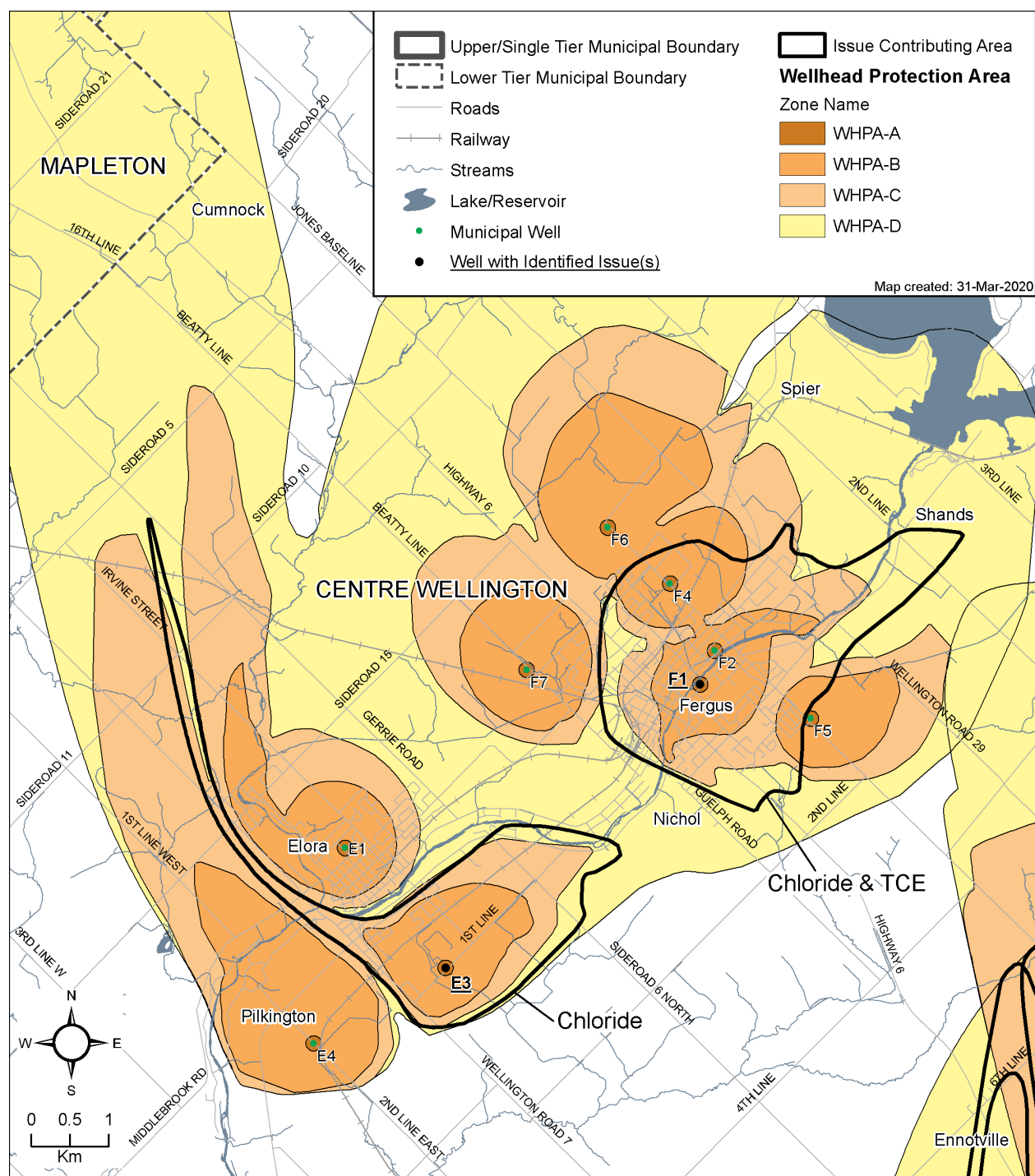
The Issue Contributing Areas for Well E3 and Well F1 are shown on **Map 6-36**.

Summary of Drinking Water Issues Evaluation

Chloride concentrations at Well E3 and F1 appear to show an increasing trend with concentrations measured above 50% of the Ontario Drinking Water Aesthetic Objective (250 mg/L). Measured chloride concentrations at wells E3 and F1 are 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 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 existing and future rates (Matrix, 2018). Additional details about the delineation of the ICAs can be found in Wellington Source Water Protection, 2020b. The Issue Contributing Areas are shown on **Map 6-36**.

Map 6-36: Issue Contributing Areas for Well E3 (Chloride) and Well 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, the 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 staff, previous contaminant/historical land use information, and data collected during windshield surveys. No site specific information was collected.

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).

Data Sources for the Enumeration of Significant Drinking Water Threats

For the initial enumeration in the 2012 Assessment Report, the key data sources used to identify threats on properties within the WHPAs included 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 land uses within vulnerability zones of 10 (i.e., locations of significant chemical and pathogen threats) within the urban boundary indicated that all of the land uses, except Highway Commercial and Residential Transition Area, were present. In addition, all the land uses, except Residential Transition Area were present within WHPA-C, which were possible locations for DNAPL threats. The same threats that were associated with the various MPAC property codes were assumed for similar land use planning zones, for example, application of commercial fertilizer to recreational areas.

The completed threat enumeration included 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 approves any zoning change, or issuance of a building permit, these conditions of the Counties current groundwater management plan 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 where 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 6-29: 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	<ul style="list-style-type: none"> • Storage and handling of pesticides, fuel, commercial fertilizer, agricultural source material, septic system. • Application of pesticide, commercial fertilizer, agricultural source material.
Agricultural property with residence and outbuilding – buildings not in WHPA	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied.
Residence with no gas line	<ul style="list-style-type: none"> • Oil furnace
Organic solvent	<ul style="list-style-type: none"> • Storage below grade in a quantity that would make it a significant threat
No sanitary sewer infrastructure	<ul style="list-style-type: none"> • Septic system
Presence of any chemical	<ul style="list-style-type: none"> • Storage is below grade
Multiple PINs associated with one Assessment Roll number	<ul style="list-style-type: none"> • One threat point assigned to the entire assessed property.
Where an assessment line transects a property, but has one PIN	<ul style="list-style-type: none"> • One threat point assigned to the entire property.
Lawn/turf	<ul style="list-style-type: none"> • Potential application of commercial fertilizer (ID dependent on the percent of managed land and the application of NU to the surrounding properties)

Table 6-29: Land Use Activity Assumptions for the Purpose of Enumerating Significant Drinking Water Quality Threats in the Centre Wellington Well Supply

Scenario	Assumption
Municipal well sites	<ul style="list-style-type: none"> Commercial fertilizer not applied unless the well is within a municipal park, in which case there is potential that fertilizer is applied.
All properties	<ul style="list-style-type: none"> If buildings and structures are located outside the vulnerable area – circumstance IDs associated with storage and handling are not applied
Septic system	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 was to complete the verification of significant drinking water threats and where warranted, negotiate risk management plans and conduct inspections. This work was focused within the WHPAs delineated in the 2012 and 2015 Assessment Reports. The Township's WHPAs were redelineated in 2018, however, there is overlap between the 2015 and the more recent WHPAs.

To update the significant drinking water quality threats in the current WHPAs, a review of the existing database of verified threats, municipal servicing data, and air photos was completed.

The 2019 threats inventory was completed by a desktop/GIS exercise, using the Municipal Property Assessment Corporation (MPAC) parcel GIS layer and its associated property codes, other data sources and local knowledge. Using ArcGIS, the MPAC parcel information was intersected spatially with the draft WHPA and ICA delineations, as well as the vulnerability scores, to determine which parcels should be examined for possible significant drinking water threats, and which should be excluded. The process of determining the properties and threats enumerated differed slightly for each of the prescribed threats.

Septic System

The septic system threats were enumerated by intersecting the MPAC parcel data with the areas with a vulnerability score of 10. The list of properties was compared to the list of properties identified in the approved 2015 Assessment Report as having a septic system threat and it was confirmed, via the 2015 to 2017 septic inspection data, whether those properties contained septic

systems. Any properties with confirmed septic systems from the 2015 to 2017 septic inspection data that are also within the newly delineated WHPAs, score 10 were enumerated as septic system threats. The list of properties was then compared to municipal infrastructure data to identify all properties not serviced by municipal sewage systems. For the properties not serviced by municipal sewage system data, air photo analysis was completed to determine the location of the WHPA score 10 on each property, in particular whether the WHPA score 10 area was located over or near a house, other buildings or developed land near the house such as grassed areas, yards, driveways etc where a septic system could reasonably be sited. For these properties, septic system threats were enumerated. If the WHPA score 10 area was only located over undeveloped land such as vacant land, parks, wooded areas or agricultural lands then no septic threat was enumerated for that property. Similarly, if the WHPA score 10 area was located over only portions of developed land that are too small to contain a septic system, no septic threat was enumerated for that property. All remaining properties were given a septic system threat.

Sewage Works

Sewage works threats were enumerated for municipal sanitary sewage, industrial sewage and municipal and / or private stormwater management facilities. These threats were enumerated where present in either a vulnerability score of 10 or an ICA for chloride.

For municipal sanitary sewage threats, threats were enumerated for collection systems, individual pumping stations and wastewater treatment plants based on municipal asset management databases and / or records. Each individual pumping station and / or wastewater treatment plant was enumerated as a separate sanitary sewer threat. The remaining components of the municipal sanitary sewage collection systems (ie sewer mains, laterals, siphons, grinder pumps etc) were collectively enumerated as one threat per municipal or type of system. For Centre Wellington, this resulted in three collection threats being enumerated to reflect the Elora and Fergus gravity wastewater collection systems and the Elora / Salem low pressure system.

For municipal stormwater management facilities, threats were enumerated based on municipal asset management databases and / or records. For private stormwater management facilities and industrial sewage works, the provincial Environmental Compliance Approvals (ECA) data was searched and all identified private sewage ECAs were enumerated. Additional private stormwater management facilities were also enumerated based on municipal planning approval records and / or local knowledge.

Pesticide Vendors

Provincial Pesticide Vendor Licence and Operator records were reviewed. Pesticide vendors and operators present within vulnerability score 10 were enumerated as significant drinking water threats.

Waste, DNAPLs and Organic Solvents

To enumerate the waste, DNAPL and organic solvent threats, the MPAC parcels were intersected spatially with the WHPA zones A-C, as well as the issues contributing area (ICA) for trichloroethylene (TCE). Of those remaining properties, the parcels within the vulnerability score of 10 were also identified. As these threats are mostly associated with industrial, commercial and institutional land uses, all parcels with purely residential or agricultural property codes were removed. If a property code indicated mixed use, such as residential/commercial or agricultural/industrial, those properties were included. Then all properties also located within the approved 2015 WHPAs, where significant drinking water threats were confirmed not to be

occurring through the threats verification process, were removed in the threats enumeration count. All properties also located within the approved 2015 WHPAs, where significant drinking threats were confirmed to be occurring through the threats verification process or where a risk management plan has been agreed to, were included in the threats enumeration count.

All remaining properties were examined using the 2015 Southwestern Ontario Orthophotography Project (SWOOP) aerial photography and Google Maps to identify any properties where the possible threat activity would be located outside the WHPA A-C or TCE ICA, or where the lot did not contain a building. Further, any property where the activity could not generate a significant drinking water threat was also removed. This was determined by using a combination of local knowledge, Google Maps data and Google Street View. All remaining properties were given a DNAPL threat, and those identified as being located in a score of 10 were also given a waste and organic solvent threat.

Fuel

Fuel threats were enumerated by intersecting the MPAC parcel data spatially with the areas of the new WHPAs that have a vulnerability score of 10. Then all properties also located within the approved 2015 WHPAs where no fuel storage was confirmed through the threats verification process were removed. All properties also located within the approved 2015 WHPAs, where significant drinking threats were confirmed to be occurring through the threats verification process or where a risk management plan has been agreed to, were included in the threats enumeration count.

The remaining parcels were then intersected with Union Gas meter stop data to determine which properties are serviced with natural gas and removed from the threat enumeration data. All remaining properties were examined using the 2015 SWOOP photography and Google Maps to identify any properties where the possible fuel storage would be located outside the vulnerability score of 10 or where the lot did not contain a building. Those properties were removed. The remaining properties were given a liquid fuel threat for potential home heating oil. Finally, all gas stations, farms with buildings, fuel depots, and locations with known emergency power generators, such as municipal facilities, hospitals and wastewater treatment plants, which are located in the vulnerability score of 10, were included in the data and given a storage of liquid fuel threat.

Agricultural Threats

The agricultural threats were enumerated by intersecting the MPAC parcel data spatially with the areas of the new WHPAs that have a vulnerability score of 10. The MPAC property codes were then used to remove all non-agricultural parcels. All remaining properties were examined using the 2015 SWOOP photography, Google Maps, Google Street View and local knowledge to determine whether the vulnerable zone intersected with a field, with farm buildings, or if the vulnerable zone was located in a woodlot or has been developed. All properties where the zone did not cross a farm field or building were removed. Based on local knowledge or Google Maps, all properties that were agricultural use in the 2015 air photos but are now residential subdivisions were removed. Each property with farm buildings in the vulnerable zone were identified. This list of properties was cross referenced with Provincial Nutrient Management Strategy and Plan data to ensure properties with Provincial approvals were enumerated.

All properties were given a preliminary suite of prescribed threats; application of agricultural source material, non-agricultural source material, commercial fertilizers and pesticides, temporary

field storage of agricultural source material, non-agricultural source material and commercial fertilizers, and pasturing and grazing of livestock. All properties with farm buildings were additionally given the following threats; permanent storage of agricultural source material, non-agricultural source material, commercial fertilizers and pesticides, as well as the use of an outdoor confinement yard.

Parcels were then examined using the SWOOP imagery and the managed lands and livestock density mapping created by the Grand River Conservation Authority to determine which threats apply to which property. Finally, properties where a threats verification process had been completed were identified and the threats associated with that property were adjusted to reflect the results of the verification. If an application of commercial fertilizer threat had been identified as occurring during threats verification, but was determined to no longer be a threat due to updated managed lands and livestock density calculations, it was removed. All properties also located within the approved 2015 WHPAs, where significant drinking threats were confirmed to be occurring through the threats verification process or where a risk management plan has been agreed to, were included in the threats enumeration count.

Salt and Snow

The salt and snow threats were enumerated by intersecting the MPAC parcels with the ICAs for Chloride for Elora and Fergus. The property codes were then used to remove all vacant lots, residential properties with the exception of multi-residential properties greater than 4 units, and agricultural parcels with the exception of agri-business. Municipal properties were reviewed and removed if the property codes were for vacant lots, parkland or residential. Duplicate entries for private and municipal properties were reviewed and removed if confirmed as duplicate entries. All remaining parcels, located within the Chloride ICAs, were given threats for application of salt, storage of salt and storage of snow.

Significant Drinking Water Quality Threats in the Centre Wellington Wellhead Protection Areas

The results of the Centre Wellington 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 6-30: Significant Drinking Water Quality Threats in the Centre Wellington Wellhead Protection Areas			
PDWT¹ #	Threat Subcategory²	Number of Activities	Vulnerable Area
1	Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites	32	WHPA-A WHPA-B
2	Sewage System or Sewage Works- Onsite Sewage Systems	173	WHPA-A WHPA-B
	Sewage System or Sewage Works- Sanitary Sewers and related pipes	5	WHPA-A WHPA-B
	Sewage System or Sewage Works – Sewage Treatment Plant Effluent Discharges (Includes Lagoons)	5	WHPA-B ICA
	Sewage System or Sewage Works- Sewage Storage – Treatment or Holding Tanks	5	WHPA-B ICA
	Sewage System or Sewage Works- Stormwater Management Facility / Industrial Sewage Works	24	WHPA-A ICA
3	Application of Agricultural Source Material to Land	6	WHPA-A WHPA-B
4	Handling and Storage of Agricultural Source Material	6	WHPA-A WHPA-B
6	Application of Non-Agricultural Source Material to Land	5	WHPA-A WHPA-B
7	Handling and Storage of Non-Agricultural Source Material	5	WHPA-A WHPA-B
10	Application of Pesticides to Land	2	WHPA-A
11	Handling and Storage of Pesticide	1	WHPA-B
12	Application of Road Salt	416	ICA
13	Handling and Storage of Road Salt	416	ICA
14	Storage of Snow	416	ICA
15	Handling and Storage of Fuel	69	WHPA-A WHPA-B
16	Handling and Storage of DNAPLs	141	WHPA-A WHPA-B WHPA-C ICA
17	Handling and Storage of Organic Solvents	32	WHPA-A WHPA-B

Table 6-30: Significant Drinking Water Quality Threats in the Centre Wellington Wellhead Protection Areas			
PDWT¹ #	Threat Subcategory²	Number of Activities	Vulnerable Area
21	Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation (Grazing and pasturing)	5	WHPA-A WHPA-B
Total Number of Activities		1764	
Total Number of Properties		709	
<p>1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).</p> <p>2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.</p> <p>Note: Storm sewer piping is not considered to be part of a storm water management facility.</p>			

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

It should be noted that the enumerated threats listed in Table 6-31 for the road salt application, road salt storage and snow storage categories only apply to significant drinking water threats where Part IV may apply (ie prohibition or risk management plans). Due to the delineation of ICAs for chloride, all properties within the ICA that apply or store any quantity of road salt and / or store snow greater than the width of a double driveway are significant drinking water threats. This includes all residential properties. It is estimated that the total number of properties within the ICA is approximately 5,000. The vast majority of these properties would be addressed through education and outreach policies and not Part IV policies.

Limitations and Uncertainty for the Enumeration of Significant Drinking Water Threats

- The threat assessment was a desktop scale analysis based on the assumptions used for the threat rankings. The assessment involved only minor field verifications or site visits to validate the information. The current assessment identified significant water quality threats based on a number of assumptions; no site visits to confirm actual site conditions and circumstances were completed beyond site visits that had already been completed previously. Site visits may be needed to confirm actual site conditions and circumstances and in some cases to develop site specific response and risk management activities.
- The threat assessment relied on a number of pre-existing data sources to complete the evaluation. In some cases the data sources were not current. Activities taking place on a given property may change from year to year or month to month. In particular, the air photos used primarily dated from 2015.
- The MPAC property codes used to identify the use of the property and the associated threats do not always represent the current land use activity on the property. As such, threats may be applied to a property where they do not exist or vice versa. Threats may have been missed on a property where they do exist.
- Although additional data was obtained and a review was completed on a number of Condition sites since the original 2012 Assessment Report, seven (7) Condition sites

identified within the WHPAs contain insufficient information to confirm whether these sites meet the criteria to be a Condition threat. The available documentation for these sites should be assessed to identify whether further soil or groundwater assessments are warranted, by the responsible parties, to confirm whether these sites meet the criteria to be a Condition threat.

- 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 6-31** and **Table 6-32** summarize the municipal groundwater systems and the average monthly and annual pumping rates for both systems.

Table 6-31: 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 Classification¹	Number of Users served²
220005599	Rockwood Water Supply System	Guelph / Eramosa Township	GW	Large Municipal Residential System	1635
220009197	Hamilton Drive Water Supply System	Guelph / Eramosa Township	GW	Large Municipal Residential System	216
¹ as defined by O. Reg. 170/03 (Drinking Water Systems) made under the <i>Safe Drinking Water Act, 2002</i> .					
² Based on Watson & Associates Economists LTD. The Township of Guelph / Eramosa Water and Wastewater Rate Study (July 2015)					

Table 6-32: 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	292.96	3.31	240.10	230.13	232.65	392.77	331.92	305.18	315.27	361.69	296.36	318.40	487.76
Well 2	238.05	279.64	3.89	205.83	257.76	237.49	325.94	303.58	277.76	333.69	292.67	230.56	107.84
TW3/02	380.55	617.10	625.08	370.23	355.13	382.15	335.65	337.81	312.42	285.63	294.04	307.56	343.77
Hamilton Drive													
Cross Creek	69.80	54.90	74.62	74.95	64.27	90.11	108.75	83.76	77.16	63.31	41.90	42.88	60.88
Huntington	73.08	68.33	41.11	47.31	64.39	80.49	57.04	111.78	98.23	90.49	72.77	71.57	73.50
¹ source: Based on Guelph / Eramosa Township 2018 Annual Summary Report (2019)													

¹ source: Based on Guelph / Eramosa Township 2018 Annual Summary Report (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.

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).

Hydrogeology

Bedrock aquifers in the Guelph Formation and Gasport Formation are the main source of groundwater in the Township. 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 uppermost bedrock unit. Near Hamilton Drive, it 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.

6.4.1 Rockwood Water Supply System

The Rockwood Water Supply System services a population of approximately 1,635 people (2015) in the Village of Rockwood. 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 constructed 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.

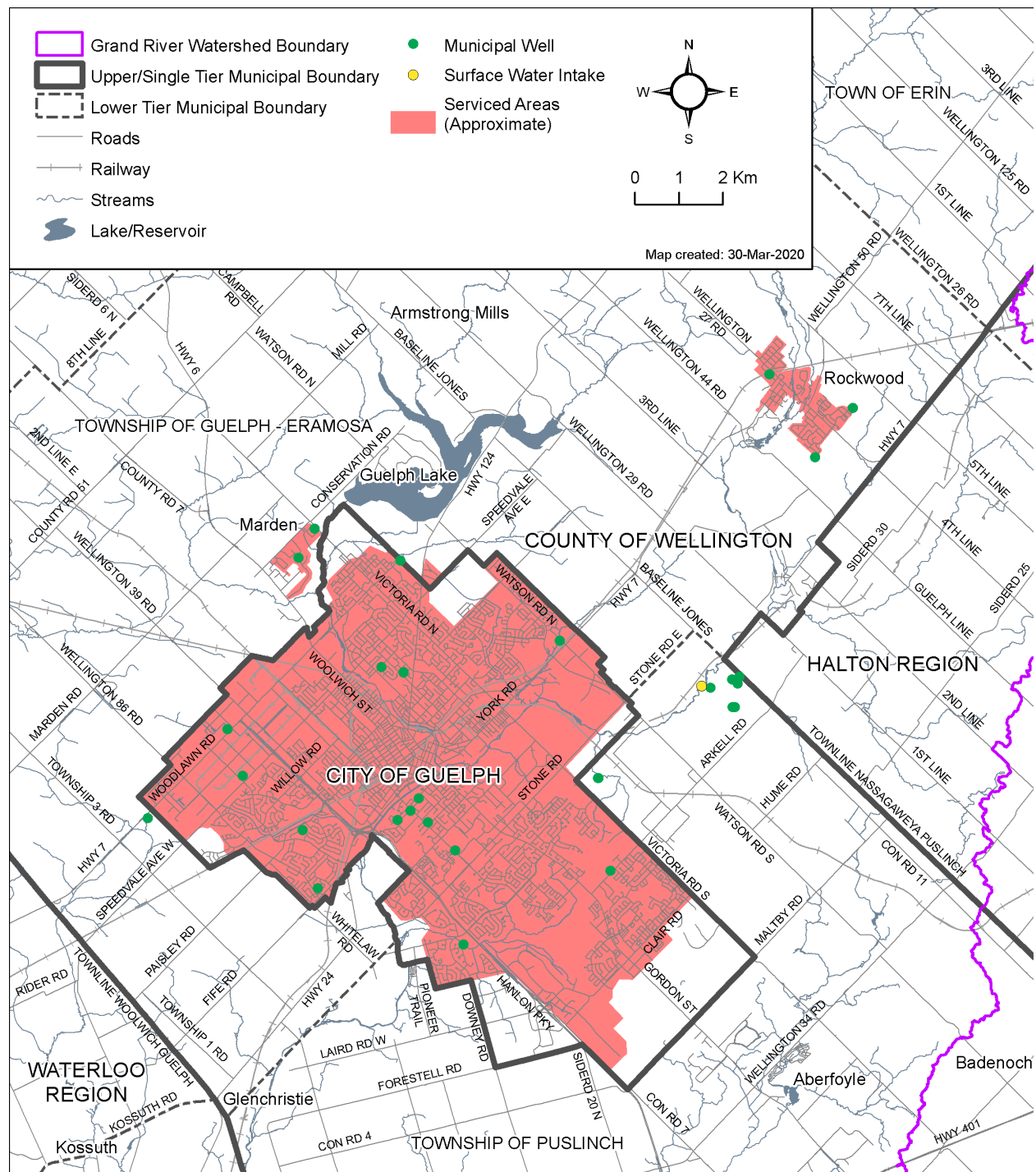
Rockwood Wells 1 and 2 are designated Groundwater Under the Direct Influence of surface water (GUDI) “based on the karstic nature of the area, the proximity of the bedrock to the surface and the immediate response to pumping recorded in the shallow bedrock at a nearby monitoring well. These occurrences 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.

6.4.2 Hamilton Drive Water Supply System

The Hamilton Drive Water Supply System services a population of approximately 216 people (2018) 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, is an open hole in bedrock from 39.62 m to a depth of 99 m bgs within the Reformatory Quarry member of the Eramosa Formation. The Huntington Well also known as Huntington Estates PW1, is an open hole in bedrock from 12.5 to 71.9 m bgs within the Guelph and middle Gasport Formations.

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

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 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; 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/Guelph-Eramosa Tier 3 FEFLOW model is referred to as the Base Case scenario. The pumping rates for the Rockwood wells (**Table 6-33**) 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 m³/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 6-33: Water Takings from Municipal Production Wells in the Rockwood and Hamilton Drive Well Supply		
Well	Permit to Take Water (m³/day)	Rate Used to Delineate WHPA (m³/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 adjusted the calibrated Base Case model parameters and evaluated 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'.

To develop capture zones, virtual particles were released in the groundwater flow model and tracked backward in time through the subsurface for various time intervals. The computed pathlines travelled by these particles were projected to ground surface and plotted on a plan view map. Time-of-travel capture zones were subsequently created by drawing polygons around the municipal well from which the particles were released and the particle pathlines for specific time intervals. All particle tracks for the Base Case and sensitivity scenarios were rotated by +/- 5 degrees around each municipal well to account for uncertainty in the groundwater flow direction.

Delineation of the Rockwood and Hamilton Drive Wellhead Protection Areas

The Rockwood WHPAs are shown on **Map 6-38**. In general, the WHPAs for all Rockwood Wells extend in a northerly direction. The “Y” shape at Rockwood Well 1 and 2 is heavily influenced by the presence of the Eramosa River, where the pumping well captures groundwater flowing toward the well from both sides of the river. In the area of Rockwood Wells 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 Cross Creek and Huntington WHPAs extend in a north northwest (NNW) direction with their zones overlapping within the WHPA-B, C and D as presented in **Map 6-39**. The WHPA-D for both Cross Creek and Huntington extends approximately 17 km from the supply wells.

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

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, 2017).

Wellhead Protection Area

Zone Name

- WHPA-A
- WHPA-B
- WHPA-C
- WHPA-D

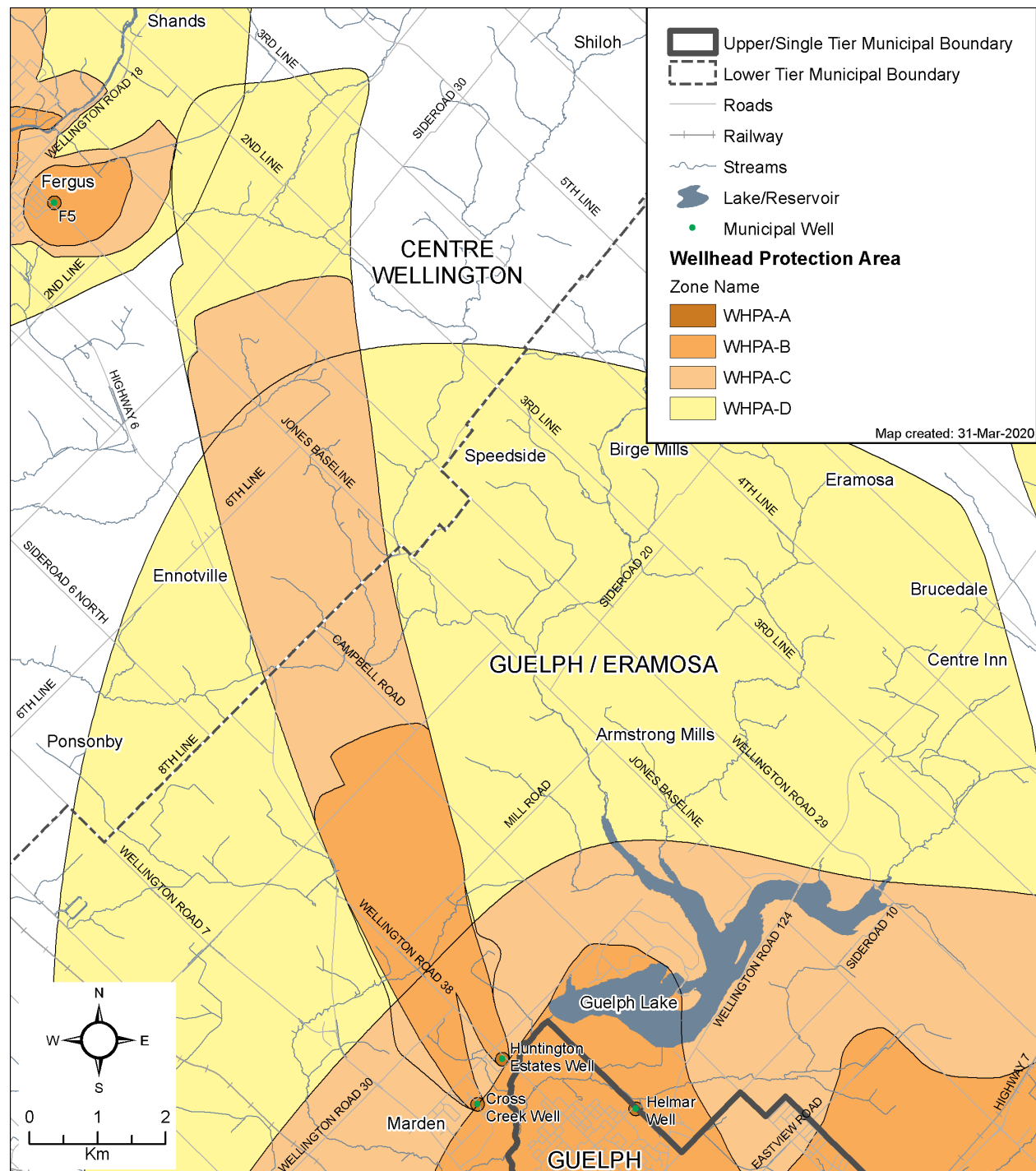
Legend:

- Upper/Single Tier Municipal Boundary
- Lower Tier Municipal Boundary
- Roads
- Railway
- Streams
- Lake/Reservoir
- Municipal Well

Map created: 30-Mar-2020

Map labels include: ERIN, GUELPH / ERAMOSA, MILTON, Brucedale, Centre Inn, Wells 1&2, Well 3, Well 4, Rockwood, Alma Street, Highway 7, Wellington Road 27, Wellington Road 29, Wellington Road 44, Wellington Road 125, Wellington Road 40, Wellington Road 32, Wellington Road 30, Wellington Road 31, Wellington Road 33, Wellington Road 34, Wellington Road 35, Wellington Road 36, Wellington Road 37, Wellington Road 38, Wellington Road 39, Wellington Road 40, Wellington Road 41, Wellington Road 42, Wellington Road 43, Wellington Road 44, Wellington Road 45, Wellington Road 46, Wellington Road 47, Wellington Road 48, Wellington Road 49, Wellington Road 50, Wellington Road 51, Wellington Road 52, Wellington Road 53, Wellington Road 54, Wellington Road 55, Wellington Road 56, Wellington Road 57, Wellington Road 58, Wellington Road 59, Wellington Road 60, Wellington Road 61, Wellington Road 62, Wellington Road 63, Wellington Road 64, Wellington Road 65, Wellington Road 66, Wellington Road 67, Wellington Road 68, Wellington Road 69, Wellington Road 70, Wellington Road 71, Wellington Road 72, Wellington Road 73, Wellington Road 74, Wellington Road 75, Wellington Road 76, Wellington Road 77, Wellington Road 78, Wellington Road 79, Wellington Road 80, Wellington Road 81, Wellington Road 82, Wellington Road 83, Wellington Road 84, Wellington Road 85, Wellington Road 86, Wellington Road 87, Wellington Road 88, Wellington Road 89, Wellington Road 90, Wellington Road 91, Wellington Road 92, Wellington Road 93, Wellington Road 94, Wellington Road 95, Wellington Road 96, Wellington Road 97, Wellington Road 98, Wellington Road 99, Wellington Road 100.

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



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**.

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**.

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

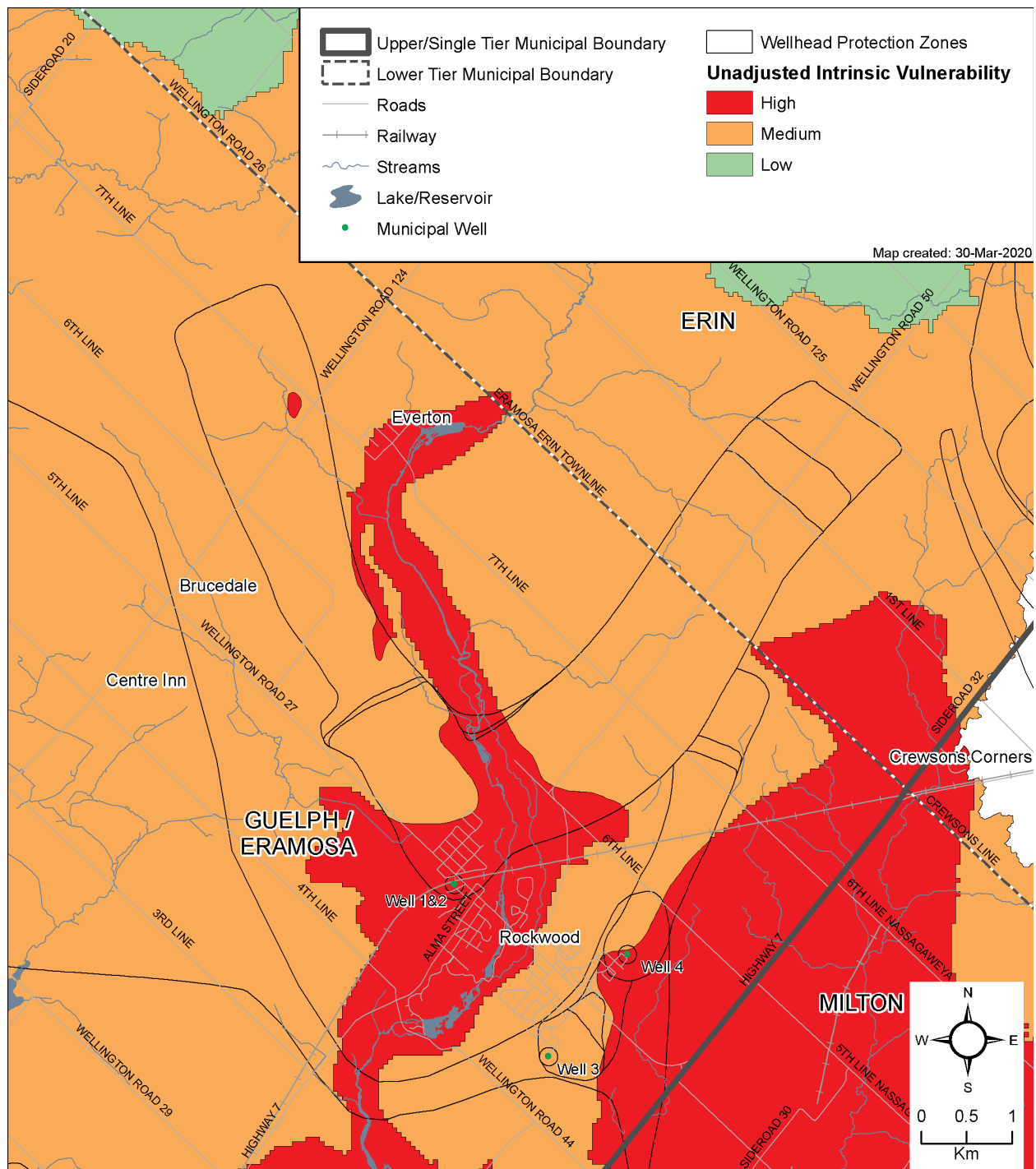
The uncertainty analysis factors considered in this assessment follow Part I.4, Rule 14 of the Technical Rules (MOECC, 2017). **Table 7-43** shows a summary of the uncertainty for the WHPA delineation and vulnerability analysis for the Rockwood and Hamilton Drive Water Supply Systems.

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 assessments completed	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 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

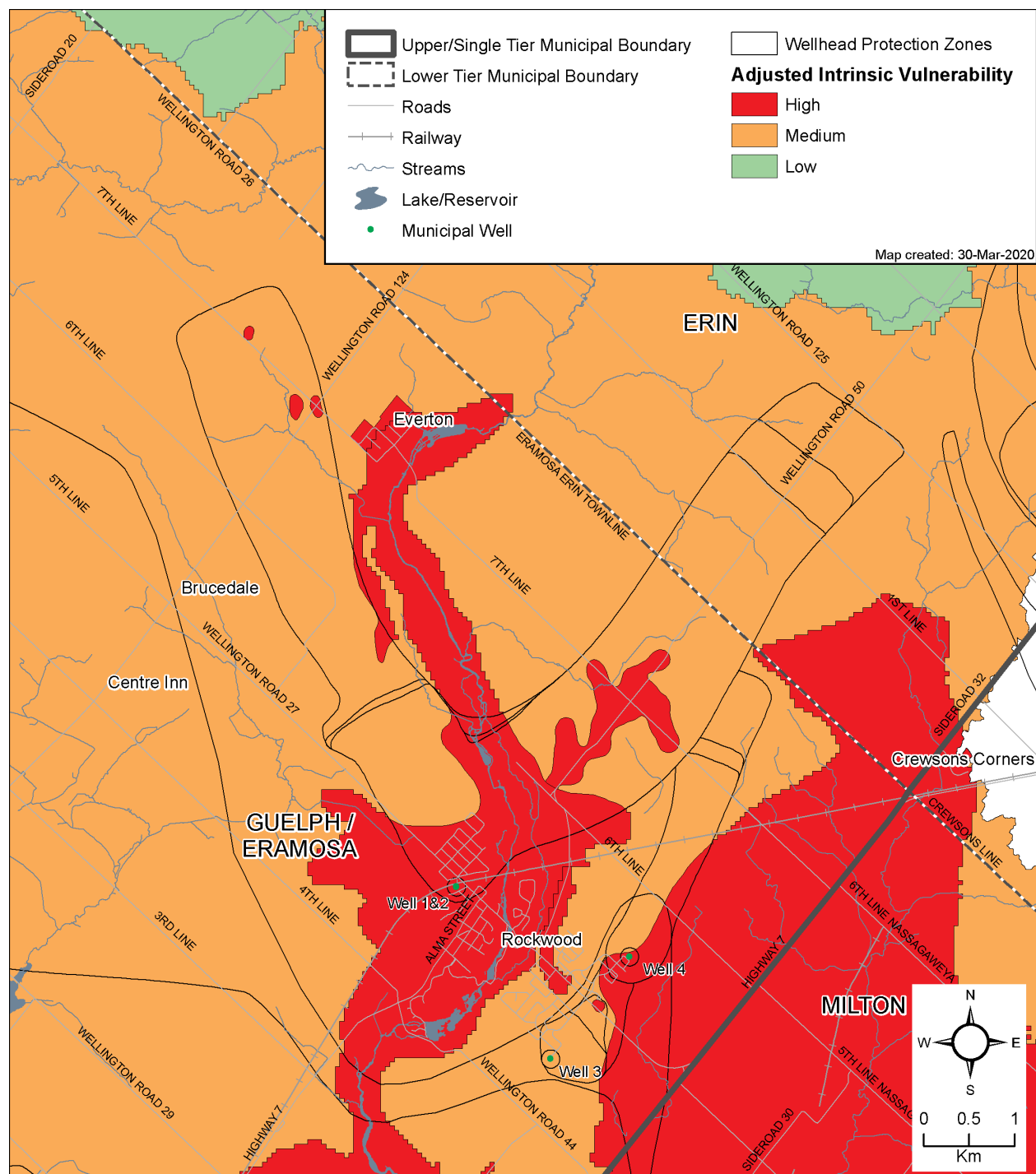
Table 7-43: Uncertainty Assessment for the Rockwood and Hamilton Drive Water Supply Systems		
Uncertainty Assessment Factor	Uncertainty Designation	Description
		vulnerability mapping is based on, has not been completed to verify whether the groundwater vulnerability categories still effectively assess 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.

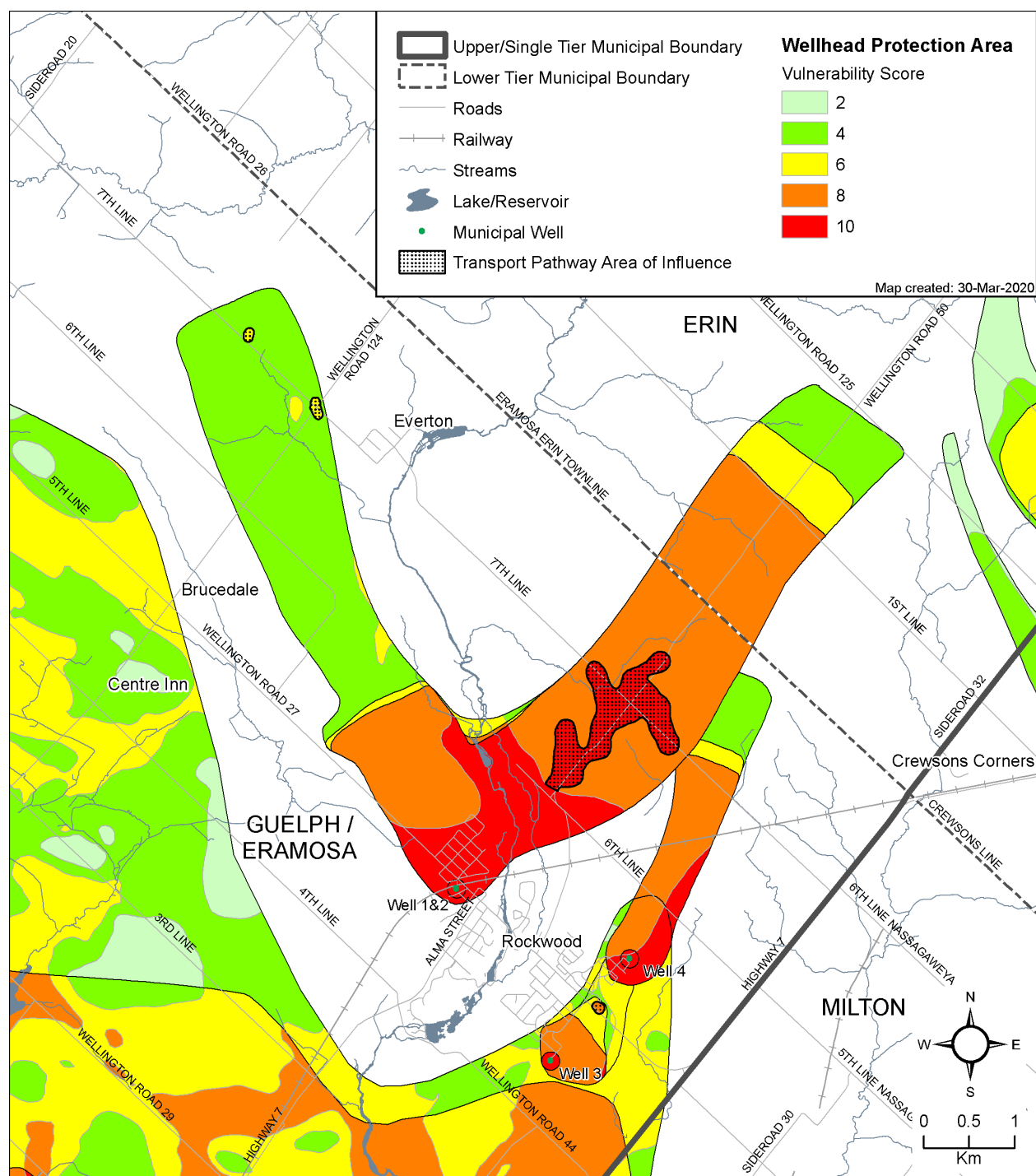
Map 6-40: Rockwood Water Supply Wellhead Protection Area Unadjusted Intrinsic Vulnerability



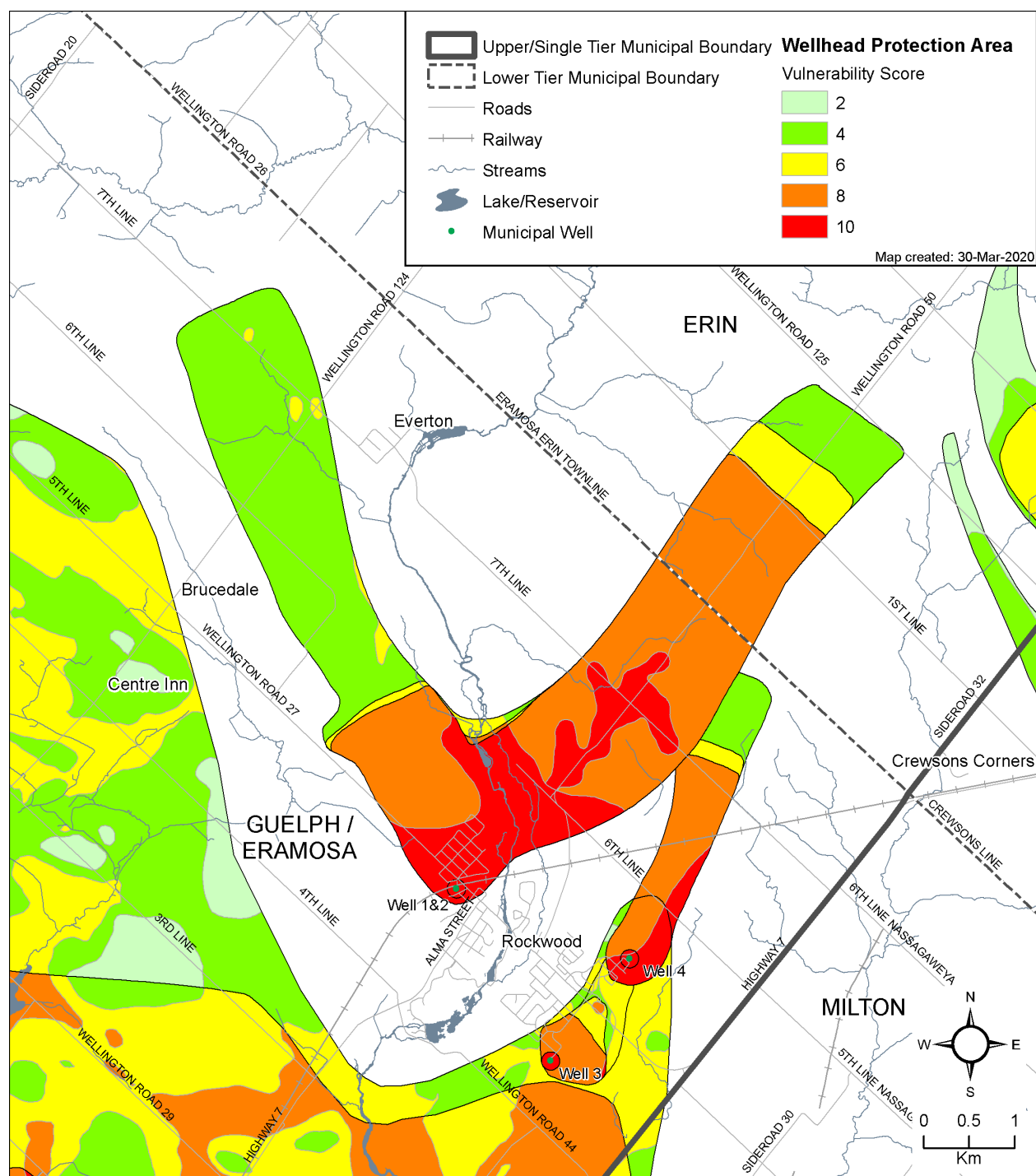
Map 6-41 Rockwood Water Supply Adjusted Intrinsic Vulnerability



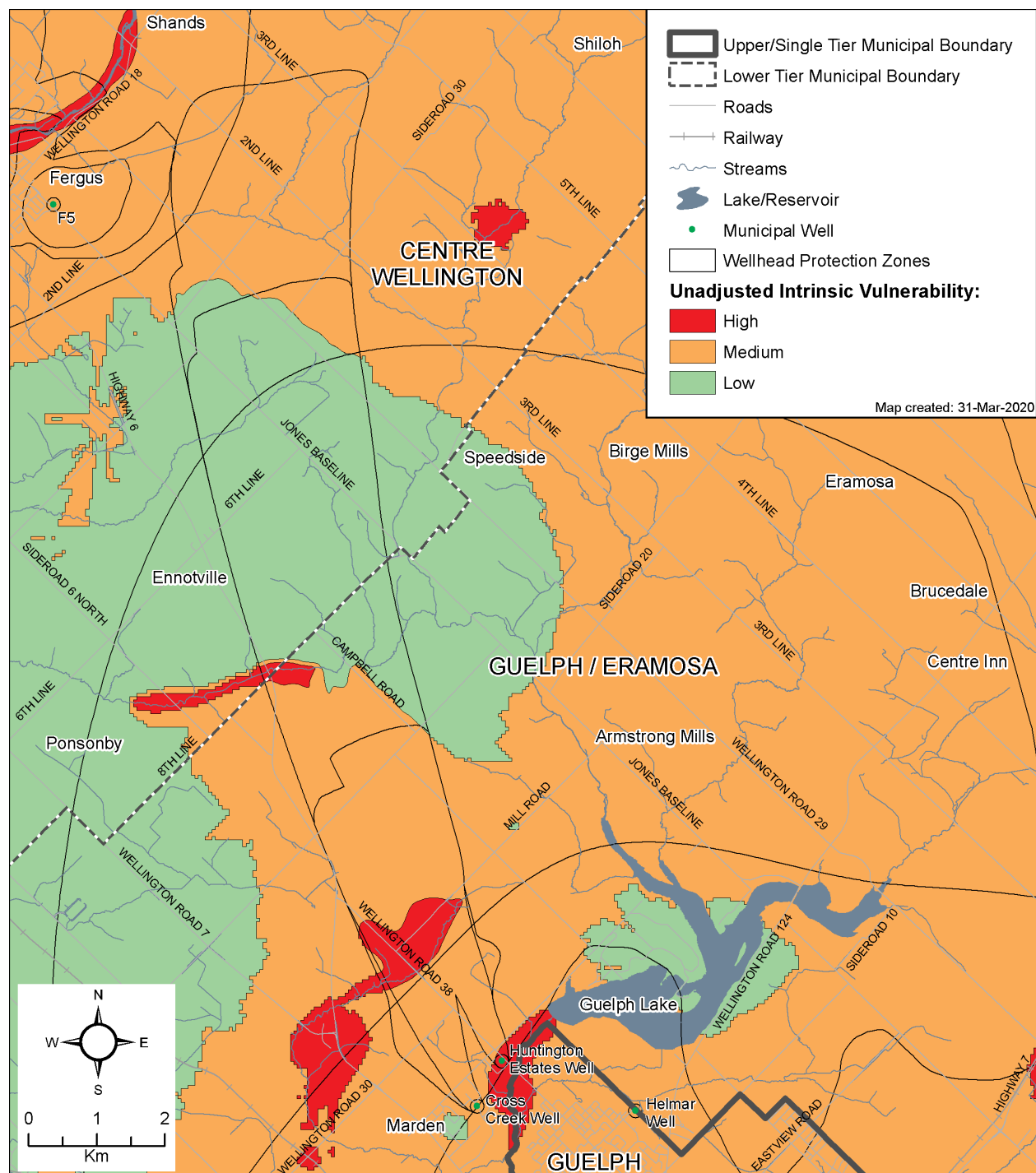
Map 6-42: Rockwood Water Supply Transport Pathway Area of Influence



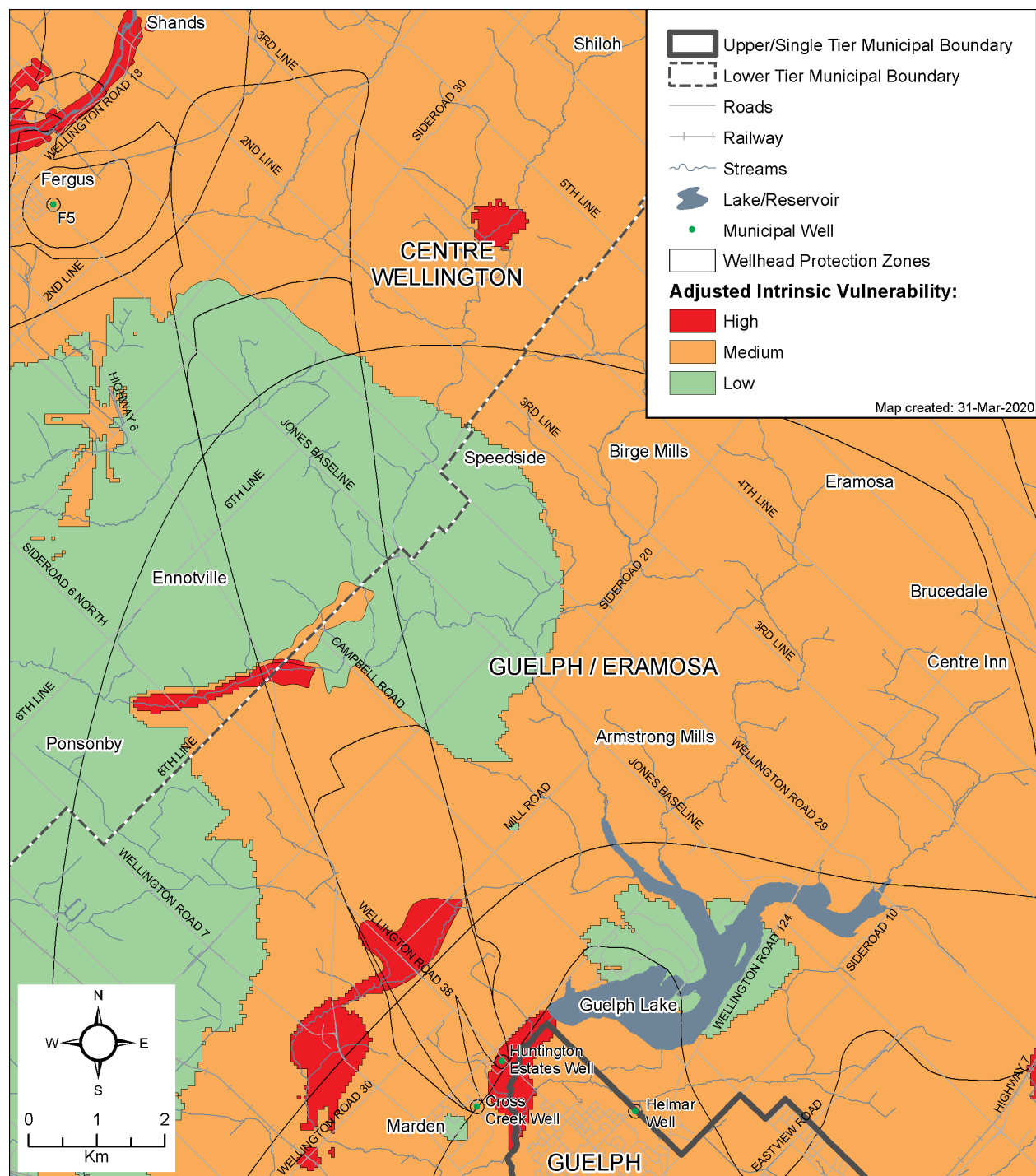
Map 6-43: Rockwood Water Supply Wellhead Protection Area Final Vulnerability



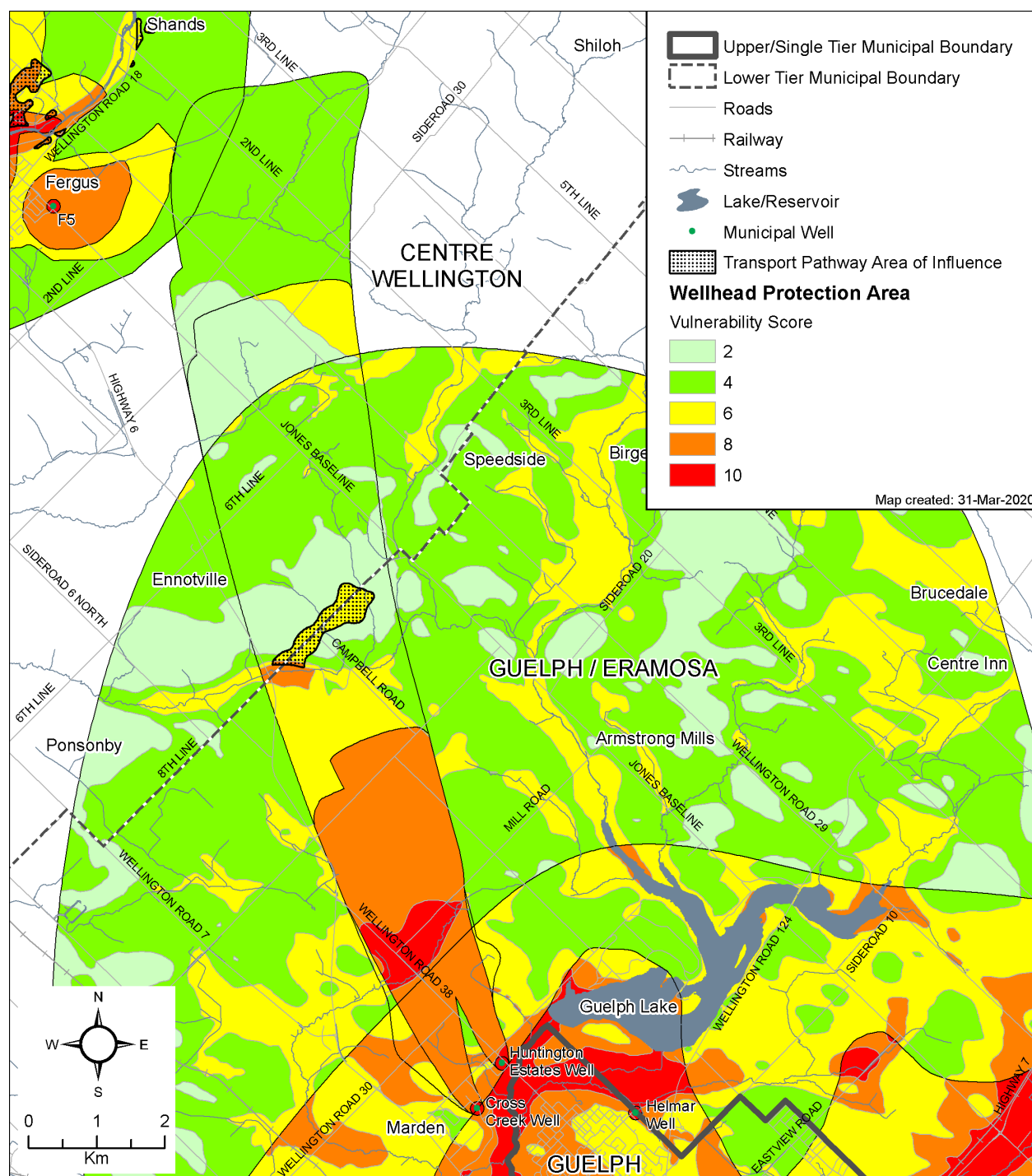
Map 6-44 Hamilton Drive Water Supply Unadjusted Intrinsic Vulnerability



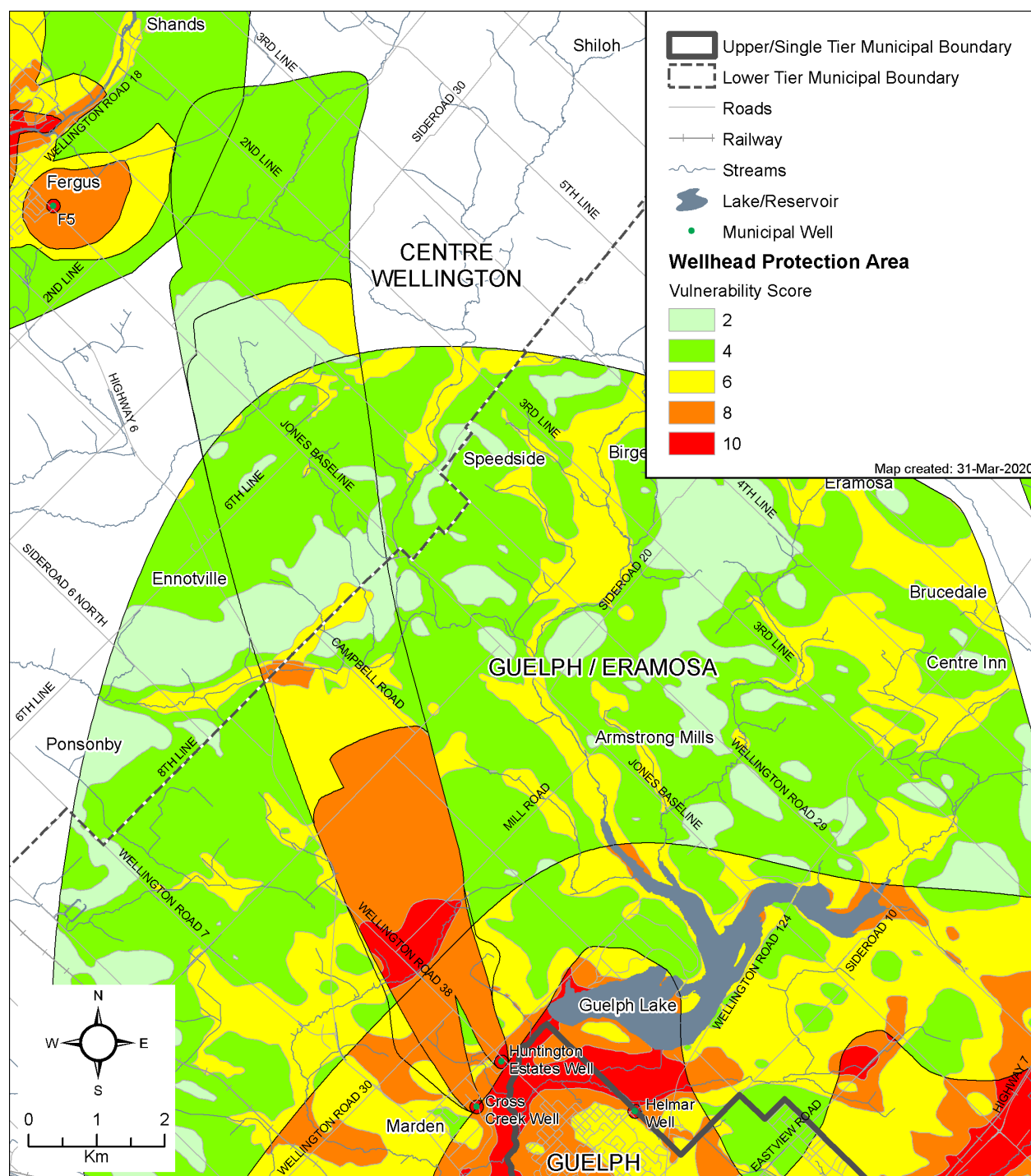
Map 6-45: Hamilton Drive Water Supply Wellhead Protection Area Adjusted Intrinsic Vulnerability



Map 6-46: 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.

Managed lands calculations for Rockwood and Hamilton Drive were completed in WHPA-A to WHPA-D where the vulnerability was 6 or higher. **Table 6-34** provides the results of the calculations and **Map 6-48** and **Map 6-49** illustrate the results.

Table 6-34: 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	17.71%	56.90%	72.90% (west); 3.55% (centre); 32.64% (east);	44.24% (west); 0% (centre); N/A (east)
		Well 3	66.03%	58.20%	36.89%	36.23%
		Well 4	25.54%	60.84%	92.69%	N/A
	Hamilton Drive	Cross Creek	71.79%	75.58%	75.80%	49.02% (west); N/A (north); N/A (east)
		Huntington	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.

The results of the calculations for livestock densities are provided in **Table 6-35** and **Map 6-50** and **Map 6-51**, for the Rockwood and Hamilton Drive Wellhead Protection Areas.

Table 6-35: 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	0.57 (west); 2.81 (centre); 0.01 (east)	0.01 (west); 0.00 (centre); N/A (east)
		Well 3	0.16	0.30	0.52	0.87
		Well 4	0.00	0.37	0.29	N/A
	Hamilton Drive	Cross Creek	0.00	0.63	0.65	5.82 (west); N/A (north); N/A (east)
		Huntington	0.00			

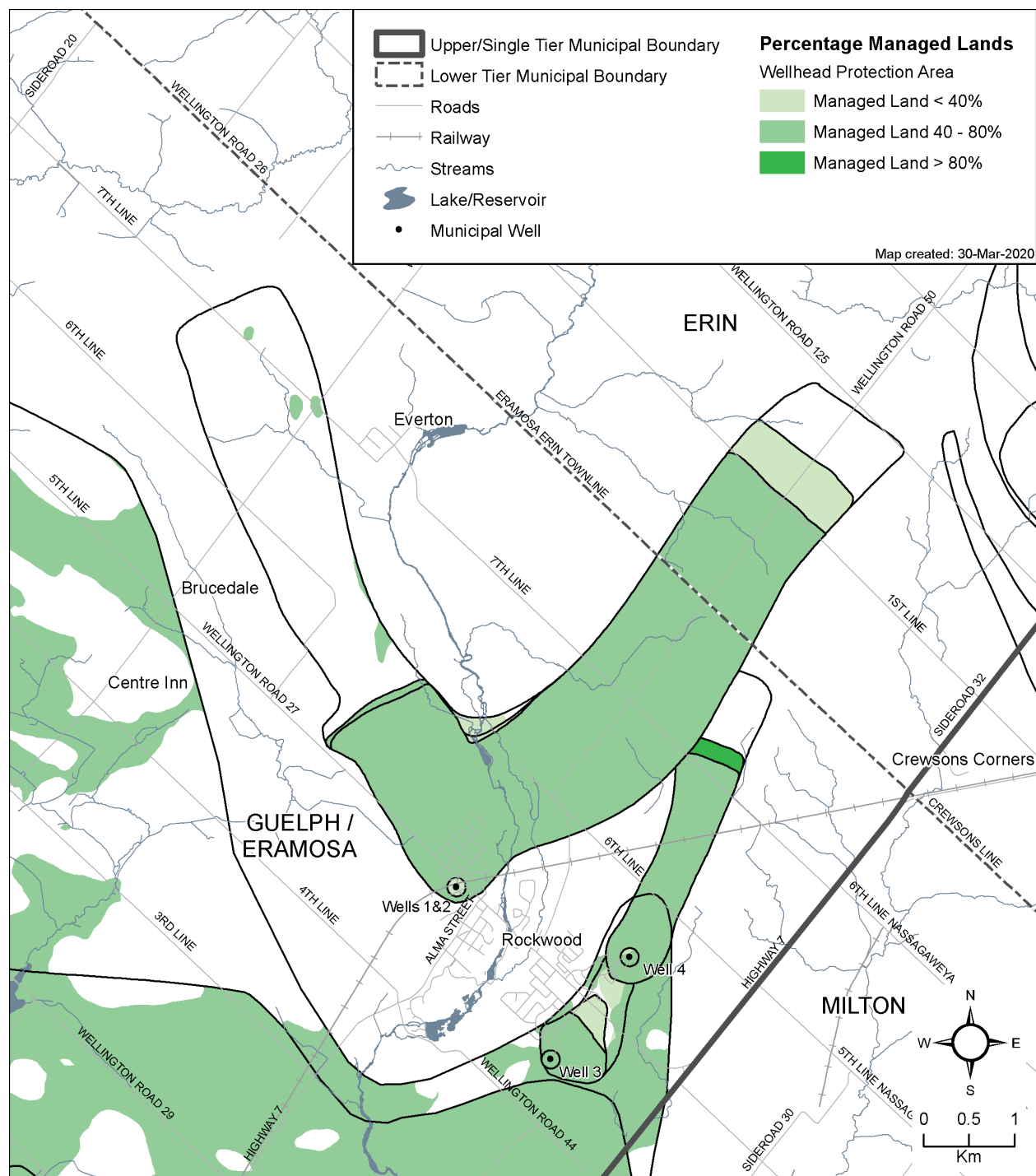
A coding of 0 in **Table 6-35** indicates that there were no agricultural livestock barns to contribute nutrients and therefore the value for livestock density is 0. A coding of N/A indicates that the vulnerability score in this area is 4 or less.

Percent Impervious Surface Area in Wellhead Protection Areas

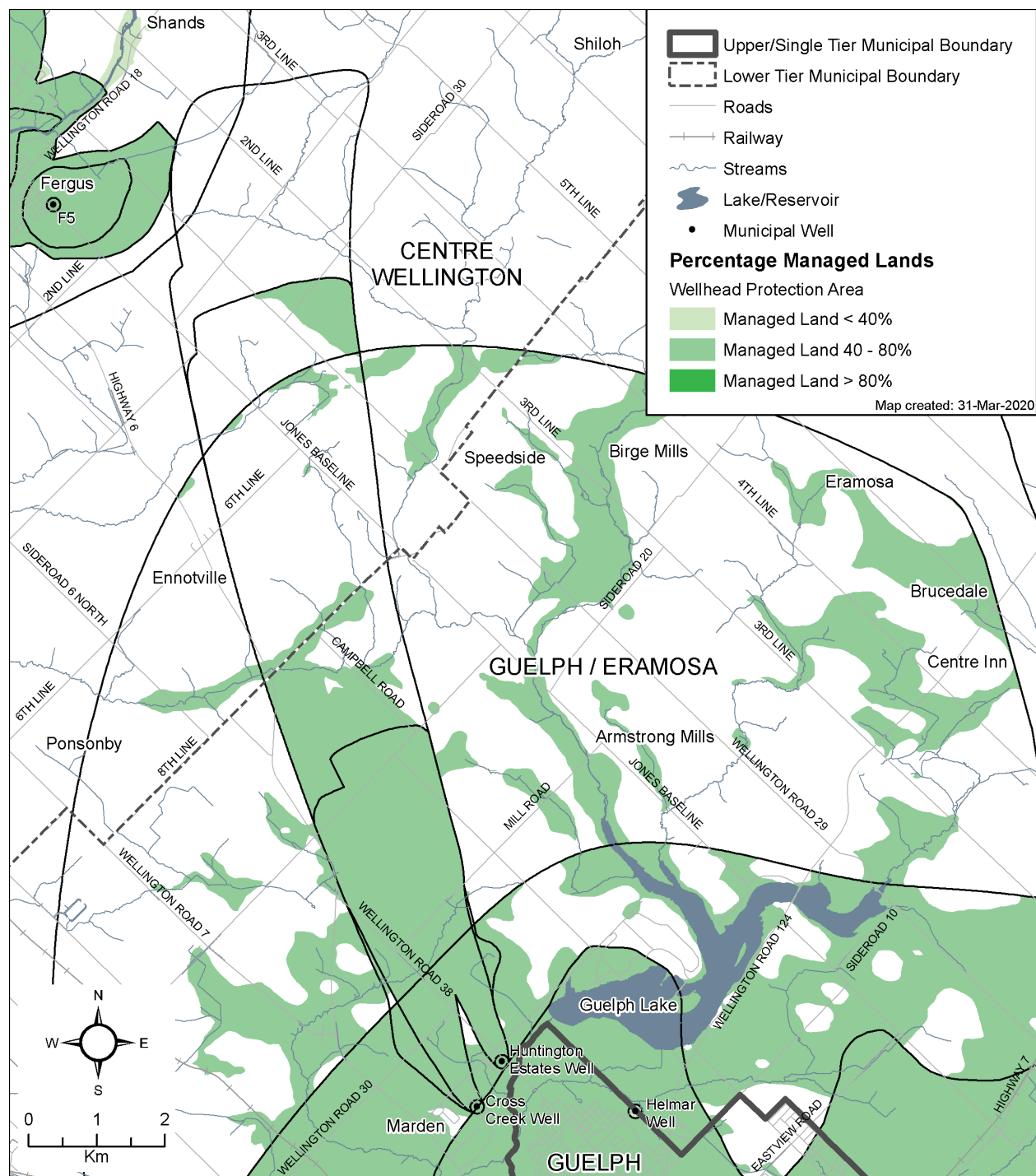
To determine whether the application of road salt poses a threat in the Township of Guelph-Eramosa, the percentage of impervious surface where road salt can be applied per square kilometre was calculated as per Technical Rules 16(11) and 17. The moving window average technique, described in Chapter 3 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 impervious surface percentages were calculated in each WHPA for the Township of Guleph/Eramosa. The results indicate a low to moderate percentage of impervious surfaces for both Rockwood and Hamilton Drive as shown in **Map 6-52 and Map 6-53**. With the current thresholds in the MECP's Tables of Drinking Water Threats the application of road salt is not a significant threat.

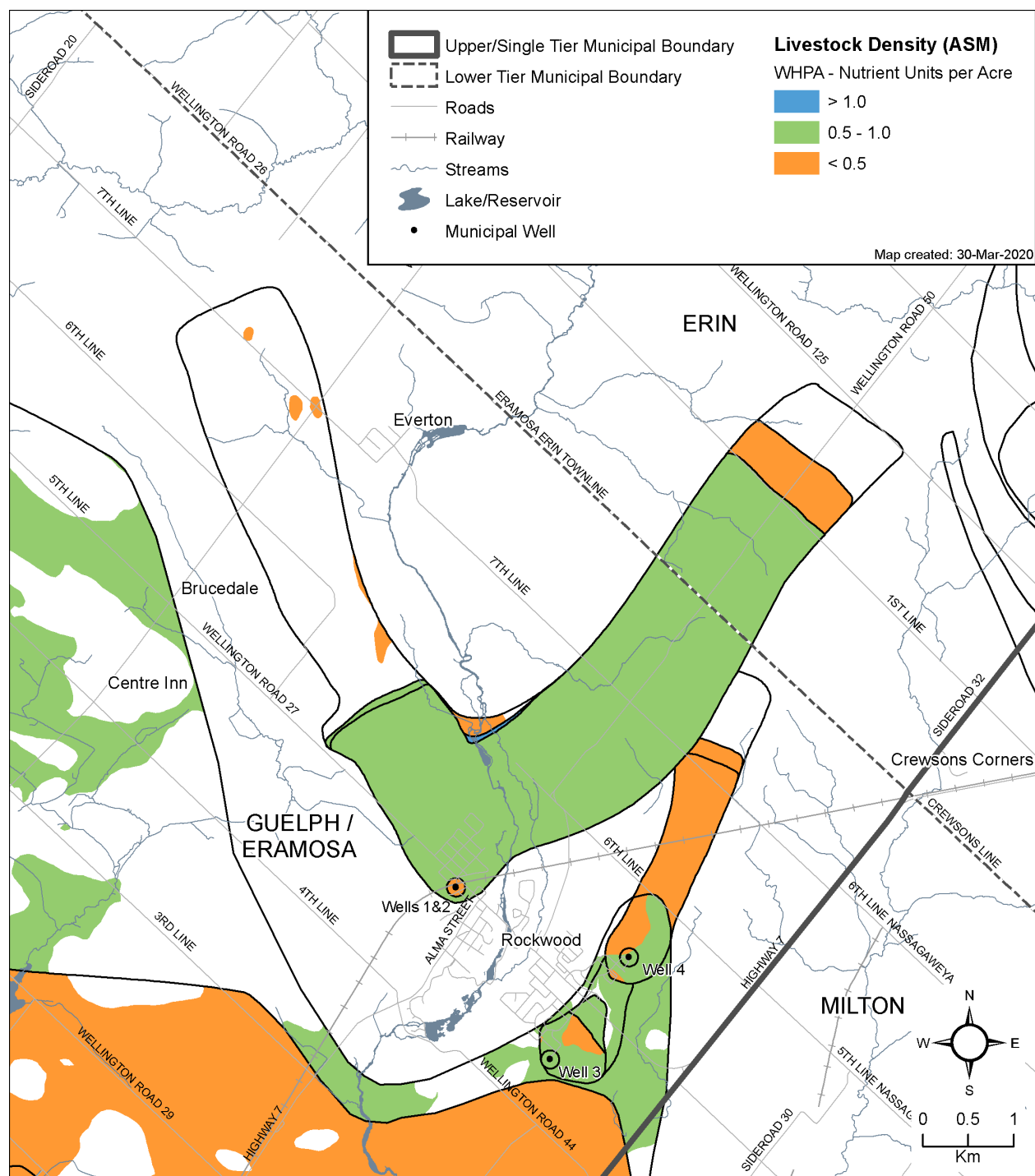
Map 6-48: Rockwood Water Supply Percent Managed Lands



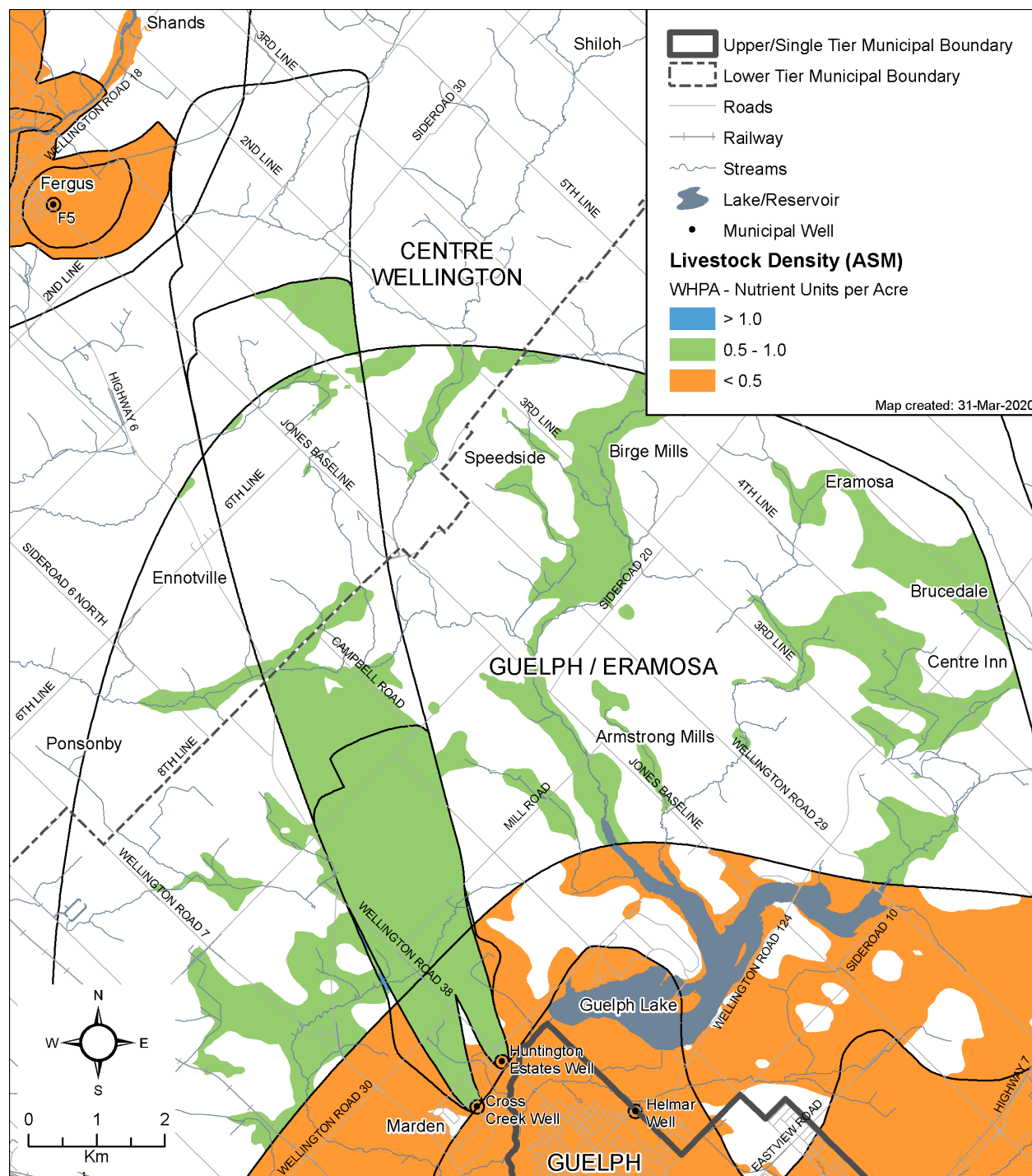
Map 6-49: Hamilton Drive Water Supply Percent Managed Lands



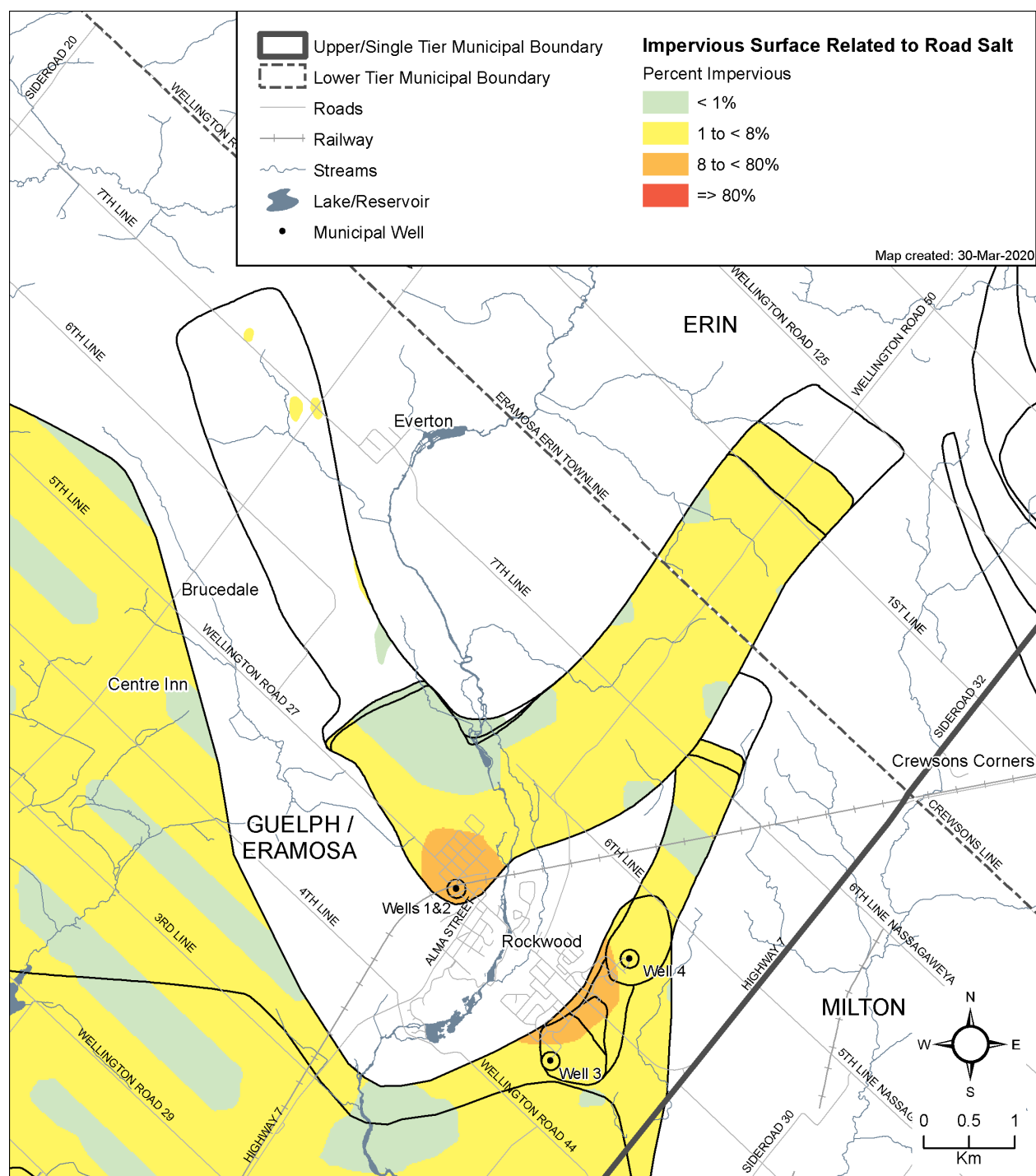
Map 6-50: Rockwood Water Supply Livestock Density



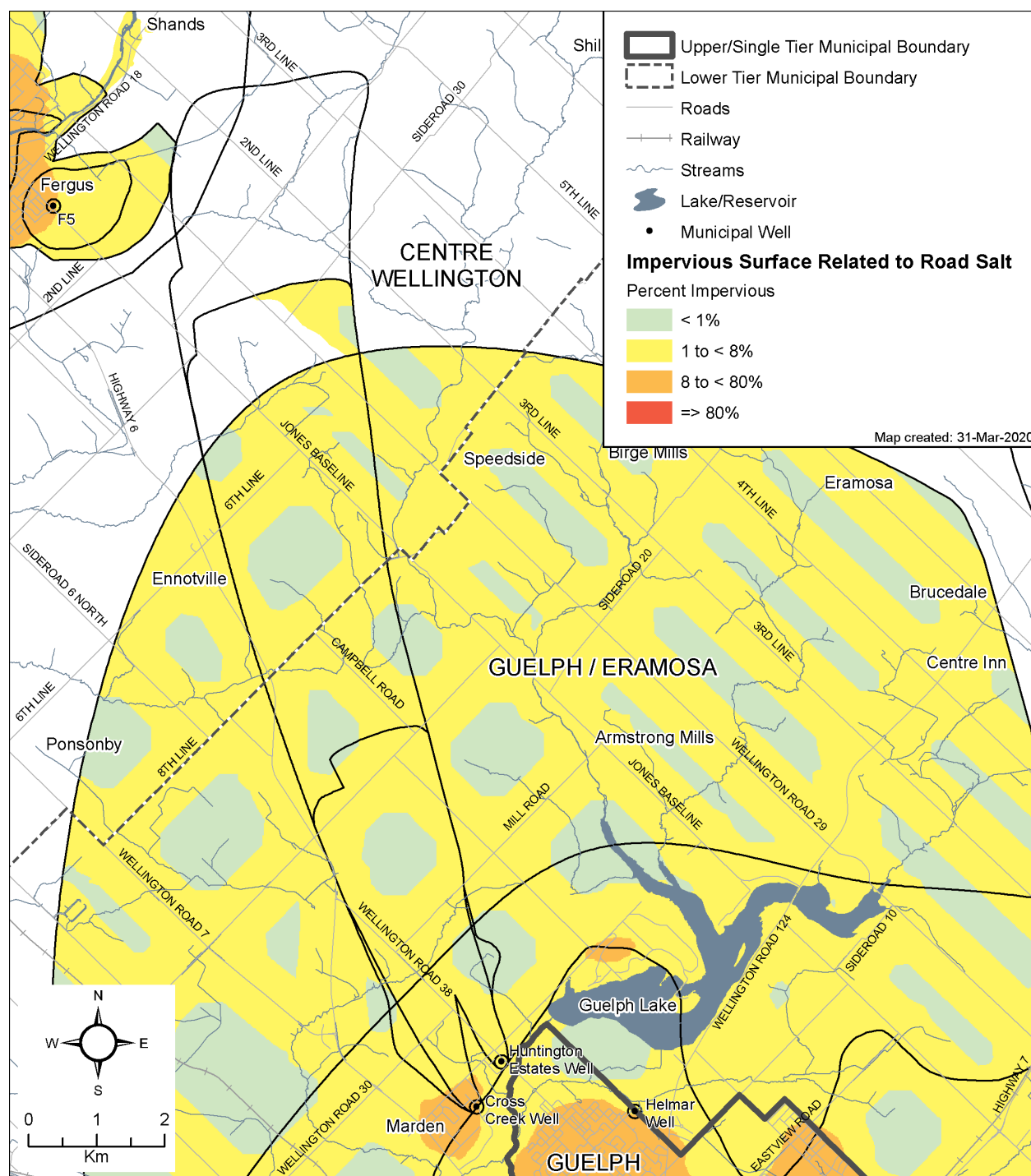
Map 6-51: Hamilton Drive Water Supply Livestock Density



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>. 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 6-36 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 6-36: 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-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		✓	✓

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. 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 6-37 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 6-37: 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 was 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. Note that one site was also assessed in the Hamilton Drive WHPAs and is located in Centre Wellington. The municipality has limited information on this site, however, based on the vulnerability score of 2 in a WHPA-C, the risk score would not exceed the threshold to be identified as a significant drinking water threat. This site is one of the seven sites identified in the Centre Wellington section as requiring further information.

Based on the documentation available in 2019, the additional, two (2) sites within Rockwood 1 / 2 WHPA- A are not considered condition sites under Technical Rule 126.

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 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, 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. 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). A hardness concentration of 480 mg/L was recorded for Well 1 and 2 in 2018. This is above the Operational Guideline of the ODWQS range of 80-100 mg/L. 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.

Water quality data for 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 (Rockwood) Wells 1 and 2. One exceedance of total coliforms (2 cfu/100 mL) was reported in June 2015.

In 2005, an exceedance of fluoride at Rockwood Well 3 was noted of 1.65 mg/L (MAC of 1.5 mg/L). No further exceedances for fluoride have been recorded since 2005. 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 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 reaching 180 mg/L in 2018 (**Figure 6-4**). 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 sharp increasing trend at Rockwood Wells 1 and 2 during 2018 and 2019. 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 6-5). Chloride concentrations range from 180 to 260 mg/L (2018 and 2019) at Rockwood Wells 1 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 higher during the winter and spring months when runoff from roads is recharging the aquifer. . 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.

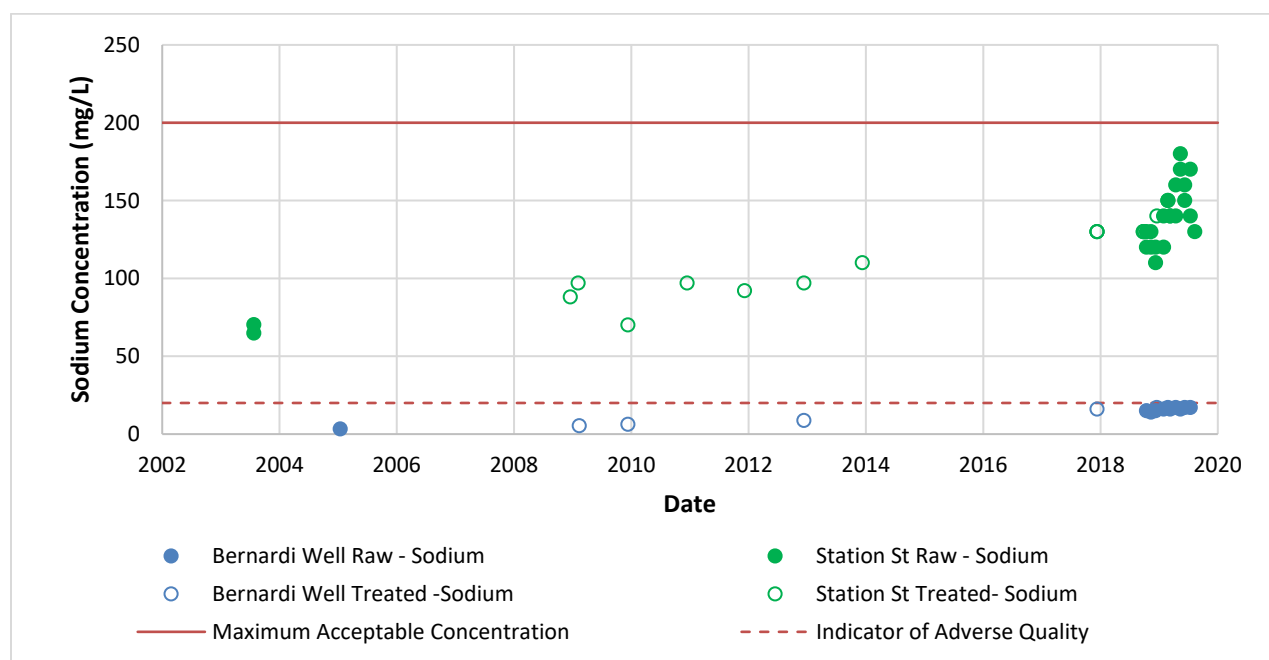


Figure 6-4 : Sodium Concentrations at Rockwood Wells (Bernardi (3) and Station St. (1 and 2))

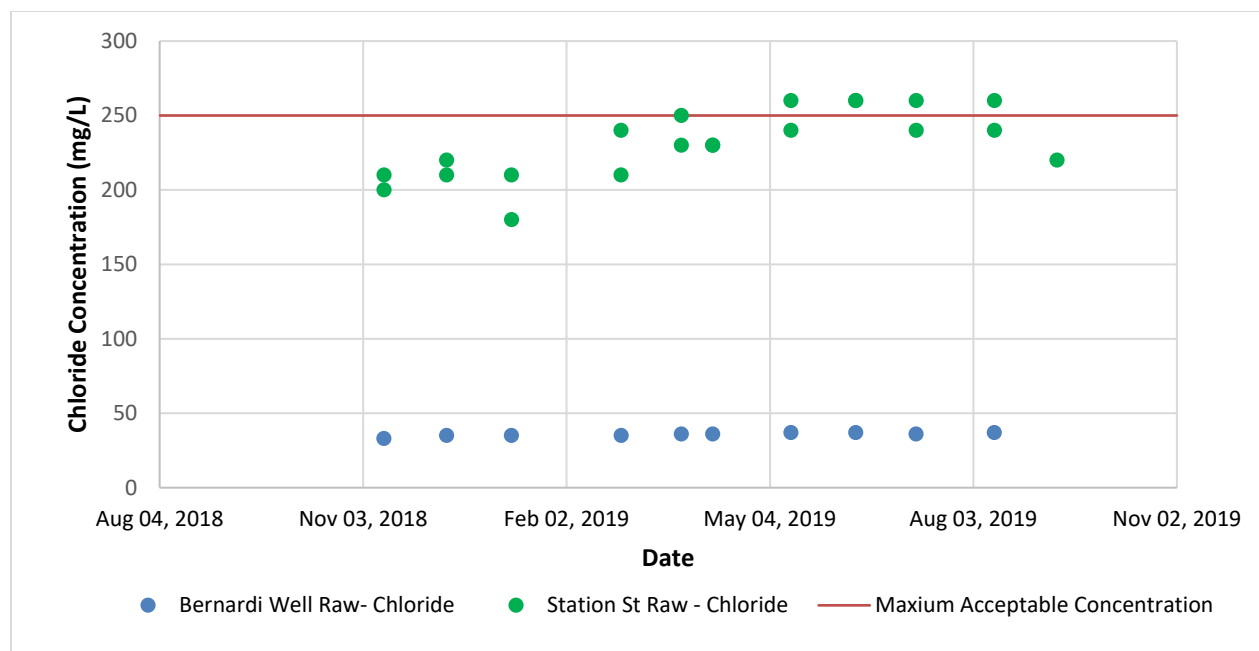


Figure 6-5: Chloride Concentrations at Rockwood Wells (Bernardi (3) and Station St. (1and 2))

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 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.

There are currently no Issues concerning drinking water quality 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 of 300 mg/L in 2019. 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.

Water quality data for up to 2019 were reviewed. Microbiological data reported exceedences in August 2015, June 2017, July 2017, and October 2017 of total coliforms. One exceedance of *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 exceedences 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 2019; however sampling frequency did not increase until 2018. This is a limited time span with frequent sampling making it difficult to confirm trends. 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, 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 6-38**.

Table 6-38: 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	<ul style="list-style-type: none"> Storage and handling of pesticides, fuel, commercial fertilizer, agricultural source material, septic system. Application of pesticide, commercial fertilizer, agricultural source material.
Agricultural property with residence and outbuilding – buildings not in WHPA	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied.
Residence with no gas line	<ul style="list-style-type: none"> Oil furnace
Organic solvent	<ul style="list-style-type: none"> Storage below grade in a quantity that would make it a significant threat
No sanitary sewer infrastructure	<ul style="list-style-type: none"> Septic system
Presence of any chemical	<ul style="list-style-type: none"> Storage is below grade
Multiple PINs associated with one Assessment Roll number	<ul style="list-style-type: none"> One threat point assigned to the entire assessed property.
Where an assessment line transects a property, but has one PIN	<ul style="list-style-type: none"> One threat point assigned to the entire property.
Lawn/turf	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Commercial fertilizer not applied unless the well is within a municipal park, in which case there is potential that fertilizer is applied.
All properties	<ul style="list-style-type: none"> If buildings and structures are located outside the vulnerable area – circumstance IDs associated with storage and handling are not applied
Septic system	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 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 assumed 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 complete 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 WHPAs, a review was conducted of the existing database of verified threats, municipal servicing data and air photos.

The threats inventory was completed by a desktop/GIS exercise, using the Municipal Property Assessment Corporation (MPAC) parcel GIS layer and its associated property codes, other data sources and local knowledge. Using ArcGIS, the MPAC parcel information was intersected spatially with the draft WHPA and ICA delineations, as well as the vulnerability scores, to determine which parcels should be examined for possible significant drinking water threats, and which should be excluded. The process of determining the properties and threats enumerated differed slightly for each of the prescribed threats.

Septic System

The septic system threats were enumerated by intersecting the MPAC parcel data with the areas with a vulnerability score of 10. The list of properties was compared to the list of properties identified in the approved 2015 Assessment Report as having a septic system threat and it was confirmed, via the 2015 to 2017 septic inspection data, whether those properties contained septic systems. Any properties with confirmed septic systems from the 2015 to 2017 septic inspection data that are also within the newly delineated WHPAs, score 10 were enumerated as septic system threats. The list of properties was then compared to municipal infrastructure data to identify all properties not serviced by municipal sewage systems. For the properties not serviced by municipal sewage system data, air photo analysis was completed to determine the location of the WHPA score 10 on each property, in particular whether the WHPA score 10 area was located over or near a house, other buildings or developed land near the house such as grassed areas, yards, driveways etc where a septic system could reasonably be sited. For these properties, septic system threats were enumerated. If the WHPA score 10 area was only located over undeveloped land such as vacant land, parks, wooded areas or agricultural lands then no septic threat was enumerated for that property. Similarly, if the WHPA score 10 area was located over only portions of developed land that are too small to contain a septic system, no septic threat was enumerated for that property. All remaining properties were given a septic system threat. For properties in the Hamilton Drive hamlet area, analysis was completed to determine which properties were located in the Hamilton Drive WHPAs, the City of Guelph WHPAs or both. For enumeration purposes, only those properties located in either only the Hamilton Drive WHPAs or in both the Hamilton Drive and City of Guelph WHPAs were enumerated as septic system threats for the Hamilton Drive system.

Sewage Works

Sewage works threats were enumerated for municipal sanitary sewage, industrial sewage and municipal and / or private stormwater management facilities. These threats were enumerated where present in either a vulnerability score of 10 or an ICA for chloride.

For municipal sanitary sewage threats, threats were enumerated for collection systems, individual pumping stations and wastewater treatment plants based on municipal asset management databases and / or records. Each individual pumping station and / or wastewater treatment plant was enumerated as a separate sanitary sewer threat. The remaining components of the municipal sanitary sewage collection systems (ie sewer mains, laterals, siphons, grinder pumps etc) were collectively enumerated as one threat per municipal or type of system.

For municipal stormwater management facilities, threats were enumerated based on municipal asset management databases and / or records. For private stormwater management facilities and industrial sewage works, the provincial Environmental Compliance Approvals (ECA) data was searched and all identified private sewage ECAs were enumerated. Additional private stormwater management facilities were also enumerated based on municipal planning approval records and / or local knowledge.

Pesticide Vendors

Provincial Pesticide Vendor Licence and Operator records were reviewed. Pesticide vendors and operators present within vulnerability score 10 were enumerated as significant drinking water threats.

Waste, DNAPLs and Organic Solvents

To enumerate the waste, DNAPL and organic solvent threats, the MPAC parcels were intersected spatially with the WHPA zones A-C. Of those remaining properties, the parcels within the vulnerability score of 10 were also identified. As these threats are mostly associated with industrial, commercial and institutional land uses, all parcels with purely residential or agricultural property codes were removed. If a property code indicated mixed use, such as residential/commercial or agricultural/industrial, those properties were included. Then all properties also located within the approved 2015 WHPAs, where significant drinking water threats were confirmed not to be occurring through the threats verification process, were removed in the threats enumeration count. All properties also located within the approved 2015 WHPAs, where significant drinking threats were confirmed to be occurring through the threats verification process or where a risk management plan has been agreed to, were included in the threats enumeration count.

All remaining properties were examined using the 2015 Southwestern Ontario Orthophotography Project (SWOOP) aerial photography and Google Maps to identify any properties where the possible threat activity would be located outside the WHPA A-C, or where the lot did not contain a building. Further, any property where the activity could not generate a significant drinking water threat was also removed. This was determined by using a combination of local knowledge, Google Maps data and Google Street View. All remaining properties were given a DNAPL threat, and those identified as being located in a score of 10 were also given a waste and organic solvent threat.

Fuel

Fuel threats were enumerated by intersecting the MPAC parcel data spatially with the areas of the new WHPAs that have a vulnerability score of 10. Then all properties also located within the approved 2015 WHPAs where no fuel storage was confirmed through the threats verification process were removed. All properties also located within the approved 2015 WHPAs, where significant drinking threats were confirmed to be occurring through the threats verification process or where a risk management plan has been agreed to, were included in the threats enumeration count.

The remaining parcels were then intersected with Union Gas meter stop data to determine which properties are serviced with natural gas and removed from the threat enumeration data. All remaining properties were examined using the 2015 SWOOP photography and Google Maps to identify any properties where the possible fuel storage would be located outside the vulnerability score of 10 or where the lot did not contain a building. Those properties were removed. The remaining properties were given a liquid fuel threat for potential home heating oil. Finally, all gas stations, farms with buildings, fuel depots, and locations with known emergency power

generators, such as municipal facilities, hospitals and wastewater treatment plants, which are located in the vulnerability score of 10, were included in the data and given a storage of liquid fuel threat.

Agricultural Threats

The agricultural threats were enumerated by intersecting the MPAC parcel data spatially with the areas of the new WHPAs that have a vulnerability score of 10. The MPAC property codes were then used to remove all non-agricultural parcels. All remaining properties were examined using the 2015 SWOOP photography, Google Maps, Google Street View and local knowledge to determine whether the vulnerable zone intersected with a field, with farm buildings, or if the vulnerable zone was located in a woodlot or has been developed. All properties where the zone did not cross a farm field or building were removed. Based on local knowledge or Google Maps, all properties that were agricultural use in the 2015 air photos but are now residential subdivisions were removed. Each property with farm buildings in the vulnerable zone were identified. This list of properties was cross referenced with Provincial Nutrient Management Strategy and Plan data to ensure properties with Provincial approvals were enumerated.

All properties were given a preliminary suite of prescribed threats; application of agricultural source material, non-agricultural source material, commercial fertilizers and pesticides, temporary field storage of agricultural source material, non-agricultural source material and commercial fertilizers, and pasturing and grazing of livestock. All properties with farm buildings were additionally given the following threats; permanent storage of agricultural source material, non-agricultural source material, commercial fertilizers and pesticides, as well as the use of an outdoor confinement yard.

Parcels were then examined using the SWOOP imagery and the managed lands and livestock density mapping created by the Grand River Conservation Authority to determine which threats apply to which property. Finally, properties where a threats verification process had been completed were identified and the threats associated with that property were adjusted to reflect the results of the verification. If an application of commercial fertilizer threat had been identified as occurring during threats verification, but was determined to no longer be a threat due to updated managed lands and livestock density calculations, it was removed. All properties also located within the approved 2015 WHPAs, where significant drinking threats were confirmed to be occurring through the threats verification process or where a risk management plan has been agreed to, were included in the threats enumeration count.

Significant Drinking Water Threats for the Rockwood Water Supply

As per the Technical Rules (MOECC, 2017), the enumeration of significant threats is required for the completion of the Assessment Report. **Table 6-39** summarizes the significant threats identified in the Rockwood Wellhead Protection Areas in the Township of Guelph-Eramosa.

Table 6-39: Significant Drinking Water Quality Threats in the Rockwood Wellhead Protection Areas			
PDWT¹ #	Threat Subcategory²	Number of Activities	Vulnerable Area
1	Waste Disposal Site- Storage of Hazardous Waste at Disposal Sites	6	WHPA-A WHPA-B
2	Sewage System or Sewage Works- Onsite Sewage Systems	39	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	30	WHPA-A WHPA-B
4	Handling and Storage of Agricultural Source Material	30	WHPA-A WHPA-B
6	Application of Non-Agricultural Source Material to Land	29	WHPA-A WHPA-B
7	Handling and Storage of Non-Agricultural Source Material	29	WHPA-A WHPA-B
9	Handling and Storage of Commercial Fertilizer	9	WHPA-B
10	Application of Pesticides to Land	19	WHPA-A WHPA-B
11	Handling and Storage of Pesticides	9	WHPA-B
15	Handling and Storage of Fuel	41	WHPA-A WHPA-B
16	Handling and Storage of Dense Non-Aqueous Phase Liquids	7	WHPA-A WHPA-B WHPA-C
17	Handling and Storage of Organic Solvents	6	WHPA-A WHPA-B
21	Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation (Grazing and pasturing)	28	WHPA-A WHPA-B
	Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation (Outdoor confinement yard)	9	WHPA-B
Total Number of Activities		292	
Total Number of Properties		107	
<p>1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).</p> <p>2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.</p> <p>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, policies must be created in order to address potential fuel storage tanks remaining on residential properties.</p> <p>Note: Storm sewer piping is not considered to be part of a storm water management facility.</p>			

Significant Drinking Water Threats for the Hamilton Drive Water Supply

As per the Technical Rules (MOECC, 2017), the enumeration of significant threats is required for the completion of the Assessment Report. **Table 6-40** summarizes the significant threats identified in the Hamilton Drive Wellhead Protection Areas.

Table 6-40: Significant Drinking Water Quality Threats for the Hamilton Drive Water Supply System			
PDWT¹ #	Threat Subcategory²	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- Onsite Sewage Systems	24	WHPA-A WHPA-B
3	Application of Agricultural Source Material to Land	7	WHPA-A WHPA-B
4	Handling and Storage of Agricultural Source Material	7	WHPA-A WHPA-B
6	Application of Non-Agricultural Source Material to Land	7	WHPA-A WHPA-B
7	Handling and Storage of Non-Agricultural Source Material	7	WHPA-A WHPA-B
8	Application of Commercial Fertilizer	1	WHPA-B
9	Handling and Storage of Commercial Fertilizer	2	WHPA-B
10	Application of Pesticides to Land	5	WHPA-B
11	Handling and Storage of Pesticides	1	WHPA-B
15	Handling and Storage of Fuel	3	WHPA-A WHPA-B
16	Handling and Storage of Dense Non-Aqueous Phase Liquids	9	WHPA-B WHPA-C
17	Handling and Storage of Organic Solvents	1	WHPA-A
21	Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation (Grazing and pasturing)	6	WHPA-B
	Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation (Outdoor confinement yard)	1	WHPA-B
Total Number of Activities		82	
Total Number of Properties		39	
<p>1: Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).</p> <p>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, policies must be created in order to address potential fuel storage tanks remaining on residential properties.</p> <p>2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.</p> <p>Note: Storm sewer piping is not considered to be part of a storm water management facility.</p>			

Limitations and Uncertainty for the Enumeration of Significant Drinking Water Quality Threats for the Rockwood and Hamilton Drive Well Supply

- The threat assessment was a desktop scale analysis based on the assumptions used for the threat rankings. The assessment involved only minor field verifications or site visits to validate the information. The current assessment identified significant water quality threats based on a number of assumptions; no site visits to confirm actual site conditions and circumstances were completed beyond site visits that had already been completed previously. Site visits may be needed to confirm actual site conditions and circumstances and in some cases to develop site specific response and risk management activities.
- The threat assessment relied on a number of pre-existing data sources to complete the evaluation. In some cases the data sources were not current. Activities taking place on a given property may change from year to year or month to month. In particular, the air photos used primarily dated from 2015.
- The MPAC property codes used to identify the use of the property and the associated threats do not always represent the current land use activity on the property. As such, threats may be applied to a property where they do not exist or vice versa. Threats may have been missed on a property where they do exist.
- 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 WHPA area scale of analysis only; and should not be used, and are not intended for use, at the scale of the individual property.