GRAND RIVER SOURCE PROTECTION AREA ASSESSMENT REPORT

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5.0 COUNTY OF DUFFERIN

5.1 Township of Amaranth

5.1.1 Waldemar Water Supply

Amaranth Township is located in the Grand River watershed and is part of Dufferin County. The Village of Waldemar is located in the southwest corner of the Township just north of Highway 109. Within the village, Waldemar Heights is a residential subdivision located just to the east of the Grand River with its water supply being from a municipal water supply system.

Waldemar currently has three water supply wells Waldemar Well 1 (PW1), 2 (PW2), and 3 (PW3) which service the Waldemar Heights Subdivision and a number of houses on the west side of the Grand River (**Map 5-1**). The population serviced is approximately 342 residents.

PW1 was drilled in 1975 as a 150 millimetre (mm) diameter well extending into the bedrock. The well is 107 m deep with an open interval in the bedrock extending from 16 m to 107 m. PW1 encountered limestone bedrock at a depth of 15 m and shale was encountered at 105 m below grade. The upper 7 m of overburden is described as primarily clay and is underlain by about 1 m of sand and gravel and 7 m of hardpan — assumed to be till. The majority of water entering the well is obtained from fractures at 48.9 and 72.4 m below the top of the casing (b toc). In 2017, the average pumping rate for PW1 was 40 m^3/day.

In 2017, PW2 was used as a backup supply for the two existing wells. PW2 was drilled in 1989 as a 150 mm diameter well with a depth of 117 m. The well is constructed as an open hole in the bedrock from 23 to 117 m. The overburden sediments are described in the well log as primarily clay. Shale was encountered at a depth of 115 m below grade. The water is obtained from fractures located at 51, 64, 75, 84, 86 and 87 m below top of casing.

PW3 was completed in 2002 and is 200 mm in diameter and has a depth of 91 m. Limestone bedrock was encountered at 17.7 m below grade and shale was not encountered in this well. According to the driller's log the overburden consists primarily of clay. The well is constructed as an open hole in the bedrock from 21 m to 91 m and obtains water from multiple fractures within the bedrock. In 2017, PW3 average pumping rate was 36.5 m^3/day.

The Waldemar Water Supply system operates according to Permit to Take Water (PTTW) No. 5201-9YMKLA. The permitted pumping rates are presented below in **Table 5-1.** A summary of the drinking water system information and annual and monthly average pumping rates is presented on **Table 5-2** and **Table 5-3**.

Table 5-1: Summary of Permit-To-Take-Water Pumping Rates for the Waldemar Water Supply

Well	Depth (m)	Open Interval	Permitted Pumping Rate (PTTW No. 5201-9YMKLA)
PW1	107	16 m to 107m	341 L/min
PW2	117	23 m to 117 m	273 L/min
PW3	91	21 m to 91 m	318 L/min

Map 5-1: County of Dufferin Water Supply Serviced Areas in the Grand River Watershed

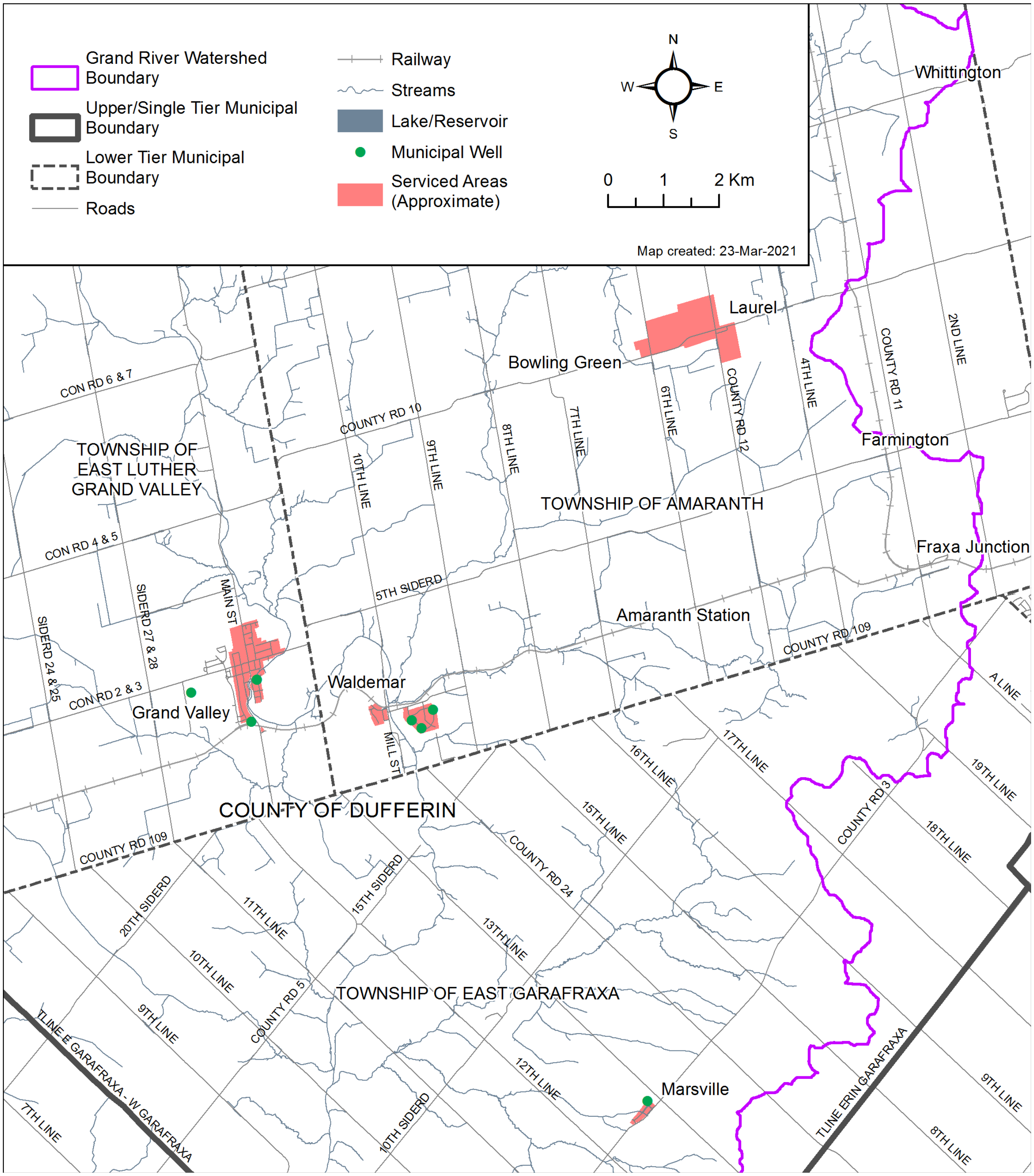


Table 5-2: Drinking Water System Information for the Waldemar Water Supply

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served[2]
220013553	Waldemar Water Supply	Dufferin Water Co. Ltd.	GW	Large Municipal Residential System	342

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

2 Dufferin Water Co. Ltd Waldemar Heights 2009 annual summary report (2010)

Table 5-3: Annual and Monthly Average Pumping Rates for the Waldemar Water Supply

Well or Intake	Annual Avg. Taking[1] (m^3/d)	Average Daily (m^3/d)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PW1	40	40.1	46.3	32.4	38.8	40.7	46.6	44.8	43.1	42.5	34.4	35.0	33.9
PW3	36.5	27.3	32.6	37.7	39.1	41.2	45.1	40.4	34.4	40.7	34.5	29.6	35.3

1 source: Dufferin Water Co. Ltd Waldemar Heights 2017 annual summary report (2018)

5.1.2 Waldemar Wellhead Protection Areas

Wellhead Protection Areas for the Waldemar water supply wells were delineated as part of a study completed by Golder in 2010 using a FEFLOW groundwater flow model. The model was constructed and calibrated with available hydrogeological data and hydrogeological mapping products (Golder, 2010a).

The model was completed based on a number of simplifying assumptions that incorporate some level of uncertainty that is dependent on the nature, spatial distribution and density of available data. The groundwater model was calibrated to represent steady state conditions in the aquifer using static water levels from 1061 points. The NRMS error for the calibration is reported as being 6.1% which is considered to be within the acceptable limits of less than 10% for numerical models. The model calibration results were compared to reported pumping tests at the wells and showed a reasonable fit to the observed groundwater conditions recorded in the tests. Stream flow data was also used for calibration. Through the calibration process, it was found that the hydraulic conductivities of the geological units, simulated flow pattern within the bedrock aquifer, and modelled baseflows are in good agreement with site specific information (Golder, 2010b).

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

To account for some of these uncertainties Golder has applied a factor of safety to the Wellhead Protection Areas. The factor of safety has been applied to two components of the Wellhead Protection Areas; the width and length of the capture zones were increased by 20% to account for uncertainty in the hydraulic characteristics of the aquifer system and the orientation of the capture zone was adjusted by 5 degrees (plus and minus) along its centre line to account for some uncertainty in the regional flow direction by increasing the width of the capture zones at increasing distances from the pumping well. This reflects the concept that the available data is typically concentrated around the pumping well and that the uncertainty in the hydrogeological understanding decreases at increasing distances from the supply wells (Golder, 2010b).

The capture zones were developed for all three municipal wells in Waldemar. PW3 is a stand-by well that is only used occasionally, but for the purposes of the assessment was assumed to be operating simultaneously with the other two wells and at a rate that is the same as that for PW1 (Golder, 2010b).

The pumping rates used were selected based on historic and estimated future pumping rates. Since the pumping rates are not expected to increase over the next 25 years due to a lack of population growth or predicted increased demand, forecast pumping rates used for the capture zone delineation were based on historical average pumping rates (Golder, 2010b) and are provided in **Table 5-4**.

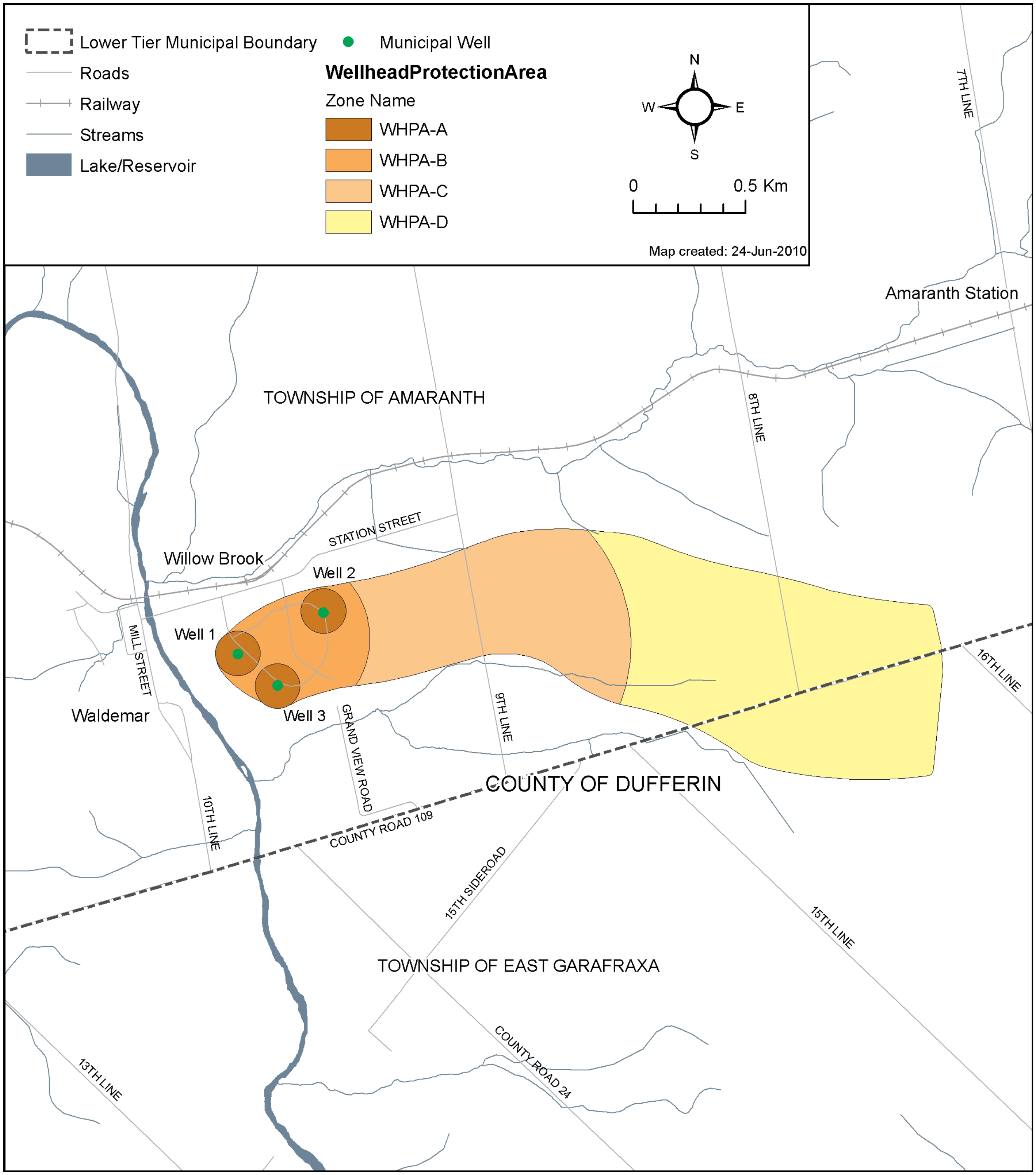
Table 5-4: Waldemar Production Well Pumping Rates

Supply Wells	Modelled Pumping Rate Used	Historical Average Pumping Rate
Waldemar PW1	61 m^3 / day	61 m^3 / day
Waldemar PW2	51 m^3 / day	51 m^3 / day
Waldemar PW3	61 m^3 / day	0 m^3 / day

To develop time of travel capture zones, groundwater particles were released at the pumping wells in the model 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.

The location and orientation of the Wellhead Protection Area is shown in Map **5-2**. The Waldemar capture zones extend eastward from the well for a distance of approximately 3.2 km and cover an area of 205 ha.

Map 5-2: Waldemar Water Supply Wellhead Protection Areas



Vulnerability Scoring in the Waldemar Wellhead Protection Areas

Aquifer vulnerability mapping was completed within the GRCA watershed using the Surface to Aquifer Advection Time (SAAT) approach. The GRCA retained Earthfx to complete the vulnerability mapping using the SAAT method for the entire Grand River watershed as described in the Earthfx 2008 report. The intrinsic vulnerability is shown on **Map** 5-3**.**

The intrinsic vulnerability scoring for the Waldemar WHPAs was completed in accordance with Rule 82 of the Technical Rules. Vulnerability scores range from 10 for areas with the highest vulnerability to 2 for areas with low vulnerability. Scores were assigned as per Table 2(a) in Part VII of the Technical Rules (MOE, 2009b). A summary of the process used to define vulnerability scores is outlined in the **Table 5-5** below:

Table 5-5: Wellhead Protection Area Vulnerability Scores - SAAT

Time of Travel Zone (WHPA)	0 to 5 years (High)	5 to 25 years (Medium)	> 25 years (Low)
WHPA-A (100m)	10	10	10
WHPA-B (2yrTOT)	10	8	6
WHPA-C (5 yr TOT)	8	6	2
WHPA-D (25 yr TOT)	6	4	2

The mapping illustrates that most of the Wellhead Protection Area is rated as low intrinsic vulnerability. This is a reflection of the fine-grained till overburden mapped in the area. Areas of medium and high intrinsic vulnerability are located on the southwest side of the wells towards the Grand River valley. The 2 year TOT zone includes the Waldemar Heights subdivision and has scores of 6 and 8 while the 100 m radius around each well has a score of 10. The aggregate pit located in WHPA-D has a score of 6 since the vulnerability was increased to high based on transport pathways as discussed below.

Identification of Transport Pathways and Vulnerability Adjustment

Technical Rules 39 to 41 (MOE, 2009b) allow for a vulnerability rating increase of an aquifer due to the presence of transport pathways that may increase the vulnerability of the aquifer. These pathways provide a conduit for contaminants to bypass the natural protection of the aquifer.

Transport Pathways in the Waldemar Wellhead Protection Areas

Water Wells

A review of water well records from the MOE water well database and a field survey were conducted to identify wells within the Wellhead Protection Areas. The wells were then evaluated and ranked based on their risk to the supply aquifer, which included an analysis of the age of the well and its likely condition, as well as a visual inspection of the well, where possible. The survey resulted in the identification of five water wells within the Wellhead Protection Areas and classified three of the wells as high risk wells.

Residential Septic Systems

The municipal aquifer for the Waldemar Water Supply wells is a confined aquifer overlain by up to 20 m of fine grained sediments. Individual septic systems assumed present at all residential homes within the Wellhead Protection Area are not considered to constitute a transport pathway due to their relatively shallow depth of penetration.

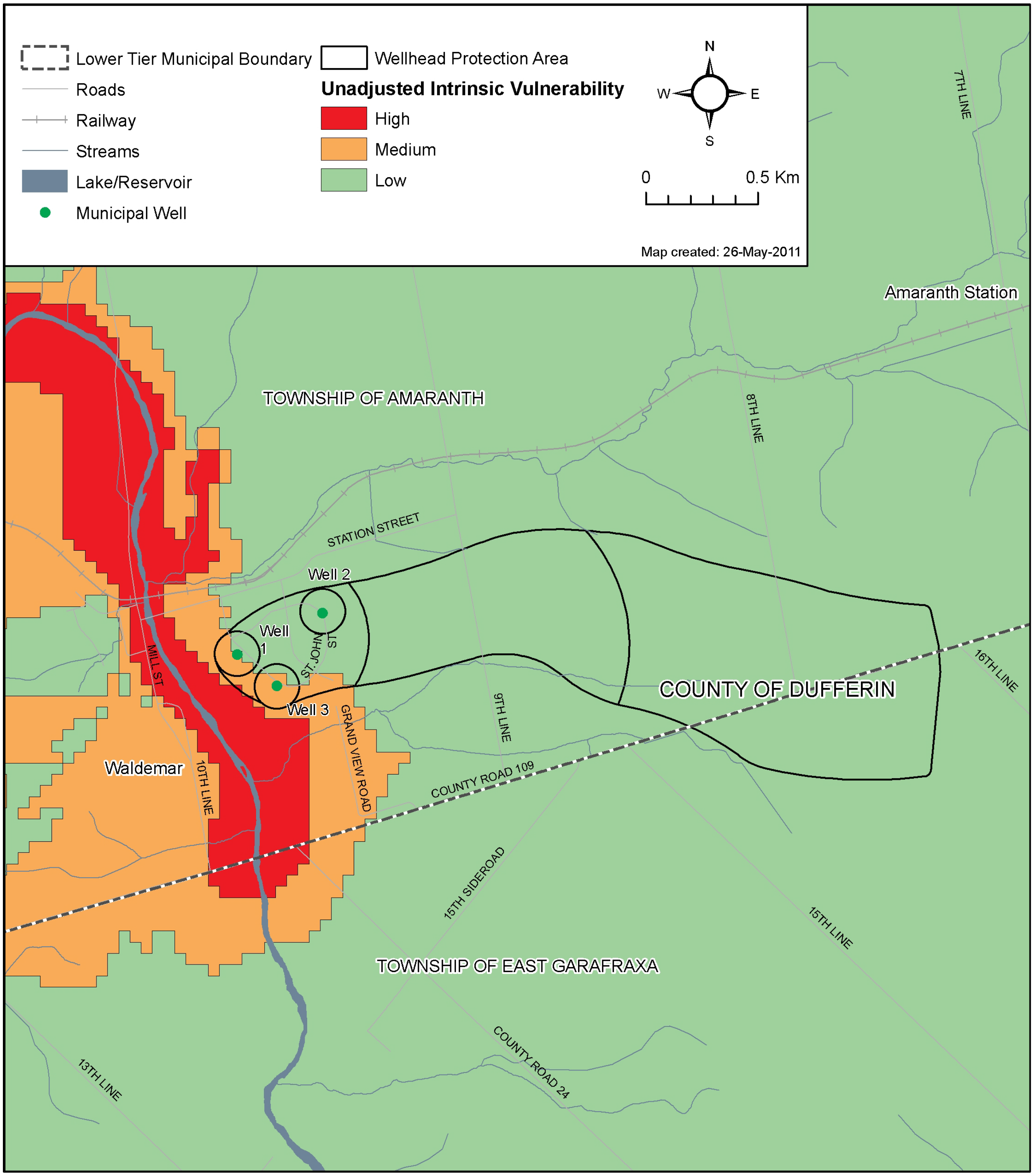
Surface Water Features

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 pond, dugouts and aggregate extraction ponds. Based on the hydrogeology of the areas, the aquifer used 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.

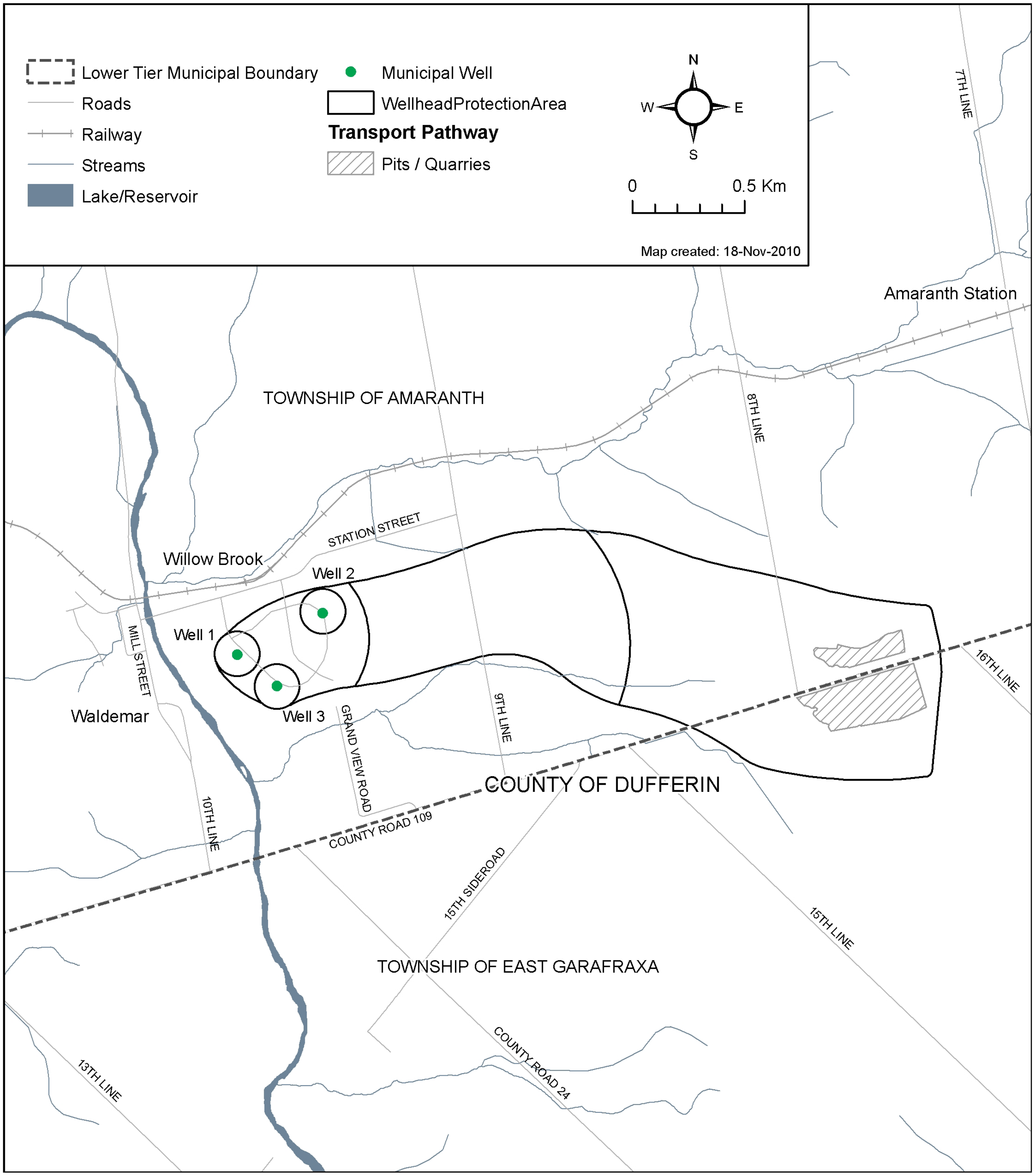
Aggregate Operations

As part of the current study, aggregate operations have been mapped based on existing databases and the review of aerial photography and satellite imagery along with a windshield survey of the Wellhead Protection Areas. An operational sand and gravel pit is located at the intersection of 8th Line and County Road 109. Part of the footprint of the pit has filled with water indicating that the excavation has intersected the water table. This transport pathway for the Waldemar Water Supply is shown on **Map 5-4** and the area of influence is shown on Map 5-5**.**

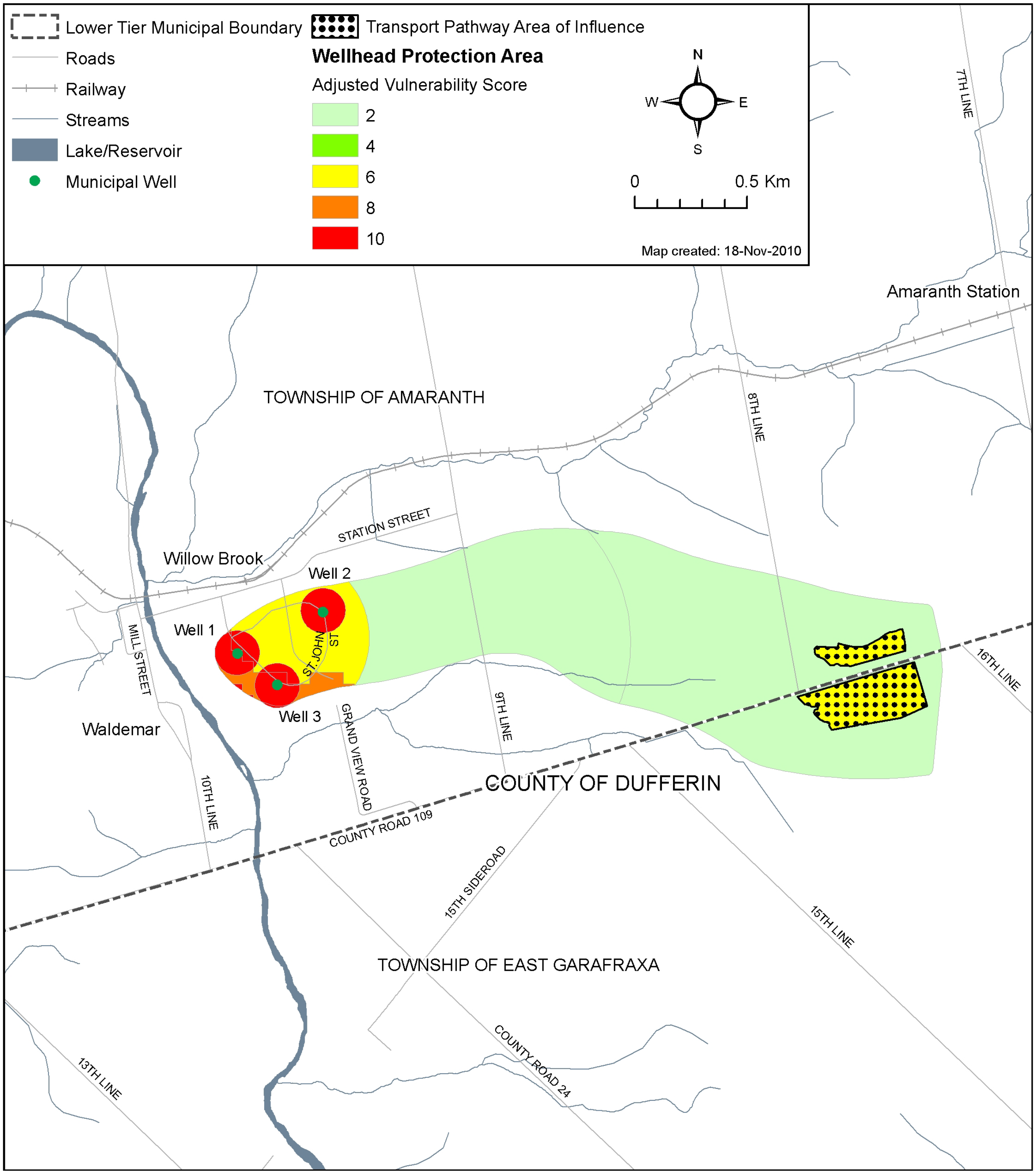
Map 5-3 Waldemar Water Supply Unadjusted Intrinsic Vulnerability



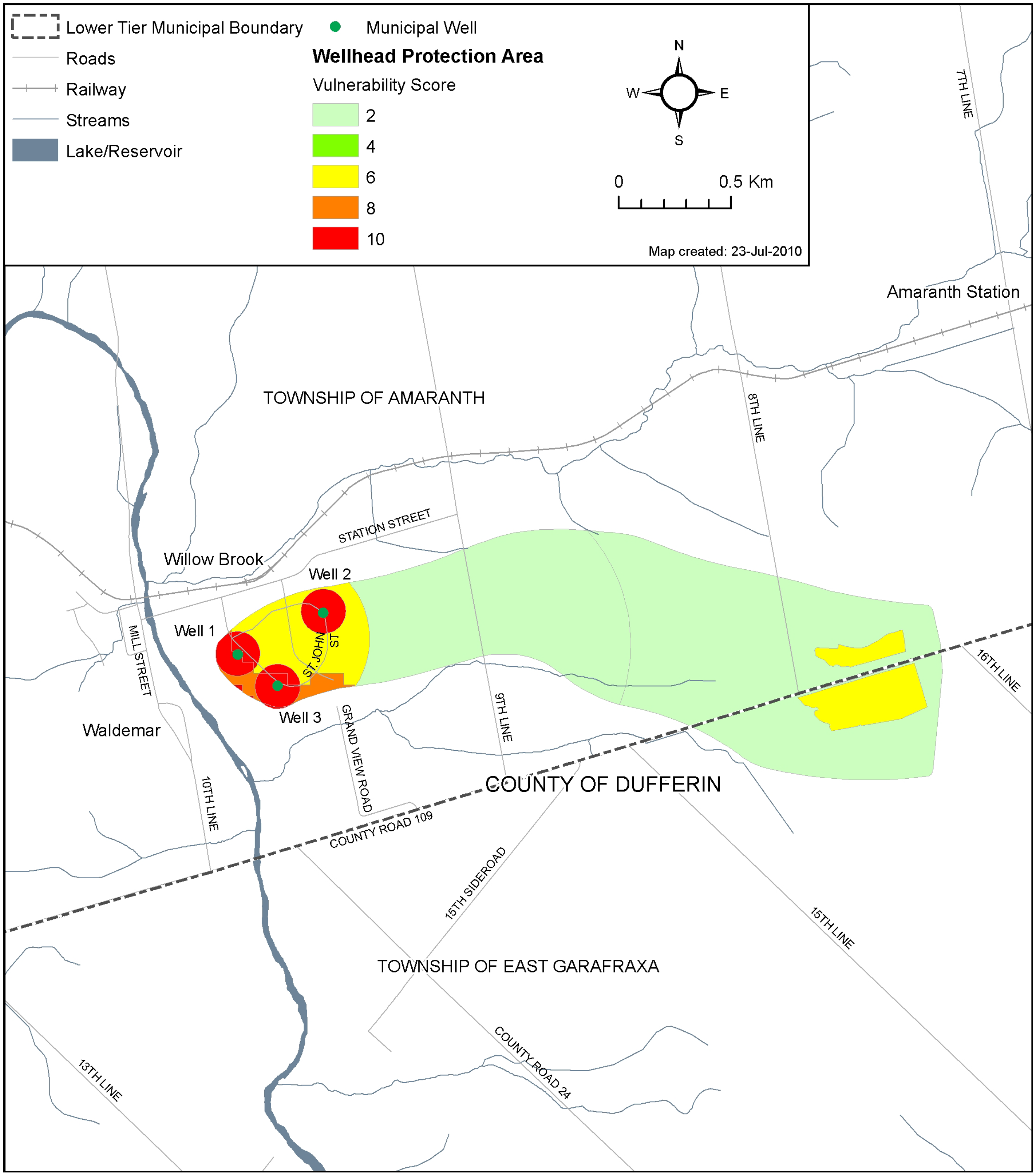
Map 5-4: Waldemar Water Supply Wellhead Protection Area Transport Pathways



Map 5-5: Waldemar Water Supply Wellhead Protection Area Transport Pathways Area of Influence



Map 5-6: Waldemar Water Supply Wellhead Protection Area Final Vulnerability



Adjusted Vulnerability Scoring for the Waldemar Wellhead Protection Area

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.

For this study the only transport pathway of concern is the sand and gravel pit located at the eastern edge of the WHPA-D. The rationale for an increase in vulnerability due to the presence of this feature was examined in the context of the guidelines provided by the MOE. It is recognized that within the footprint of this gravel pit, the entire overburden layer has been removed. The removal of the overburden has resulted in the opening up of the underlying overburden and perhaps bedrock layers. This opening up will have resulted in a loss of the protective layers overlying the aquifer across the entire footprint of the gravel pit. Based on this assumption, the vulnerability within the footprint of the gravel pit was increased from a low vulnerability to high as all protective sediments overlying the water table have been removed. The final vulnerability for the Waldemar Water Supply is shown on **Map 5-6.**

Uncertainty in the Wellhead Protection Area Delineation and Vulnerability Scoring for the Waldemar Water Supply

Uncertainty associated with a vulnerability assessment can be attributed to a number of factors including density of input data; quality and reliability of data; and assumptions made when reducing or synthesizing data. The uncertainty associated with the vulnerability is important as it will be used, along with the risk assessment score, to determine the need for the spatial extent of additional data collection and/or analysis.

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

Although the calibration results were good, the lack of information on the impact of variations in model parameters on the resulting capture zones suggests that there has been inadequate work completed for the full evaluation of uncertainty.

In the Earthfx study both components were computed based on simplifying assumptions included in the MOE provided formulae. The results of the UZAT analysis showed a high degree of variance which may be attributed to variance in the input GAWSER model. The results of the analysis indicate that there is a 95.5% certainty that the UZAT time calculated is within +/- 42 years of the actual time at any well. This indicates that the variability of the UZAT value is greater than the divisions of the vulnerability range i.e. the vulnerability could vary across the entire range of classifications from low to medium or high based on its margin of error. The potential for this high variation indicates that the uncertainty related to this component is high.

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

The results of a statistical analysis of WAAT 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.

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

Given the poor data distribution of wells used for the SAAT analysis within the Wellhead Protection Area and the variability of surficial geology in the study area, there is high uncertainty in the SAAT vulnerability mapping.

In relation to transport pathways, the vulnerability was increased around the footprint of a sand and gravel pit based on air photography. This footprint may change in the future, but the uncertainty can be considered low since it is based on local field observations.

Managed Lands within the Waldemar Wellhead Protection Area

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 lands include crop land, fallow land, improved pasture, golf courses, sports fields and lawns. Managed land can be broken down into two subsets; agricultural and non-agricultural managed land. Agricultural managed land includes cropland, fallow and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses (turf, sports fields, lawns (turf and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer).

The managed land mapping was completed for areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats (a score of 6 or higher). Managed lands were completed using the methodology outlined in Chapter 3, with the results for the Waldemar wells summarized in **Map 5-7.**

Livestock Density within the Waldemar Wellhead Protection Area

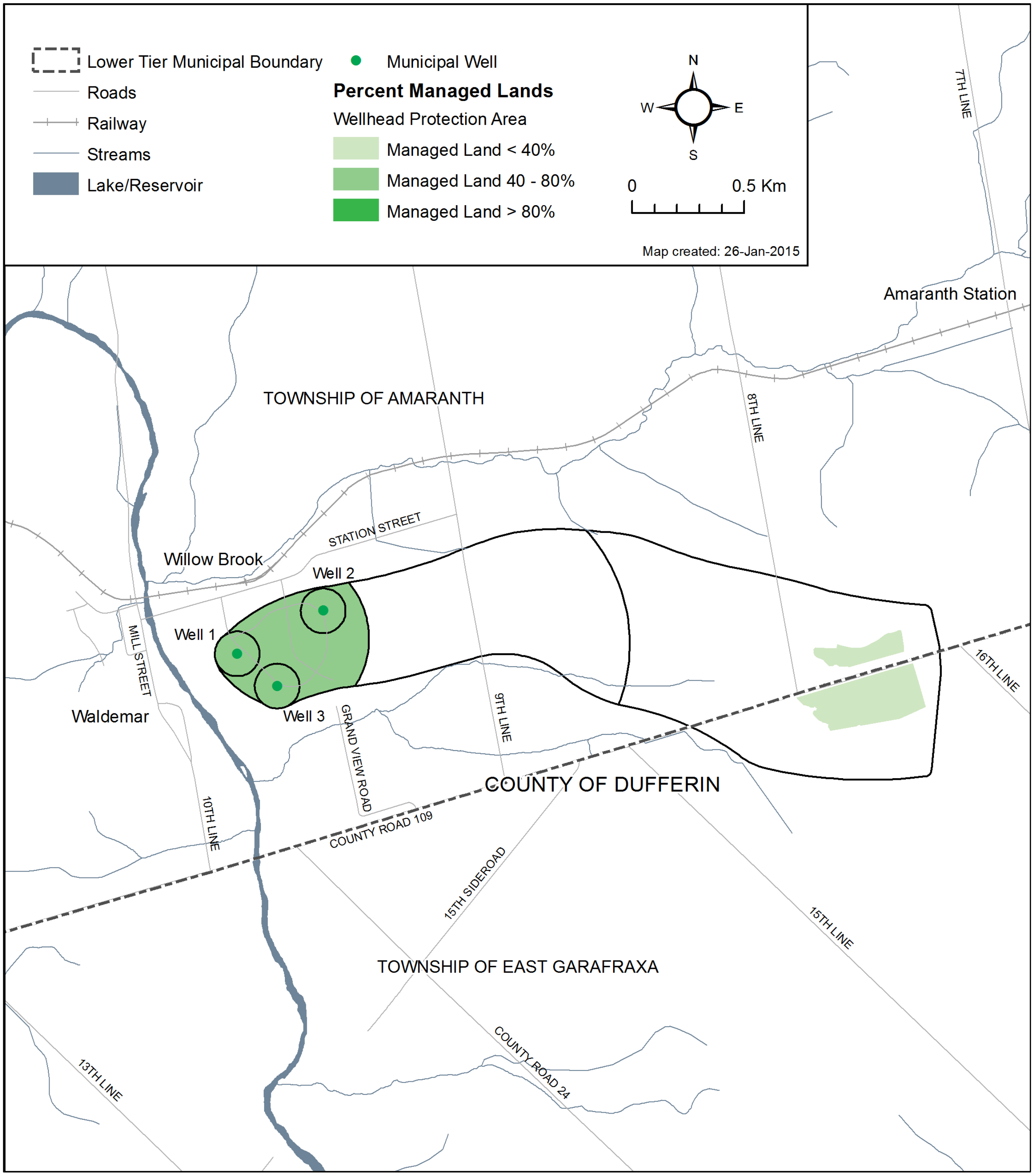
Livestock density is used as a surrogate measure of the potential for generating, storing and land applying agricultural source material as a source of nutrients vulnerable areas. A map of livestock density for the Waldemar Wellhead Protection Areas is provided in **Map 5-8.**

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

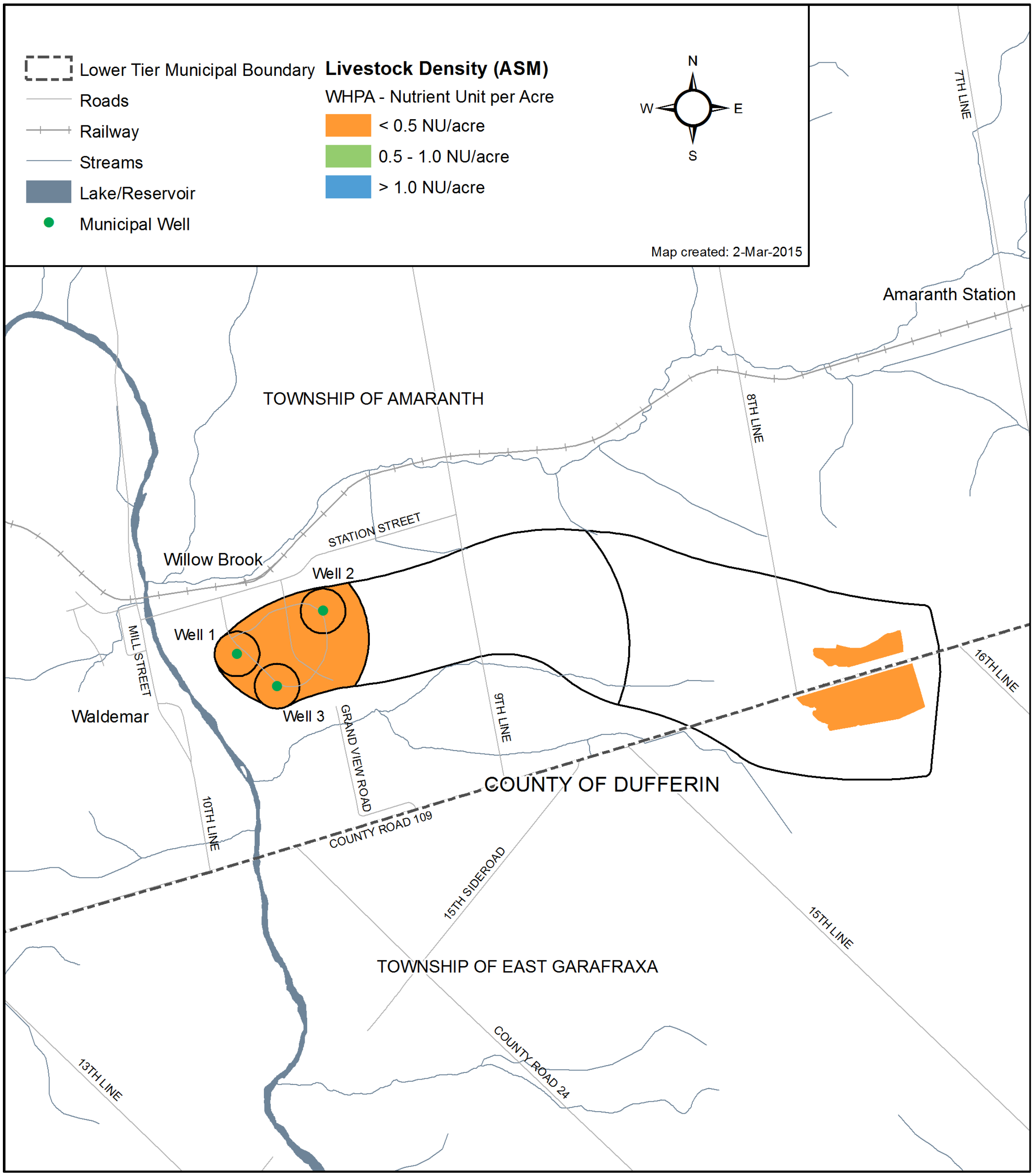
Percentage of Impervious Surface Area within the Waldemar Wellhead Protection Area

Impervious surfaces are defined in the Technical Rules (MOE, 2009b) as areas that receive road salt application and include roads and parking lots. The areas were calculated using road mapping from the National Road Network (Natural Resources Canada) and satellite air photography to identify large parking lots and paved areas. Using a 1 km x 1 km grid centered over each vulnerability area, the percentage of impermeable surfaces within each square kilometre was calculated. The percentage of total impervious surface areas are shown in **Map 5-9.** 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.

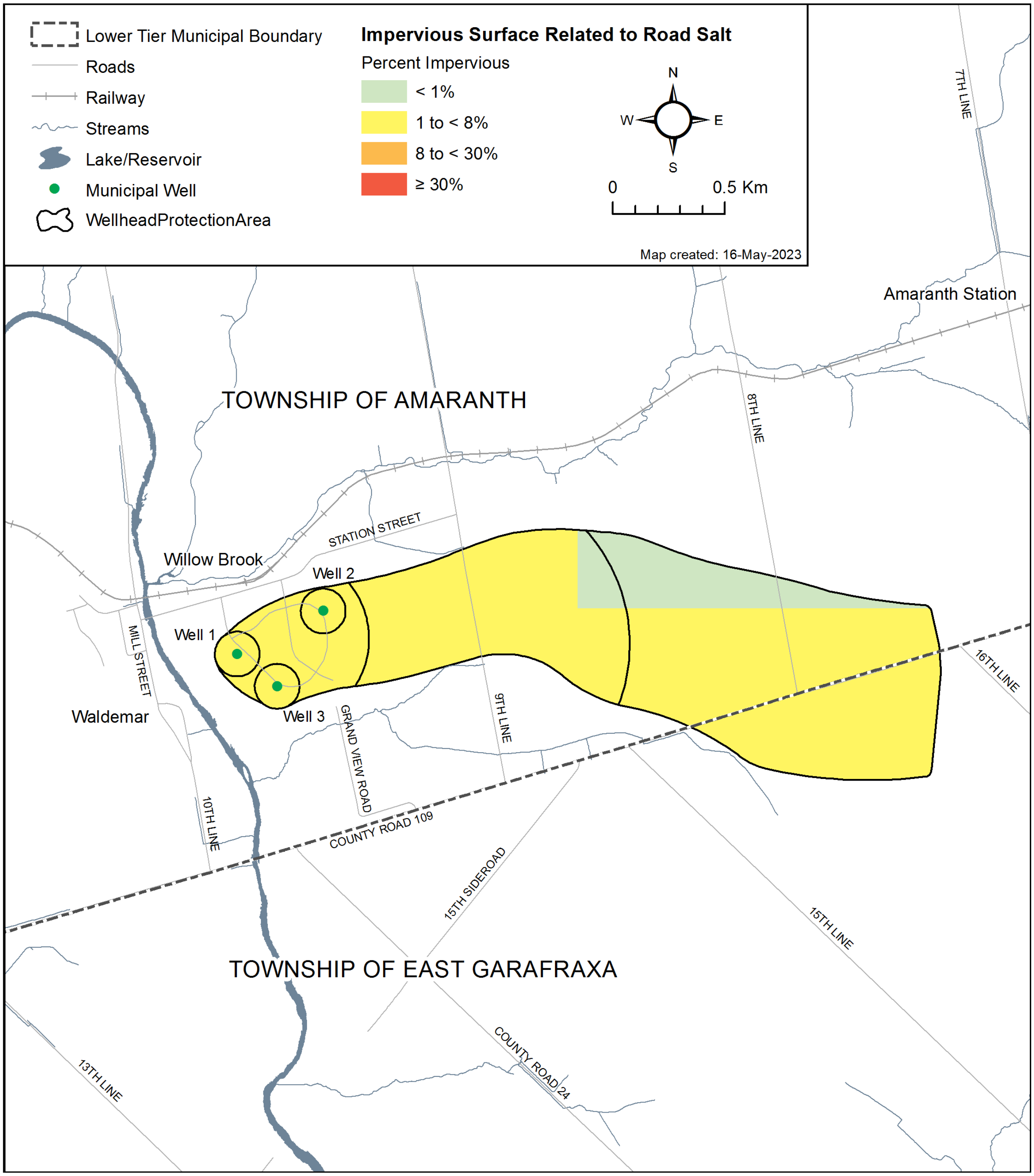
Map 5-7: Waldemar Water Supply Percent Managed Lands



Map 5-8: Waldemar Water Supply Livestock Density



Map 5-9: Waldemar Water Supply Percent Impervious Surfaces



5.1.3 Drinking Water Threats Assessment

The *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." 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 Waldemar Water 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 Director's Technical Rules (2021) under the *Clean Water Act, 2006*. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool. For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**. The information above can be used with the vulnerability scores shown in **Map 5-6** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 5-8 provides a summary of the threat levels possible in the Waldemar 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 5-6**.

Table 5-6: Identification of Drinking Water Quality Threats in the Waldemar Well Supply 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	8	✔	✔	✔
	WHPA-B/D	6		✔	✔
	WHPA-C/D	2			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✔		
	WHPA-D	6			✔
	WHPA-D	2			
Pathogens	WHPA-A/B	10	✔	✔	
	WHPA-B	8		✔	✔
	WHPA-B	6			✔
	WHPA-C/D	Any Score			

5.1.4 Conditions Evaluation for the Waldemar Water Supply

In addition to present land use activities, any conditions resulting from past activities are also considered drinking water threats. 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, MOE Spills Database and Occurrence Reporting Information System (ORIS).

Three spills were recorded in the ORIS database as potential being within the Wellhead Protection Area. **Table 5-7** 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 5-7: Summary of Potential Conditions for the Waldemar Water Supply - Ecolog ERIS search

Source Database	Description	Location	Details
CR15	Oil spill	East Half of Lot 2, Con 8	4 L oil spill to ground in 1992, possible impact (Spill ID 77495)
ORIS	Furnace oil spill	Residence on Hwy 9	450 L furnace oil spill to ground, soil contamination confirmed (Spill ID 94911)
ORIS	Mineral oil spill	South Half of Lot 2, Con 9	Unknown amount of mineral oil spill to ground in 1993, impact possible (Spill ID 139544)

Based on the available data there were no Conditions identified in the Waldemar Wellhead Protection Areas.

5.1.5 Waldemar Drinking Water Quality Issues Evaluation

As part of the Issues evaluation, a review of available water quality data was undertaken to assess whether any contaminants are impacting, have the potential to impact or have the potential to interfere with the Waldemar Water Supply 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.
- Water Operator interview.

All available water quality data for the Waldemar water supply wells was collected and reviewed. This included hydrogeological studies, engineering reports and MOE annual reports for the water supply systems.

Water Quality Issues Evaluation for the Waldemar Water Supply

The MOE Drinking Water Systems O. Reg. 170/03, 2005 and 2008 Annual Reports for the Waldemar Water Supply system were reviewed to identify any water quality concerns. The sampling results provided in the report indicate that the water obtained from PW1, PW2 and PW3 contains elevated concentrations of fluoride. Previous water quality data collected from the wells in 2003 also showed elevated concentrations of fluoride with concentrations in the range of 1.7 to 1.94 mg/L.

The water quality data also indicates that hardness concentrations are elevated above the Operational Guideline (OG) of the ODWQS range of 80-100 mg/L, being 337 mg/L. This level, (337 mg/L), is typical of drinking water obtained from a dolostone bedrock source. Elevated hardness and total dissolved solids were also noted during the 2003 sampling event. Hardness in water is an aesthetic objective and is typically handled using household water softeners; the occurrence of elevated total dissolved solids is not considered an Issue that threatens the groundwater as a safe drinking water source.

Review of available microbiological data was conducted for the Waldemar Heights wells. No concerns with total coliforms or *E.coli* were documented.

Fluoride concentrations at the Waldemar wells have exceeded the Maximum Allowable Concentration (MAC) ODWQS of 1.5 mg/L with measured concentrations ranging from 1.7 to 1.94 mg/L. The MOE recommends that public awareness concerning additional fluoride sources be raised when natural fluoride concentrations are between 1.5 mg/L and 2.4 mg/L. The current concentration of fluoride observed at the wells is naturally occurring and not considered a condition that threatens the groundwater as a safe drinking water source.

The operator of the Waldemar Water Supply system, was consulted to identify any Issues that may result in the deterioration of the water quality. No Issues under Technical Rule 114 were identified for the Waldemar Water Supply system.

Summary of Water Quality Issues Evaluation for Waldemar Water Supply

Upon review of available current drinking water quality data there are no identified Issues under Technical Rule 114 for the Waldemar wells. The concentrations of fluoride and hardness are elevated but are naturally occurring and therefore do not reflect a deterioration of water quality. Neither of the above parameters is currently interfering or is anticipated to interfere with the use of the groundwater as a source of drinking water.

Limitations and Uncertainty for the Water Quality Issues Evaluation for the Waldemar Water Supply

The water quality data reviewed includes data from 2000 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 are no monitoring wells for the water supply system.

5.1.6 Enumeration of Significant Drinking Water Quality Threats

As per the Technical Rules, the enumeration of significant threats is required for the completion of the Assessment Report. The 2009b version of the Technical Rules was used for the threats enumeration.

<u>*Data Sources for the Activity Threats Assessment of the Waldemar Water Supply*</u>

Enumerating 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.

Initially no site specific information was collected; therefore, all drinking water threats were considered potential threats. As more site specific information becomes available through

Verification of activities the presence of drinking water threats and their current level of management has been documented by Risk Management Officials and threat enumeration has been updated.

Ecolog ERIS Search

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 1989-1 996
- 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 1990-1 998
- Coal Gasification Plants 1987, 1988
- Non-Compliance Reports 1992(water only), 1994-2003
- Ministry Orders 1995-1 996
- 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
- Scoff'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 191 5-1 953
- ERIS Historical Searches, March 1999-2005

The database search identified five items within the search radius around the Site. Two Certificates of Approval associated to the municipal water supply system were identified. Three items were identified by a search of the Occurrence Reporting Information System (spills) that may be potentially within the Wellhead Protection Areas. The exact locations were not provided (EcoLog ERIS, 2006).

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 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 WHPAs. Current aerial photography of the WHPAs was obtained from the GRCA Watershed orthoimagery. While the resolution of the photographs limits the detail that can be observed, the following is a summary of what can be discerned:

- 1978 Aerial Photography

  The site inspection program confirmed the land uses noted in the most recent aerial photography.

- 2000 Aerial Photography

  The 2000 photograph revealed that land use within the well capture zone has remained largely unchanged since the 1978 photograph. Some development has occurred to the west of the production wells. The site inspection revealed this to be a community park. The residential area surrounding the wells is now almost fully developed. The agricultural lands noted in the previous aerial photograph appear to remain unchanged. A sand and gravel pit just east of 8th Line adjacent to Highway 109 was identified within the WHPA.

The site inspection program confirmed the land uses noted in the most recent aerial photography.

Site Reconnaissance and Inspection

A drive-by roadside inspection of the Wellhead Protection Areas was conducted on June 26, 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.

The predominant land uses within the WHPAs included residential and agricultural activities. A residential subdivision surrounds the three production wells. All houses are serviced with municipally supplied water and use individual septic systems and natural gas heating. Septic systems within the WHPA-A have been verified through inspections by the County of Dufferin in 2014. Residential homes outside of the subdivision can also be assumed to have septic systems since there is no servicing. Land east of the subdivision included meadows and cash crop fields. An operational sand and gravel pit is located on Highway 109. A proposed gravel pit was identified just east of 9th Line which would be located within WHPA-D. The area west of the Wellhead Protection Area includes a park, some residential uses and the Grand River. The pump house and associated water treatment equipment is located to the northeast of the Wellhead Protection Area.

Significant Drinking Water Quality Threats for the Waldemar Water Supply

Table 5-8 summarizes the significant threats identified in the Waldemar Wellhead Protection Areas. In the case of Waldemar, all significant threats occur in a WHPA-A, the 100 m radius circle around each of the supply wells.

Table 5-8: Waldemar Water Supply Significant Drinking Water Quality Threats

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
1	Application Of Untreated Septage To Land	1	WHPA-A
2	Sewage System Or Sewage Works - Septic System	35	WHPA-A
3	Application Of Agricultural Source Material (ASM) To Land	1	WHPA-A
6	Application Of Non-Agricultural Source Material (NASM) To Land (Including Treated Septage)	1	WHPA-A
10	Application Of Pesticide To Land	1	WHPA-A
Total Number of Properties		**36**	
Total Number of Activities		**39**	

1. *Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).*
2. *Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

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

A review of the data for the Waldemar Water Supply System did not identify any Conditions or any Issues with the drinking water sources.

Limitations and Uncertainty for the Enumeration of Significant Drinking Water Threats for the Waldemar Water Supply

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, a field reconnaissance was completed to confirm the data and to decrease the error in the database information.

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.

5.2 Town of Grand Valley

5.2.1 Grand Valley Well Supply

The Town of Grand Valley is located about 20 km northwest of the Town of Orangeville and is part of Dufferin County (**Map 5-10**). The Village of Grand Valley is located on the southeast side of the Township along the Grand River. An assessment of the Town of Grand Valley drinking water supply was completed by R.J. Burnside & Associates in June 2010.

The Grand Valley Water Supply System provides water for the Village of Grand Valley which has population of approximately 2,100 residents.

The Grand Valley Water Supply System consists of two wellfields, the Grand Valley Wells (Well 1 (PW1) and Well 2 (PW2)) and the Melody Homes Well (Well 3 (PW3)). The Grand Valley Wells (Well 1 and Well 2) are located in the middle of the Village just east of the Grand River. The Melody Homes Well (Well 3) islocated on the south end of the Village beside the Melody Homes subdivision.. In 2021, an assessment of a new well, that is part of the Town of Grand Valley drinking water supply, was completed by R.J. Burnside & Associates. New Well PW5 was completed in 2020 and is intended to be added to the system.

Grand Valley Wells PW1 and PW2 are completed into limestone bedrock (Guelph-Gasport Formation) below approximately 10 m of glaciofluvial deposits. Well 1 is 300 mm in diameter and was drilled to a depth of 86.6 m in 1991. Well 2 was drilled to a depth of 87 m in 1993 and is a 200 mm diameter standby well. The wells obtain water from a leaky confined bedrock aquifer (Burnside, 2010). Both PW1 and PW2 obtain most of their water from a large set of fractures at about 374 metres above sea level (m above sea level). The average pumping rate for the well field is 185 L/min (Burnside, 2010b).

Melody Homes Well 3 was drilled in 1988 to provide water for a 60 lot subdivision located at the south end of the Village. Well 3 is a 150 mm well with an open hole in the limestone bedrock from 28.5 to 114.6 m. The bedrock in the area of Well 3 is protected by over 24 m of fine-grained overburden (Geo-Environ, 1989).

PW5 was drilled in March 2020 as a 250 mm diameter well completed as an open hole in the bedrock from 60.0 m to 114.3 m. The PW5 well is drilled through the upper bedrock (Guelph Formation) and is interpreted to draw most of its water from the Gasport Formation which is separated from the Guelph Formation by the Goat Island Formation. The primary water producing formation is located at 106 m below ground surface consisting of a zone of interconnected channels dissolved in the bedrock. Water producing zones were also identified at 76.1 m and 112 m below ground surface (Burnside, 2021).

The Grand Valley Water Supply system operates under Permit to Take Water No. PTTW 1336-BMRKT5 issued in April 2020. PW1 and PW2 are permitted to pump at a combined maximum rate of 1,591.1 L/min and a maximum daily of 2,291,000 L/day. PW3 is permitted to pump 454 L/min with a maximum daily pumping rate of 654,000 L/day. An amendment to the permit to include PW5 is in process and this seeks to have PW5 permitted at a rate of 2,160,000 L/day. **Table 5-9, Table 5-10** and **Table 5-11** provide a summary of the municipal supply wells, the system information and the average monthly and annual water taking.

Table 5-9: Municipal Production Wells in the Grand Valley Water Supply System

Well	Depth (m)	Open Interval	PTTW Number	Permitted Pumping Rate
Well 1	86.6	8.2 m to 86.6 m	1336-BMRKT5	1591.1 L/min
Well 2	86.9	15.2 m to 86.9 m		
Well 3	116.4	28.5 m to 114.6 m	00-P-2661	454 L/min
Well 5	114.3	60 m to 114.3 m		1500* L/min

*Proposed pumping rate, permit pending

Map 5-10: County of Dufferin Water Supply Serviced Areas in the Grand River Watershed

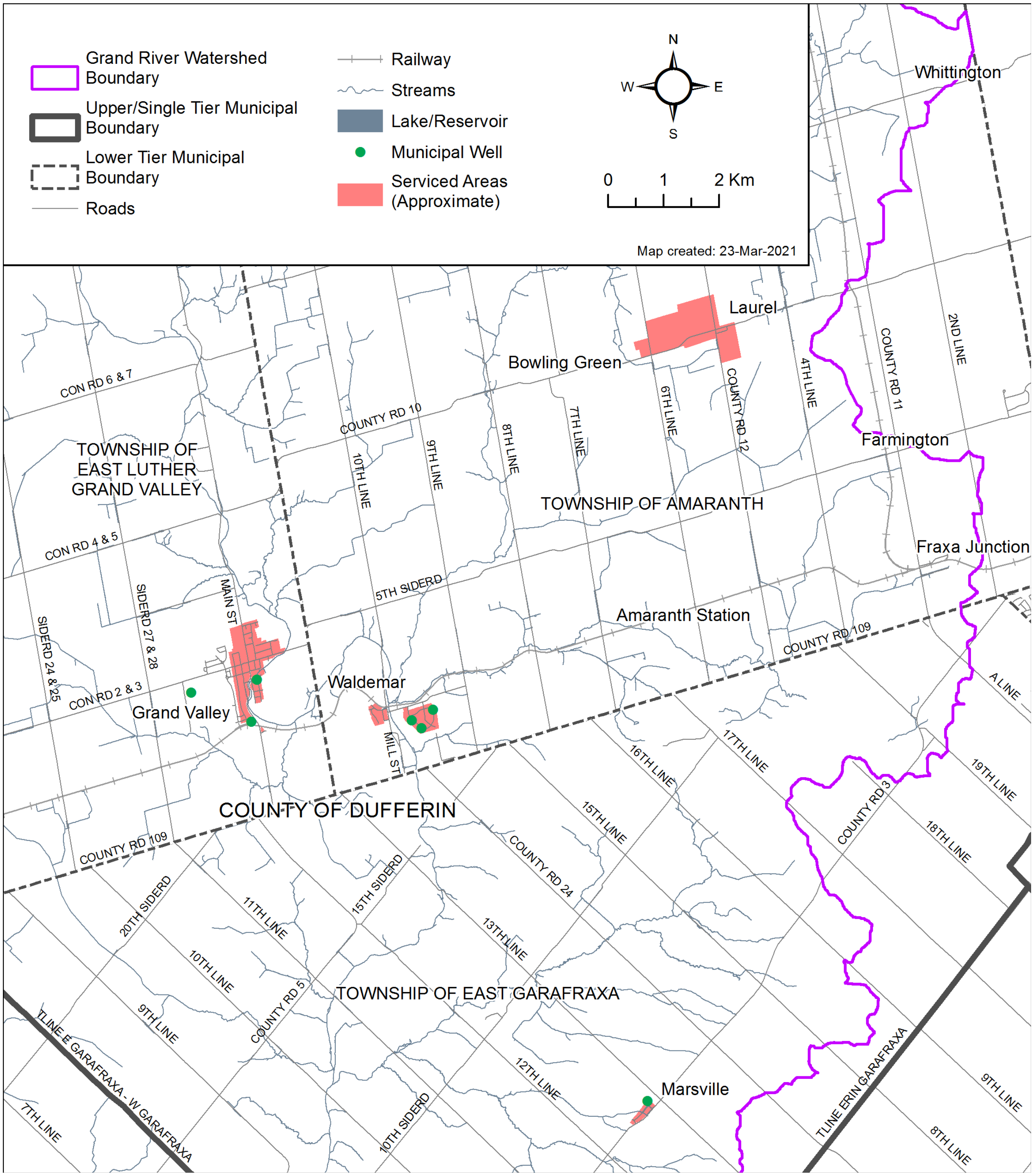


Table 5-10: Drinking Water System Information for the Grand Valley Water Supply

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served[2]
220007016	Grand Valley Well Supply	Corporation of the Town of Grand Valley	GW	Large Municipal Residential System	2,100

1 as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*
2 Dufferin Water Co. Ltd 2019 Grand Valley Summary Report (2020a)

Table 5-11: Annual and Monthly Average Pumping Rates for Grand Valley Water Supply

Well or Intake	Annual Avg. Taking[1] (m^3/d)	Monthly Average Taking[1] (m^3/d)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Well 1 (PW1)	148.04	150.8	142.1	144.1	152.0	163.6	148.6	153.0	144.7	161.6	139.1	139.4	137.5
Well 2 (PW2)	130.74	122.7	133.6	132.5	129.6	149.3	131.9	136.1	121.6	110.6	160.4	118.9	121.7
Well 3 (PW3)	127.12	121.0	121.5	134.5	124.1	140.6	126.8	126.3	114.3	157.4	133.2	106.6	119.1

1. source: Dufferin Water Co. Ltd 2009 Grand Valley Summary Report (2010a)
2.

5.2.2 Grand Valley Wellhead Protection Areas

WHPA Delineations – Well PW1, PW2 and PW3

Wellhead Protection Areas for the Grand Valley Well Supply production wells were delineated as part of the study "Grand Valley, Waldemar, and Marsville GRCA Cut-Out Model" (Golder, 2010) using a FEFLOW groundwater model. This model was based on the regional scale GRCA model constructed by Waterloo Hydrogeologic (WHI) in 2005 and modified by AquaResource in 2008 as part of the water budget studies. The "Cut-Out" was improved upon and refined around the capture zones within Grand Valley, Waldemar and Marsville. The model was constructed and calibrated with available hydrogeological data and hydrogeological mapping products (Golder, 2010b).

The capture zones were developed for Wells 1, 2 and 3. Wells 1 and 2 were modelled as a combined well due to their close location.

The pumping rates used were selected based on historic and estimated future pumping rates. Since the pumping rates are not expected to increase over the next 25 years due to a lack of population growth, forecast pumping rates used for the capture zone delineation were based on historical average pumping rates (Golder, 2010b) and are provided in **Table 5-12.** The modelled rates have been compared to actual average pumping rates recorded in 2008 (DWCo. Ltd, 2009).

To develop time of travel capture zones groundwater particles were released at the pumping wells in the model 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 account for uncertainty in the model a "shape factor" was applied to effectively increase the spatial coverage of each of the time of travel capture zones. The width and length of the capture zone was increased by 20 percent to account for some uncertainty in the hydraulic characteristics of the aquifer system and the orientation of the capture zone was adjusted by 5 degrees (plus and minus) to account for uncertainty in the regional groundwater flow direction.

WHPA Delineation - Well PW5

Wellhead Protection Areas for PW5 were delineated by S.S. Papadopulos & Associates Inc. (SSP&A) by refining and updating the groundwater model used in the Golder 2010 study. The PW5 WHPAs were delineated using an assumed average pumping rate of 25.8 L/sec (2,226 m^3/day) while keeping PW1/ PW2 and PW3 at the rates modelled by Golder (300 m^3/day and 133 m^3/day respectively).

The Wellhead Protection Areas for PW5 are delineated based on specified ground travel times to the well. The travel times are estimated with reverse particle tracking. Tracer particles are placed around PW5 and tracked backwards through the simulated groundwater flow field. Groundwater velocities are estimated using the effective porosity of the bedrock assumed in the original Golder (2010) analyses, 0.05 (5%) (SSP&A, 2020).

Table 5-12: Pumping Rates Used for the Grand Valley Well Supply Wellhead Protection Area Delineation

Supply Wells	Modelled Pumping Rate	Actual Pumping Rate*
Well 1 / Well 2	300 m^3 / day	291.5 m^3 / day
Well 3	133 m^3 / day	130.2 m^3 / day
Well 5	2,226 m3/day	Well not pumping to system

* Average daily pumping rate in 2008 (DWCo. Ltd, 2009)

The location and orientation of the WHPAs are shown in **Map 5-11.** The WHPAs for Wells 1 and 2 extends in a northwest direction approximately 1,322 m from the wells and cover a total area of 112.5 ha. The WHPAs for Well 3 extends southwest, approximately 1,270 m from the wells and covers a total area of 35.4 ha. The WHPAs for PW5 extend approximately 1,000 m in all directions from the well.

Delineation of WHPA-E and WHPA-F for the Grand Valley Well Supply

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

As part of the Engineer's Report on the Grand Valley Water Supply System, Wells PW1, PW2, and PW3were identified as not being impacted by surface water (Burnside, 2001a). This was based on microbiological data, raw water characterization and hydrogeological review. There were no microbiological Issues identified to suggest impacts from surface water. Grand Valley Well PW5 was identified as not being impacted by surface water (Burnside, 2021).

Since the wells in this study have not been identified as GUDI, the delineation of a WHPA-E was not required. The Technical Rules also require that a WHPA-F be delineated for a well when the wells WHPA 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 in the Delineation of the Grand Valley Wellhead Protection Areas

Grand Valley Well 1, Well 2 and Well 3

The delineation of the Wellhead Protection Areas was completed by Golder (2010b) through the use of a FEFLOW groundwater model. The model was completed based on a number of simplifying assumptions that incorporate some level of uncertainty that is dependent on the nature, spatial distribution and density of available data.

The groundwater model was calibrated to represent steady state conditions in the aquifer using static water levels from 1061 points. The normalized root mean squareerror for the calibration is reported as being 6.1% which is considered to be within the acceptable limits of less than 10% for numerical models. The model calibration results were compared to reported pumping tests at the wells and showed a reasonable fit to the observed groundwater conditions recorded in the tests. Stream flow data was also used for calibration. Through the calibration process it was found that the hydraulic conductivities of the geological units, simulated flow pattern within the bedrock aquifer and modelled baseflows are in good agreement with site specific information (Golder, 2010b).

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

To account for some of these uncertainties Golder has applied a factor of safety to the Wellhead Protection Areas. The factor of safety has been applied to two components of the Wellhead Protection Areas; the width and length of the capture zones were increased by 20% to account for uncertainty in the hydraulic characteristics of the aquifer system and the orientation of the capture zone was adjusted by 5 degrees (plus and minus) along its centre line to account for some uncertainty in the regional flow direction by increasing the width of the capture zones at increasing distances from the pumping well. This reflects the concept that the available data is typically concentrated around the pumping well and that the uncertainty in the hydrogeological understanding decreases at increasing distances from the supply wells (Golder, 2010b).

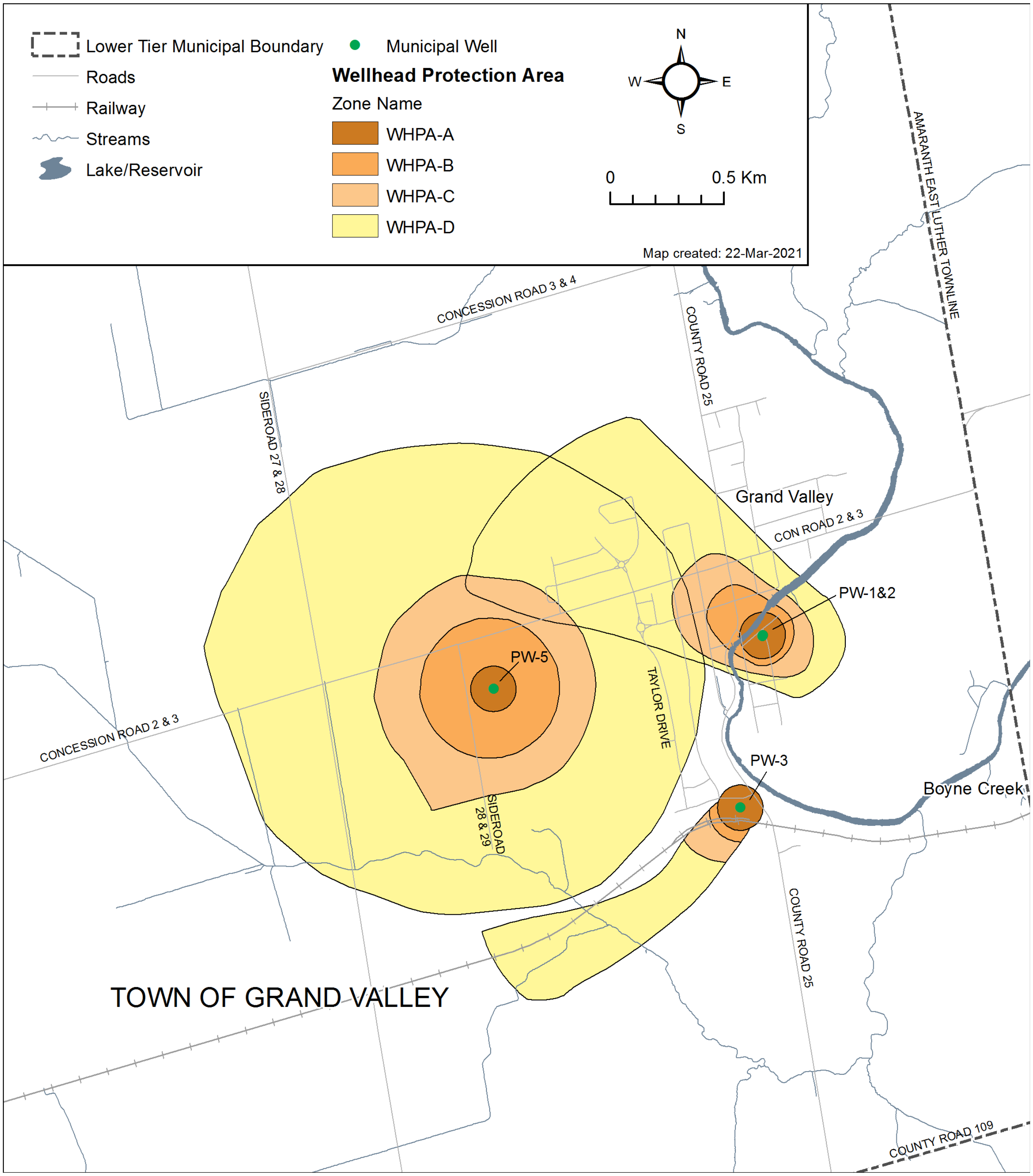
Based on known variations in hydraulic properties, the factor of safety approach is not considered to adequately address the issue of uncertainty. It is known that slight variations of aquifer properties may impact the shape and orientation of the capture zones. The safety factor, while attempting to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

Although the calibration results were good, the lack of information on the impact of variations in model parameters on the resulting capture zones suggests that there has been inadequate work completed for the full evaluation of uncertainty.

Grand Valley Well PW5

The groundwater model was completed based on a number of simplifying assumptions that incorporate some level of uncertainty that is dependent on the nature, spatial distribution and density of available data. As such the uncertainty of the WHPAs is considered to be low in the WHPA-A, but high in the WHPA-B, C and D where the density of available data is limited.

Map 5-11: Grand Valley Well Supply Wellhead Protection Areas



Vulnerability Scoring in Wellhead Protection Areas

Aquifer vulnerability mapping was completed within most of the Grand River watershed using the Surface to Aquifer Advection Time (SAAT) approach. The GRCA retained Earthfx to complete the vulnerability mapping using the SAAT method for the entire Grand River watershed (Earthfx, 2008). As described in the Technical Rules (MECP, 20017), a vulnerability score is assigned to each vulnerable area according to the groundwater's susceptibility to becoming contaminated and that contamination reaching a well. Within WHPAs the vulnerability score is calculated based on overlaying the SAAT aquifer vulnerability classification (high, medium, low) with the defined WHPAs. The unadjusted intrinsic vulnerability is shown on **Map 5-12.** The adjusted intrinsic vulnerability for the Grand Valley Wellhead Protection Areas is provided on **Map 5-13.**

The vulnerability scoring for the current study was completed in accordance with Rule 82 of the Technical Rules. Vulnerability scores range from 10 for areas with the highest vulnerability to 2 for areas with low vulnerability. Scores were assigned as per Table 2(a) in Part VII of the Technical Rules (MECP, 20017). A summary of the process used to define vulnerability scores is outlined in the **Table 5-13**. **Map 5-15** shows the vulnerability scores assigned to the Grand Valley Wellhead Protection Areas.

Table 5-13: Well Head Protection Area Vulnerability Scores – SAAT

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

In Grand Valley, adjustments to the regional SAAT mapping were applied to assign bedrock outcrops as areas of high vulnerability and areas of less than 9 m of overburden thickness as high vulnerability. In addition, local qualitative adjustments were used to refine the alignment with the local SAAT scores. In addition, the well log for Well 3 was used to re-assign the SAAT result as low in the vicinity of Well 3 (Golder, 2010a).

Uncertainty of Vulnerability Scoring for the Grand Valley Wellhead Protection Areas

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

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

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

Using the results of the UZAT and WAAT calculations as outlined in the Earthfx report it is concluded that the level of uncertainty associated with the computation of SAAT is high. While the corrections applied to well locations resulted in spatially correct analyses, the underlying uncertainty in the computations themselves results in an overall ranking of high uncertainty for the process.

Detailed descriptions of the methodology and associated assumptions for these calculations are included in the report *Aquifer Vulnerability mapping for Norfolk, Brant Counties, Catfish Creek and Kettle Creek watershed* (Earthfx, 2008).

Transport Pathways in the Grand Valley Wellhead Protection Areas

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

Water Wells

A review of water well records from the MECP water well database and a field survey were conducted to identify wells within the 5 year time of travel zone (WHPA-C) on wells PW1, PW2 and PW3. The wells were then evaluated and ranked based on their risk to the supply aquifer. The risk evaluation process included an analysis of the age of the well and its likely condition as well as where possible a visual inspection of the well.

Prior to the provision of municipal water in Grand Valley, the majority of residents used individual wells for their water supply. The majority of these wells were never decommissioned in accordance with MECP Ontario Regulation 903 guidelines. The survey and field verification resulted in the identification of 38 water wells within the 5 year (Zones A, B and C of well PW1, PW2 and PW3) time of travel and classified 25 of the wells as high risk wells.

MECP well records within the PW5 WHPA were reviewed as well as information from a water well survey completed as part of the PW5 pumping test (Burnside, 2020). Due to the low density of wells within the PW5 WHPA and that the wells outside of the Village are still in use (likely maintained), an increase in vulnerability due to private water supply wells was not applied.

Residential Septic Systems

In areas where no municipal sewerage systems exist, residences are assumed to be using individual septic systems. 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 from which the sewage discharge infiltrates 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. Septic systems are assumed to be used by all rural residences outside of the village limits. For Wells 1 and 2 the majority of the Wellhead Protection Area is located within the village where there is wastewater servicing. WHPA-C and D for Wells 3 and 4 are outside the serviced area, but the area is agricultural with no houses. Most of the WHPA for PW5 is located outside of the serviced area and the density of houses with septic systems is low. The overburden in the area of PW5 is 25 m thick (Burnside, 2020) and these systems will not pose a threat to the bedrock aquifer.

Utilities

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. The Village of Grand Valley is serviced with storm-water trunk sewers and sanitary sewers. Most of the PW5 WHPA is located outside of the area of servicing.

Surface Water Features

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 pond, dugouts and aggregate extraction ponds. There were no surface water features identified within the Wellhead Protection Areas of PW1, PW2, and PW3. Boyne Creek and a drainage outlet are located within the WHPA-D for PW5. The overburden in the area of the creek and drainage outlet is greater than 25 m thick and therefore the watercourses do not pose a threat to the bedrock aquifer (Burnside, 2020).

Aggregate Operations

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

As part of the current study aggregate operations have been mapped based on existing databases and the review of aerial photography and satellite imagery along with a windshield survey of the Wellhead Protection Areas. A large aggregate operation is located southeast of Wells 1 and 2 in a portion of the Wellhead Protection Area. There are no aggregate operations located within the WHPAs or Wells PW3 and PW5.

Adjusted Vulnerability Scoring for the Grand Valley Wellhead Protection Areas

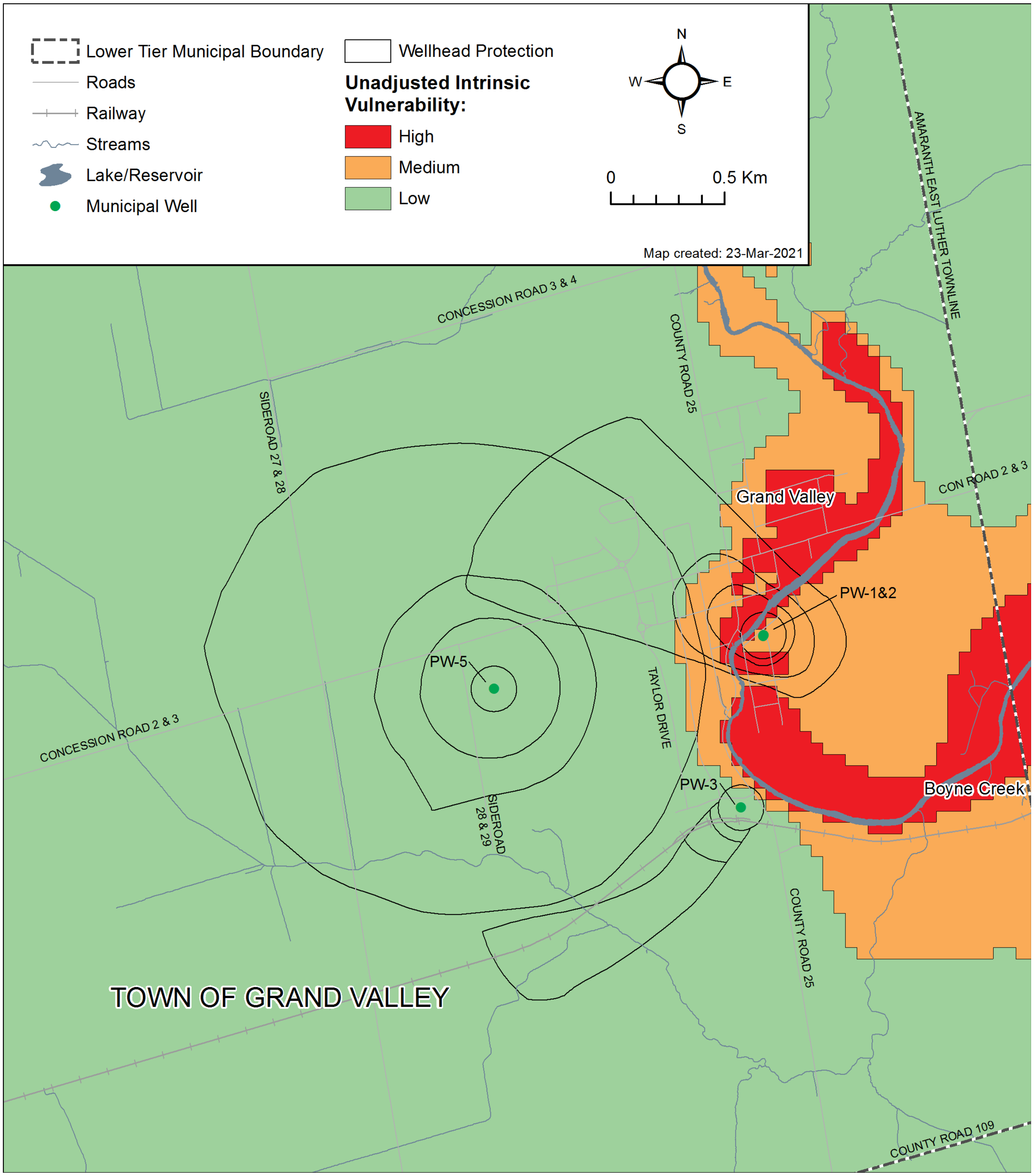
Within the current study, to account for the presence of high risk wells as potential transport pathways, increases in vulnerability were applied in areas with a high density of high risk wells. For this evaluation a visual survey of high risk well locations was undertaken and where there was a significant concentration of well points the update was made.

The increase in vulnerability due to transport pathways was applied around the Village limits due to the high density of unused wells and the presence of underground infrastructure. There are a large number of wells are located within the serviced areas. These wells may not be properly abandoned and present a risk to supply aquifer. Sewer lines and other underground utilities within the Village limits may also present a risk to the aquifer in areas of thin overburden. The footprint of the aggregate operation within the Wellhead Protection Area was also increased to high vulnerability. The transport pathways are shown on **Map 5-14**. The final aquifer vulnerability scoring for the Grand Valley Wellhead Protection Areas is shown on **Map 5-15.**

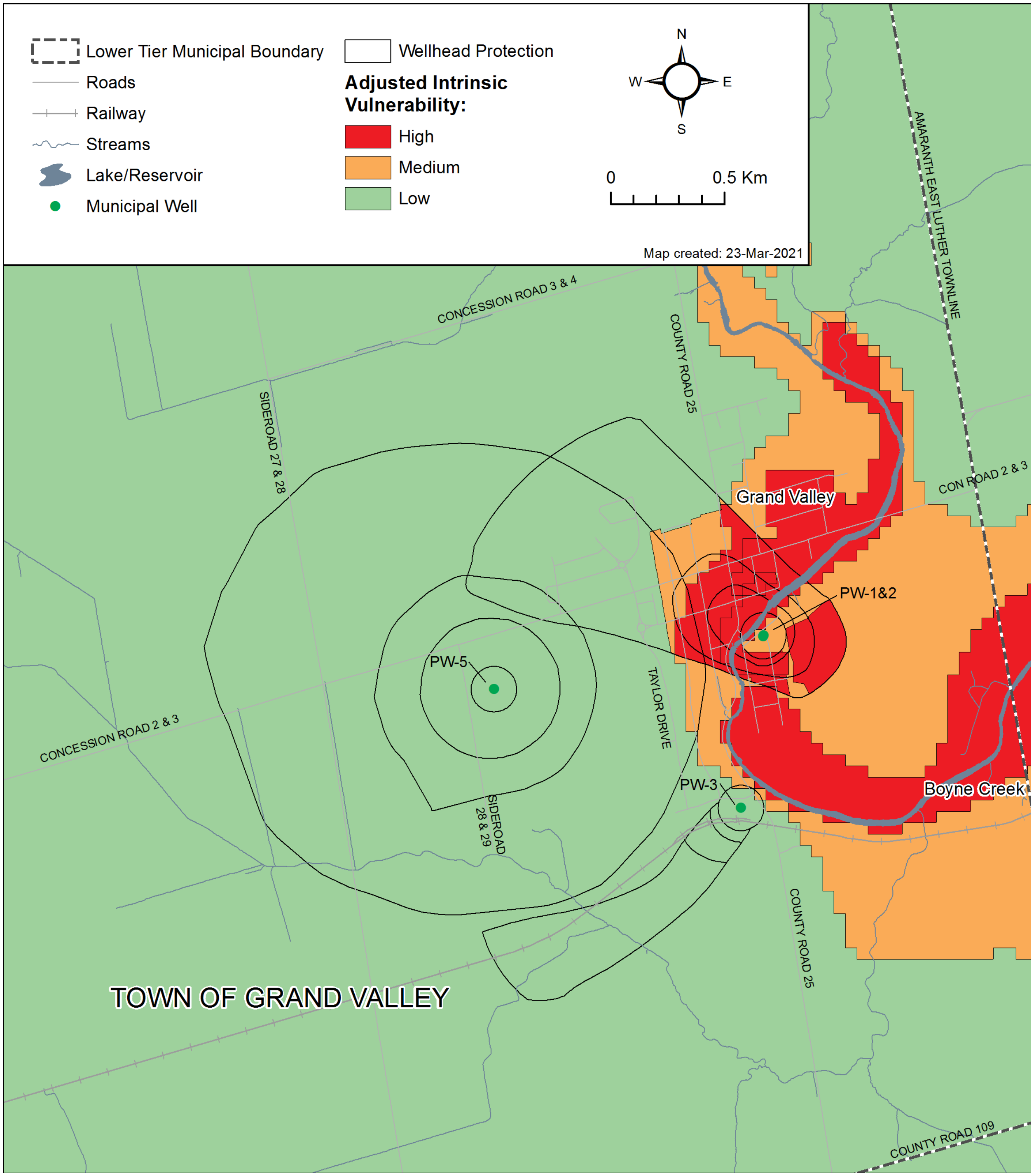
Uncertainty in the Identification of Transport Pathways

In this study the aquifer vulnerability was modified to consider increases in vulnerability due to transport pathways within the Wellhead Protection Areas. For this study the vulnerability was increased around the Village limits due to the high density of unused wells and the presence of underground infrastructure. The exact locations of the wells are not known however the presence of wells indicates that the area was not serviced at the time the houses were built and a well can be assumed to be present at all houses with low uncertainty. The presence of underground infrastructure is also low uncertainty. The vulnerability was also increased around the footprint of a sand and gravel pit based on air photography. This footprint may change in the future, however, the uncertainty can be considered low since it is based on local field observations.

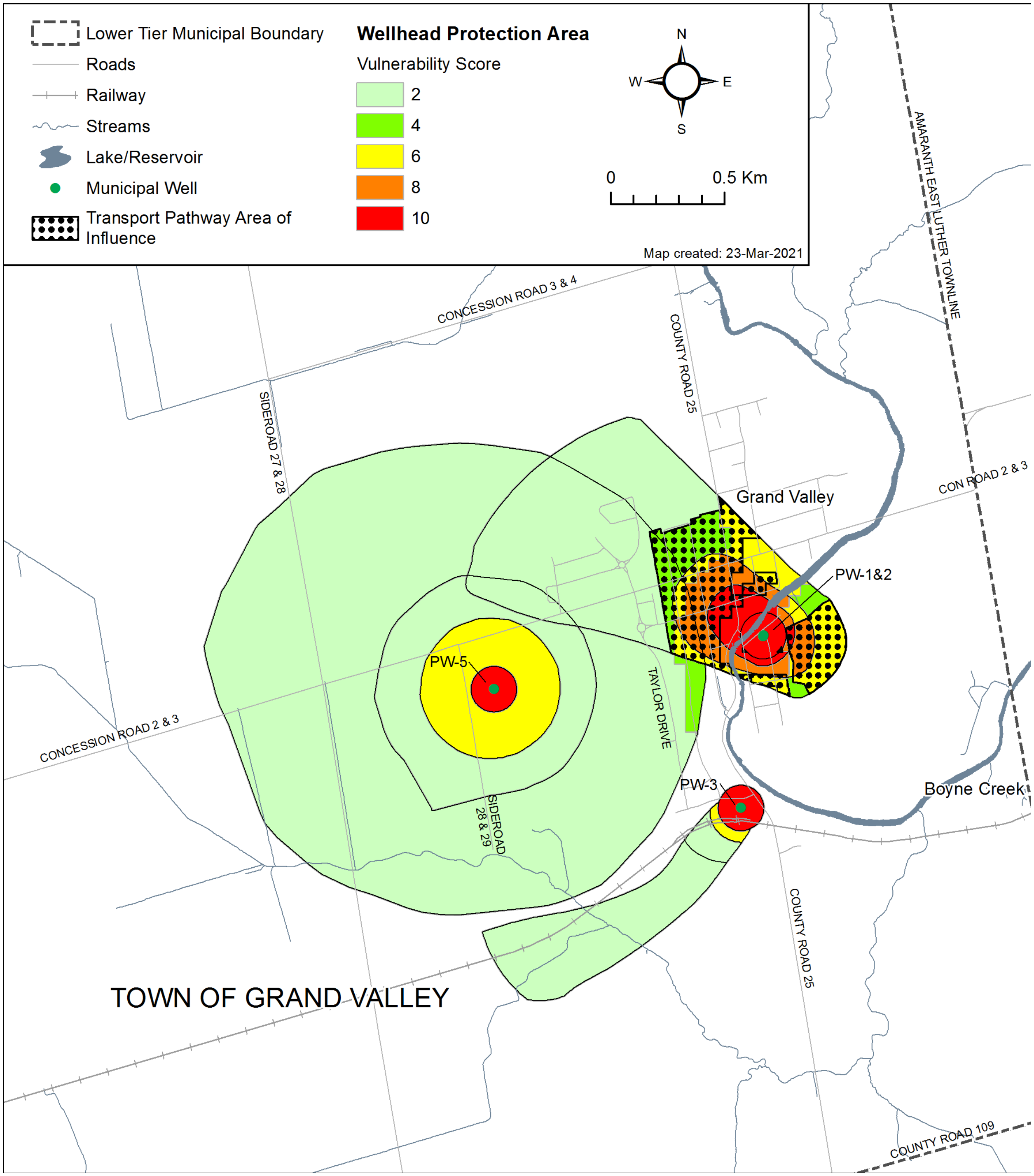
Map 5-12 Grand Valley Well Supply Unadjusted Intrinsic Vulnerability



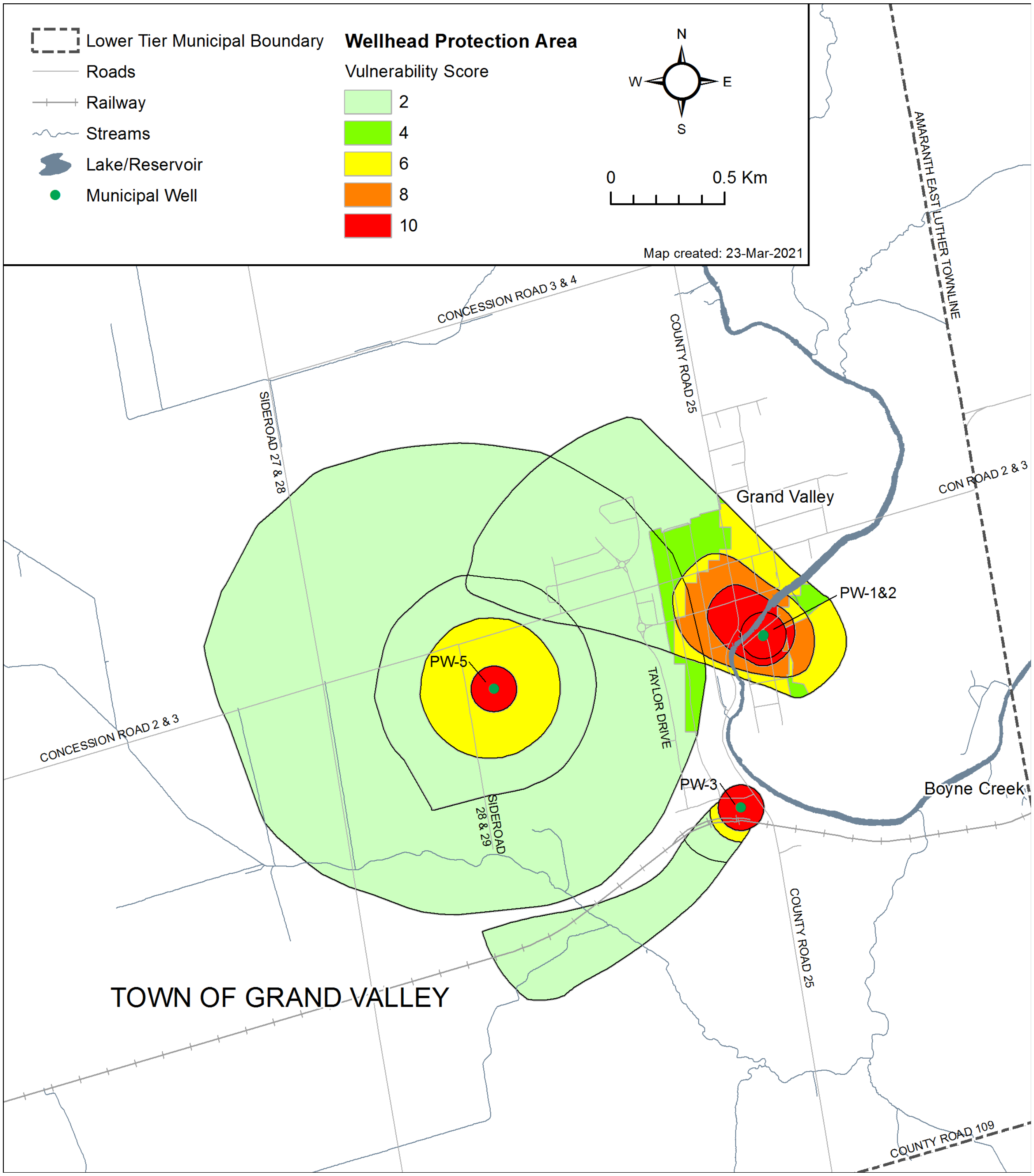
Map 5-13: Grand Valley Well Supply Wellhead Protection Area Adjusted Intrinsic Vulnerability



Map 5-14: Grand Valley Well Supply Wellhead Protection Area Transport Pathways Area of Influence



Map 5-15: Grand Valley Well Supply Wellhead Protection Area Vulnerability



Managed Lands within the Grand Valley Wellhead Protection Area

Managed lands are lands that may receive agricultural source material (ASM), non-agricultural source material (NASM) or commercial fertilizer and can be divided into 2 categories of agricultural managed lands (AML) and non-agricultural managed lands. 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.

The managed land mapping was completed for those areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats (a score of 6 or higher). Managed lands were completed using the methodology outlined in Chapter 3, with the results for the Grand Valley Wells are summarized in **Table 5-14** and **Map 5-16**.

Table 5-14: Managed Lands Percentage in the Grand Valley Wellhead Protection Areas

Township	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Grand Valley	Grand Valley	Wells 1 & 2	40-80%	<40%	<40%	<40%
		Well 3	<40%	40-80%	N/A	N/A
		Well 5	40-80%	>80%	N/A	40-80%

Livestock Density within the Grand Valley Wellhead Protection Area

Livestock density is used as a surrogate measure of the potential for generating, storing and land applying agricultural source material as a source of nutrients 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 generates enough manure to fertilize an area of land. A detailed methodology for managed lands is discussed in Chapter 3 of the Grand River Assessment Report.

The results of the calculations livestock density are provided in **Table 5-16** and **Map 5-17** for the Grand Valley Wellhead Protection Area. In **Table 5-16** 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.

Table 5-15: Livestock Density (NU/acre) in the Grand Valley Wellhead Protection Areas

Township	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Grand Valley	Grand Valley	Wells 1 & 2	0	0	0	0.43
		Well 3	0	0	N/A	N/A
		Well 5	0	0	N/A	0

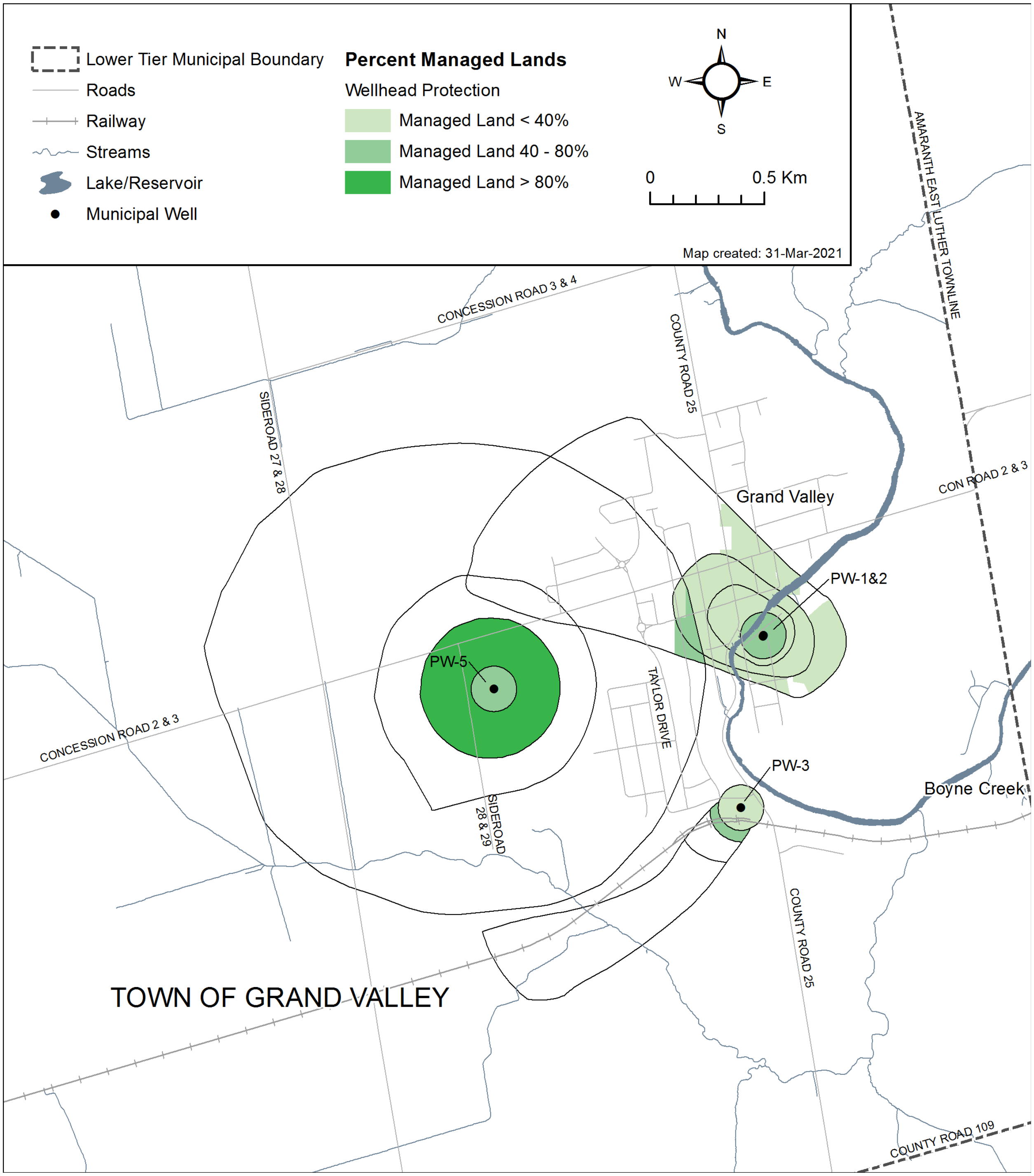
Assumptions While Assigning Non-Agricultural Managed Lands

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.

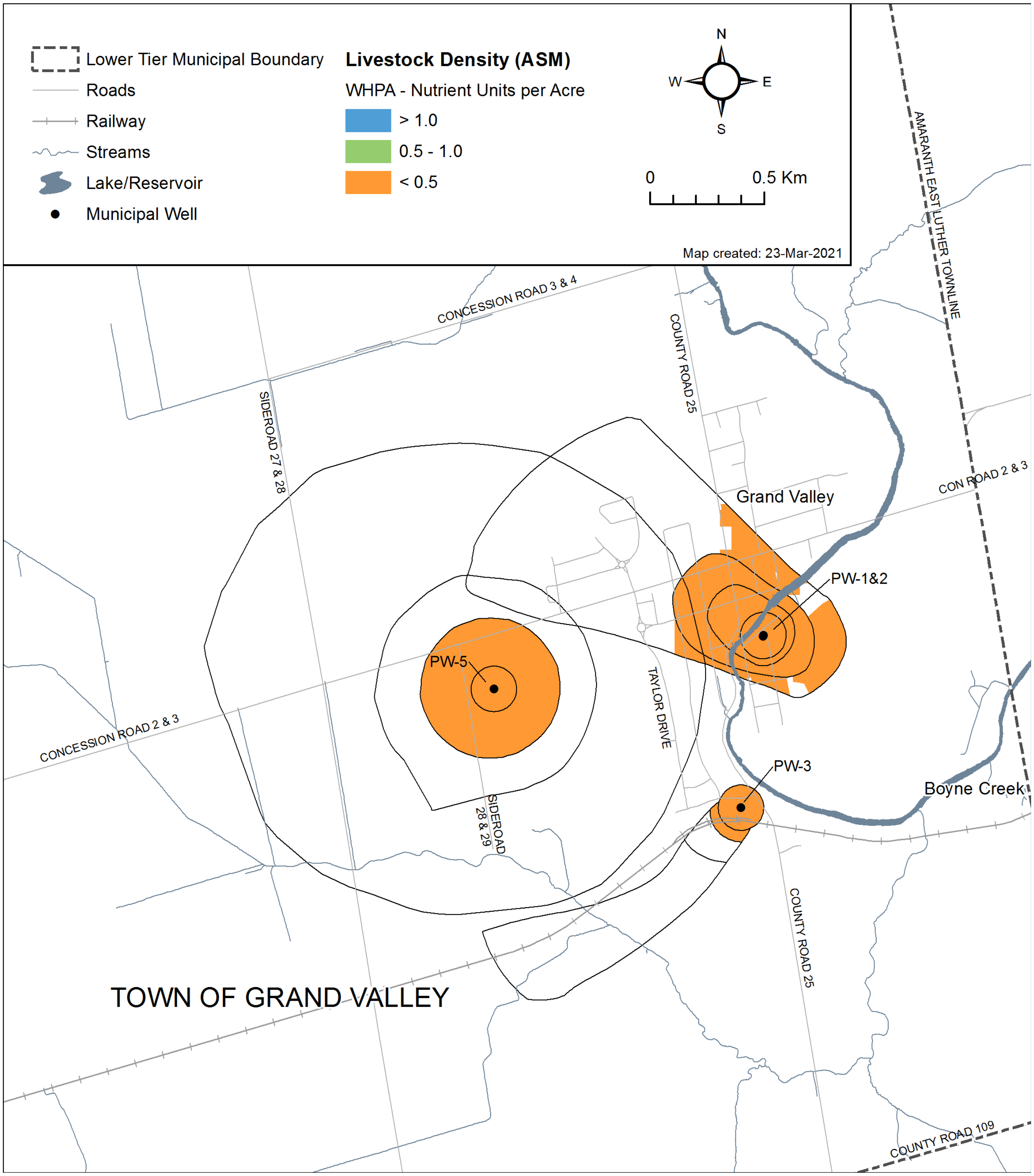
Percent Impervious Surface Area within the Grand Valley Wellhead Protection Areas

Impervious surfaces are defined in the Technical Rules (MECP, 2017) as areas that receive road salt application and include roads and parking lots. The areas were determined using road mapping from the National Road Network (Natural Resources Canada) and satellite air photography to identify large parking lots and paved areas. Using a 1 km x 1 km grid centered over each vulnerability area, the percentage of impermeable surfaces within each square kilometre was calculated. The percentage of total impervious surface areas within each square kilometre of vulnerable areas is shown in **Map 5-18.** The percentage of impervious surfaces is an indicator for the potential for impacts due to road salt. In areas with a high percentage of impervious surfaces (roads) there is an increased likelihood that road salt would be applied. Impervious surfaces range from 0% to 8.44% in the Grand Valley wellfields. Road salt application would not be a significant drinking water threat within these WHPAs.

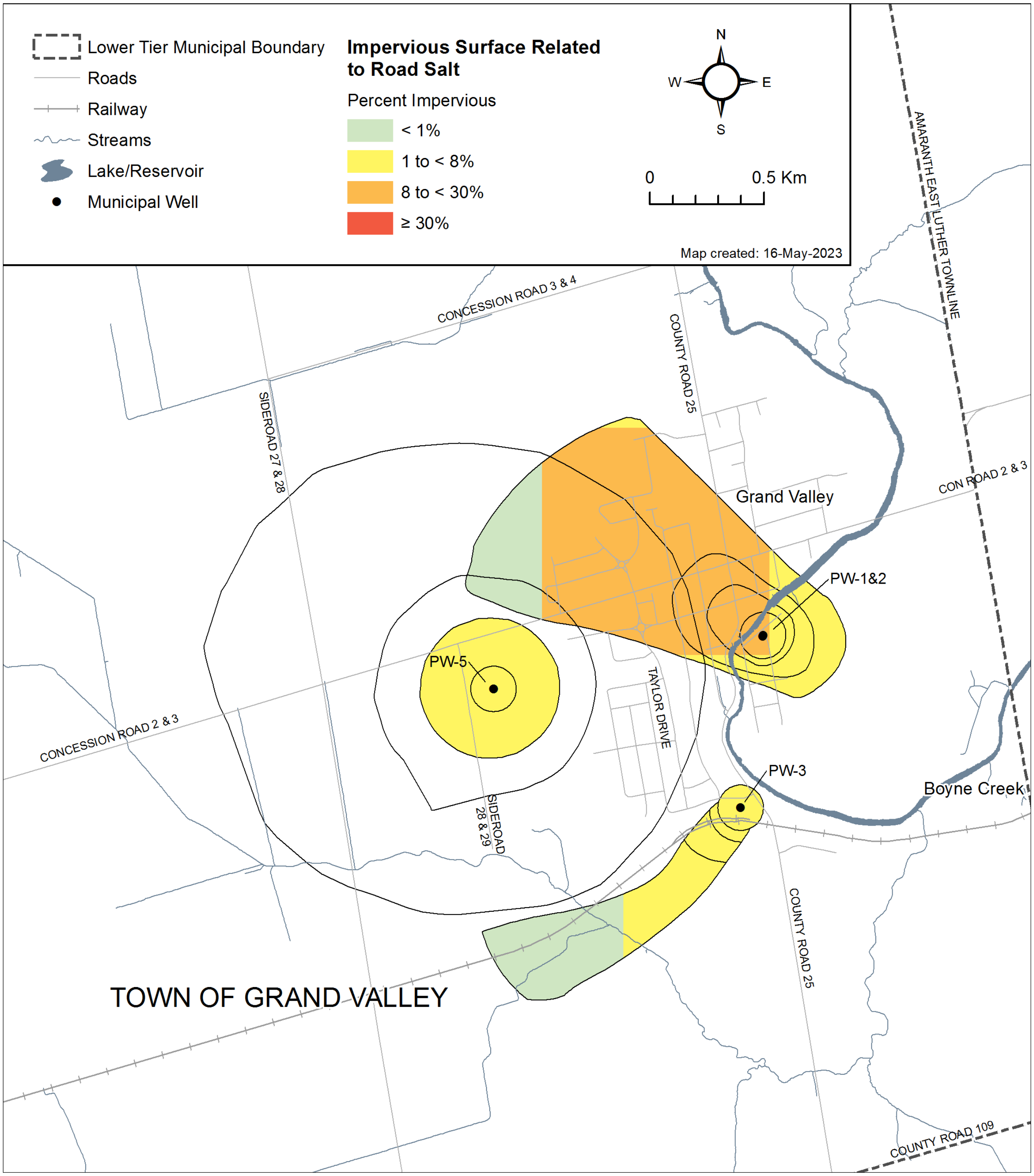
Map 5-16: Grand Valley Well Supply Percent Managed Lands



Map 5-17: Grand Valley Well Supply Livestock Density



Map 5-18: Grand Valley Percent Impervious Surfaces



5.2.3 Drinking Water Threats Assessment

The *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.” The 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 Grand Valley 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 Director’s Technical Rules (2021). Information on drinking water threats is also accessible through the Source Water Protection Threats Tool. The information above can be used with the vulnerability scores shown in **Map 5-15** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 5-16 provides a summary of the threat levels possible in the Grand Valley 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 5-15.**

Table 5-16: Identification of Drinking Water Quality Threats in the Grand Valley Wellhead Protection Areas

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

5.2.4 Conditions Evaluation

Conditions Evaluation for the Grand Valley Well Supply

A review of available data regarding potential contamination within the WHPAs 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 and data collected in previous groundwater studies.

Ecolog ERIS databases did not identify any contamination recorded in the Record of Site Condition, MECP Spills Database and Occurrence Reporting Information Centre.

A known contaminated site was identified in a previous study (Burnside, 2001a) on Mill Street within the WHPA-B for Wells 1 and 2 (**Map 5-11).** The site is reported to have been a bulk fuel depot with underground storage tanks (Burnside, 2001a). The site was identified by a review of MOE contaminated site databases and is recorded as MOE Project No. 4112. A report on the site was completed by MGI Limited in 1999 and reported groundwater samples with concentrations of various pollutants including, 0.096 mg/L benzene, 0.482 mg/L ethylbenzene, 1.79 mg/L xylene and 0.0755 mg/L 1-methylnapthalene. These concentrations exceed the maximum concentrations of benzene, ethylbenzene, xylene, and 1-methylnapthalene standards in Table 2 of Soil, Ground Water and Sediment Standards. The report documents that the groundwater plume has moved 60 m south and that the average shallow groundwater velocity is 4 m/year.

Based on this information the plume may have moved an additional 44 m since the report in 1999 and the contamination has moved off of the property. The Condition is given a hazard rating of 10 since the plume has moved off-site, and it has a vulnerability score of 10 because it is located in WHPA-B. The calculated risk score is 100 and the Condition is, therefore, identified as a significant drinking water threat.

In 2021, an assessment of condition sites was completed for Well PW5 (Burnside, 2021). A review of historical air photographs from 1954 to 1990 was completed to identify any past land use activities that may result in groundwater contamination. The air photographs do not show any activities on the lands except for agricultural activities. Therefore, it is assumed that there are no conditions within the Well PW5 WHPA-A.

5.2.5 Grand Valley Drinking Water Quality Issues Evaluation

Historical water quality data was collected and reviewed for samples taken between 1991 and 2000. The data showed regular exceedances of the Maximum Allowable Concentration (MAC) ODWQS for the parameters of hardness and fluoride (Burnside, 2001a).

Historical water quality data for the Grand Valley wells indicate that the water is traditionally very hard and often exceeds the ODWQS standards. Hardness concentrations measured between 1991 and 2000 ranged between 217 mg/L and 850 mg/L. This is above the Operational Guideline of the ODWQS range of 80-100 mg/L (Burnside, 2001a). 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.

All wells have elevated naturally occurring fluoride content which often exceeds the ODWQS MAC of 1.5 mg/L. The results from 1991 to 2000 show fluoride concentrations ranging from 0.02 mg/L to 1.8 mg/L. In 2000, all wells had fluoride exceedances ranging from 1.6 to 1.8 mg/L (Burnside

2001a). In 2003 fluoride levels ranged from 1.4-1.7 mg/L and in 2008 fluoride was recorded at 1.8 mg/L.

Elevated sodium concentrations have been recorded in the Grand Valley wells. Sodium concentrations in Well 1 and Well 2 ranged from 10 to 36 mg/L and sodium concentrations in Wells 3 and 4 ranged from 4 mg/L to 24.8 mg/L. The ODWQS MAC for sodium is 200 mg/L, however the local Medical Officer of Health should be notified when sodium concentrations exceed 20 mg/L.

A review of available microbiological data for the Grand Valley Water Supply wells for years 2000, 2005, and 2006 to 2009. No Issues with total coliforms or *E.coli* have been documented.

Water Operator Interview

The operator of the Grand Valley system from Dufferin Water Systems was consulted to identify any Issues that may result in the deterioration of the water quality. No water quality Issues under Technical Rule 114 at the Grand Valley Water Supply System were identified.

Summary of Water Quality Issues Evaluation for Grand Valley Well Supply

Upon review of available current drinking water quality data there are no Issues for the Grand Valley wells. Hardness and fluoride have elevated concentrations however are naturally occurring and therefore do not reflect a deterioration of water quality. Sodium concentrations do not exceed the ODWQS and do not show any increasing trends. None of the above parameters are currently interfering or anticipated to interfere with the use of the groundwater as a source of drinking water.

Limitations and Uncertainty for the Water Quality Issues Evaluation for the Grand Valley Well Supply

The water quality data reviewed includes data from 1991 to 2009 however not all parameters were sampled during each year. This makes it difficult to identify 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 PTTW requirements.

5.2.6 Enumeration of Significant Drinking Water 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 2017 version of the Director's Technical Rules was used for the threats enumeration.

The threats enumeration was compiled using the data from various sources that were reviewed as part of the Burnside 2010 and Burnside 2021 studies.

Threats Assessment 2010 – Well PW1, PW2 and PW3

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 Activity Threats Assessment of the Grand Valley Well Supply

The threats inventory was compiled using the data and information sources outlined below. Following the preliminary research field assessments were conducted to complete the threats inventory. All threats were recorded in a database provided by the MOE.

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 prescribed radius around the wells' 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 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 1886-2005Mineral 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 several items within the Wellhead Protection Areas. There were three Certificates of Approval mapped within the search area. Two Certificates of Approval were related to municipal water supply and municipal sewage.

The water supply Certificates of Approval were for water supplied by the production wells discussed in this study. The third Certificate of Approval concerned industrial air emissions for a standby diesel generator located at the pump house for Wells 3 and 4. The Ecolog ERIS report also identifies four further Certificates of Approval but did not indicate locations. Three of the Certificates concerned municipal water supplied by the Melody Homes wells discussed in this study. The fourth Certificate of Approval concerned municipal sewage.

There were five registered Waste Generators mapped within the Wellhead Protection Area. The current presence of the businesses listed was confirmed by field assessment.

Two businesses in Grand Valley are registered to sell pesticides according to the Pesticide Register database.

Three fuel storage tanks were identified in a search of the Retail Fuel Storage Tanks database. All three tanks are located at the same property. The field assessment confirmed the location and presence of the tanks. The former gas station is currently not in operation.

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 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. 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: Land uses in the Wellhead Protection Area include mostly residential areas and some urban commercial areas within the Village and agricultural areas outside of the Village. One pit or quarry is located on the southeast corner of the Village, east of the Grand River. Agricultural land uses and residential housing including the Melody Homes subdivision were similar to present. No waste disposal sites or potential brownfields sites were noted in the photograph.

2000 Aerial Photography: This photograph revealed that land use within the Wellhead Protection Areas has remained largely unchanged since the 1978 photograph. The quarry in the southeast corner of the village is now three times the size it was in 1978. The agricultural lands noted in the previous aerial photograph appear unchanged.

Site Reconnaissance and Inspection

A drive-by roadside inspection of the Wellhead Protection Areas on June 26, 2006 to verify and compliment the dataset compiled during the records review portion of the assessment. The inspection consisted of a fence line/roadside documentation of the properties and their land uses included in the Wellhead Protection Area.

Well 1 and Well 2, are located approximately 100 m southeast of the Grand River in a residential area of the Village of Grand Valley. The land uses within the Wellhead Protection Area include residential, commercial, institutional, agricultural and aggregate extraction. An aggregate extraction operation is located southeast of the wells on the east side of the Grand River. A walking tour of the commercial portion of the Village of Grand Valley was conducted. The presence or absence of commercial establishments was noted in comparison to the inspection during the previous Groundwater Management Plan was conducted.

The Melody Homes wells, Well 3 and Well 4, are located near the south boundary of the Village of Grand Valley beside the Melody Homes sub-division. The land uses within the Wellhead Protection Area include residential and agricultural.

No waste disposal sites were noted within the Grand Valley Wellhead Protection Areas during the site inspection.

In addition to identifying current significant threats, a review of planning documents was completed to identify a list of activities permitted in approved planning documents that would be significant drinking water threats.

The Town of Grand Valley Official Plan was reviewed to identify permitted land uses within the Wellhead Protection Areas. Current permitted land uses include urban residential, downtown commercial, open space, environmental protection, extractive industrial and agriculture.

Threats Assessment 2021 – Well PW5

The current assessment has been completed for the WHPAs for Well PW5. Threats were identified based on satellite air photography, windshield survey and municipal property fabric.

Land uses within the Well PW5 WHPAs include agricultural, residential and rural (non-agricultural). Well PW5 is located on municipal owned lands that will be future parkland. A pumphouse will be constructed on the municipal lands that will include fuel storage for a back-up generator. Agricultural lands used for crops are located south of the well. Residential homes are located along Concession Road 2 and a new subdivision is being built east of PW5.

For this analysis it was assumed that any possible threats associated with an activity were present and that all potential chemicals were present. The presence and circumstances of the identified significant drinking water activities will be verified by the municipality at a later date.

Significant Drinking Water Quality Threats for the Grand Valley Well Supply

A threats assessment was completed for the Wells PW1, PW2 and PW3 WHPAs in 2010 by Burnside. These threats were reported in the initial Grand Valley Assessment Report (January 2015) and have been updated by the municipality on an annual basis through Source Protection annual reporting. The current Assessment Report has been updated with the PW5 threats. A summary of total significant drinking water threats within the Grand Valley Well Supply WHPAs is provided in **Table 5-17**.

Table 5-17: Grand Valley Well Supply Significant Drinking Water Quality Threats – Updated April 2021

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
2	Sewage System Or Sewage Works – Sanitary Sewers and related pipes	1	WHPA-B
3	The application of agricultural source material to land	1	WHPA-A
6	The application of non-agricultural source material to land	1	WHPA-A
10	The application of pesticide to land	1	WHPA-A
15	Handling and Storage Of Fuel	23	WHPA-A WHPA-B
16	Handling and Storage Of A Dense Non Aqueous Phase Liquid (DNAPL)	6	WHPA-C
Condition	Contaminated groundwater from a bulk fuel depot with underground storage tanks	N/A	WHPA-B
Total Number of Properties		**31**	
Total Number of Activities		**33**	
Total Number of Conditions		**1**	

1. *Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*
2: *Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

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 Threats for the Grand Valley Well Supply

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, a field reconnaissance was completed to confirm the data and to decrease the error in the database information.

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. In this study a number of databases were used to create the significant threats. 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.

5.3 Township of East Garafraxa

5.3.1 Marsville Well Supply

The Township of East Garafraxa is located within the Grand River watershed and is part of Dufferin County (**Map 5-19**). The community of Marsville is located in the centre of the Township along County Road 3 at its intersection with 13th Line. The assessment of drinking water quality within the Township was completed by R.J. Burnside in June 2010.

The Marsville Water Supply System consists of two municipal groundwater supply wells (PW1 and PW2) located at the northeast end of Grand Crescent in a public park and provides water for the Thunderbird Estates Subdivision located within the Hamlet of Marsville. The system distributes to 33 homes servicing approximately 80 to 90 people.

PW1 is the main supply well and PW2 is an alternate standby well. PW1 was drilled in 1971 and is 150 mm in diameter. The well is completed as an open hole in bedrock from 61.3 m to 91.4 m. Based on information from a well inspection completed by Well Initiatives Limited in 2009, the stand-by well PW2 is a 200 mm diameter well with an open hole bedrock interval from 75 m to 103 m.

The aquifer from which the wells obtain water is the dolostone bedrock of the Guelph and Gasport Formations. Overlying the bedrock are about 62 m of Orangeville Moraine deposits consisting of silty to clayey till. The wells draw water from the upper weathered and middle competent portion of the bedrock aquifer (Burnside, 2000).

The Marsville Water Supply system is operated under to Permit to Take Water No. 0601-88MKJ7. According to the permit, PW1 is permitted to pump 364 L/min with a maximum daily rate of 182 m^3/day. PW2 is not included in the permit and a permit amendment will be required if the Township intends to bring PW2 online.

Table 5-18, **Table 5-19** and **Table 5-20** provide summaries of the municipal supply wells, the system information and the average monthly and annual water taking.

Table 5-18: Municipal Production Wells in the Marsville Well Supply

Well	Depth (m)	Open Interval	PTTW Number	Permitted Pumping Rate
PW1	91.4	61.3 m to 91.4 m	0601-88MKJ7	364 L/min
PW2	103	75 m to 103 m	No permit	-

Table 5-19: Drinking Water System Information for the Marsville Well Supply

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served[1]
210002183	Marsville Well Supply	Dufferin Water Co. Ltd.	GW	Small Municipal Drinking Water System	80-90

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

Table 5-20: Annual and Monthly Average Pumping Rates for Marsville Well Supply

Well or Intake	Annual Avg. Taking[1] (m^3/d)	Average Daily Volume (m^3/d)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PW1	21.6	17	17	17	19	18	24	20	20	25	27	26	29

[1] source: Dufferin Water Co. Ltd 2017 annual summary report

5.3.2 Marsville Wellhead Protection Areas

Wellhead Protection Areas (WHPA) for the Marsville water supply wells were delineated as part of a study completed by Golder in 2010 using a FEFLOW groundwater model called the "Grand Valley, Waldemar, and Marsville GRCA Cut-Out Model". This model was based on the regional scale GRCA model constructed by Waterloo Hydrogeologic (WHI) in 2005 for the Grand River watershed. The "Cut-Out" was improved upon by Golder and refined around the capture zones within Grand Valley, Waldemar and Marsville. The model was constructed and calibrated with available hydrogeological data and hydrogeological mapping products (Golder, 2010b). Porosity used in the model was assigned at 0.2 for all overburden units and 0.05 for all bedrock units (Golder, 2010b).

The pumping rates used were selected based on historic and estimated future pumping rates. Since the pumping rates are not expected to increase over the next 25 years due to a lack of population growth or predicted increased demand, forecast pumping rates used for the capture zone delineation were based on historical average pumping rates (Golder, 2010b). The pumping rates used in developing the capture zones were based on a forecast of anticipated future groundwater use and are provided in **Table 5-21**.

Table 5-21: Pumping Rates Used for the Marsville Well Supply Wellhead Protection Areas Delineation

Supply Wells	Pumping Rate Used	Actual Pumping Rate*
PW 1	27 m3 / day	23.2 m3 / day
PW 2	27 m3 / day	0

*Average daily pumping rate in 2008 (DWCo. Ltd, 2009)

Marsville PW2 is an alternate to PW1 and is not included in the current PTTW, however for the Wellhead Protection Area delineation it was assumed that PW1 and PW2 were operating simultaneously and at the same rate. This rationale has resulted in a more conservative capture zone with respect to the total water taking applied at the Marsville pumping wells (Golder, 2010b).

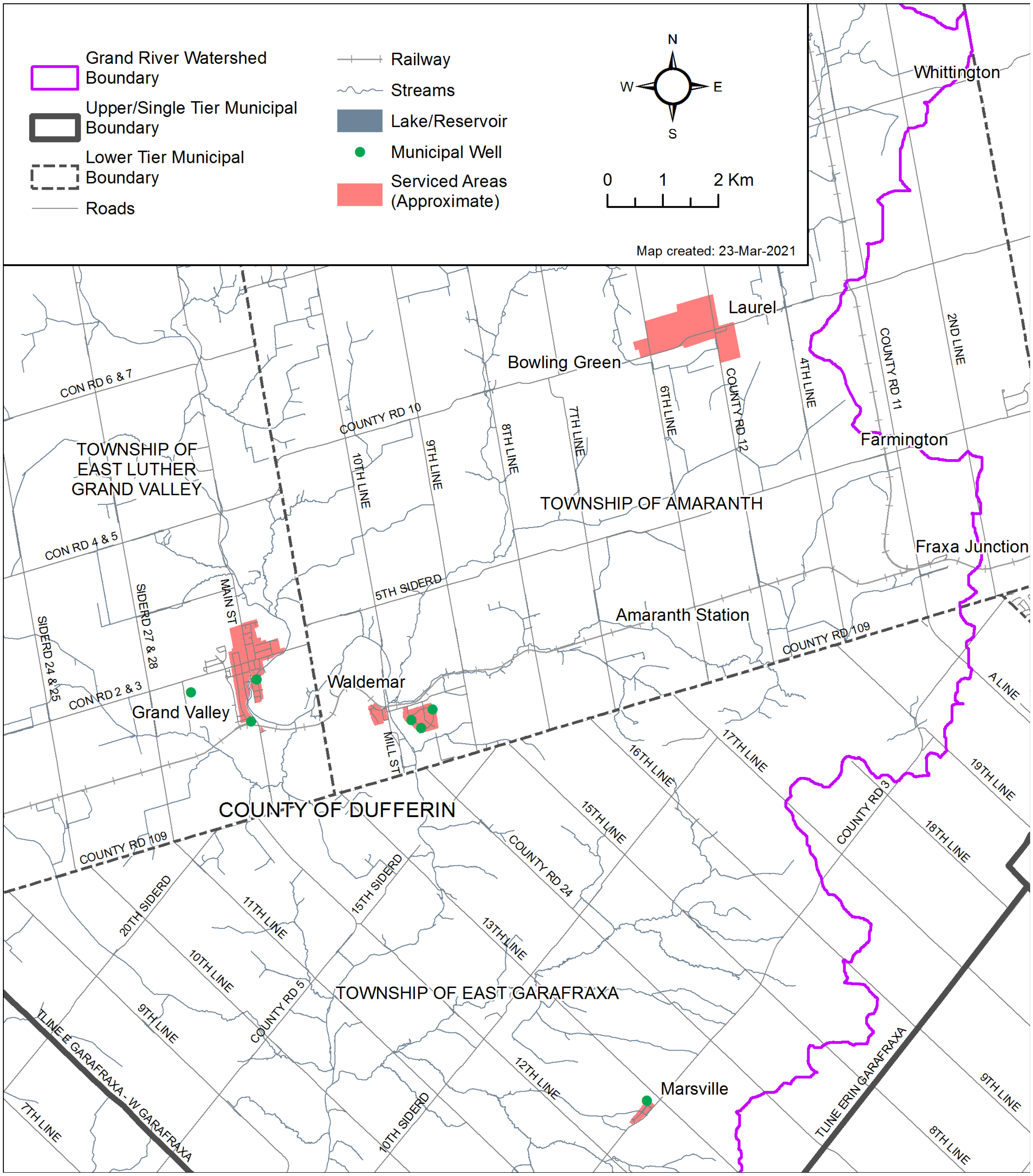
To develop Time of Travel (TOT) capture zones groundwater particles were released at the pumping wells in the model and tracked backwards towards their source of origin (recharge). At each well location, particles were released in all hydrostratigraphic units “open” to the wellbore. The time-related 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 account for uncertainty in the model a “shape factor” was applied to effectively increase the spatial coverage of each of the time of travel capture zones. The width and length of the capture zone was increased by 20 percent to account for some uncertainty in the hydraulic characteristics of the aquifer system and the orientation of the capture zone was adjusted by 5 degrees (plus and minus) to account for uncertainty in the regional groundwater flow direction.

In delineating the time of travel capture zones at the Marsville wells, it was noted that the pathlines became essentially vertical prior to the 2 year time of travel. Effectively this means that the capture zones beyond the 2 year time of travel become thin slivers, as only the horizontal component of the pathlines is projected to surface and each zone must exclude the previous zone. Therefore, it was not possible to delineate traditional 2 year (WHPA-B), 5 year (WHPA-C) and 25 year (WHPA-D) zones for these wells. The Wellhead Protection Area for the Marsville wells was therefore delineated to consist of the 100 m exclusion zone (WHPA-A) and the 2 year capture zone (WHPA-B).

The location and orientation of the Wellhead Protection Area for the Marsville Well (PW1) is shown in **Map 5-20**. The Marsville capture zone extends north-east and receives recharge water from the elevated areas of the Orangeville Moraine near the watershed divide between the Grand River and Credit River systems. The steady-state zone extends approximately 2.4 km from the well. The total Wellhead Protection Area covers an area of 94 ha.

Map 5-19: County of Dufferin Water Supply Serviced Areas in the Grand River Watershed



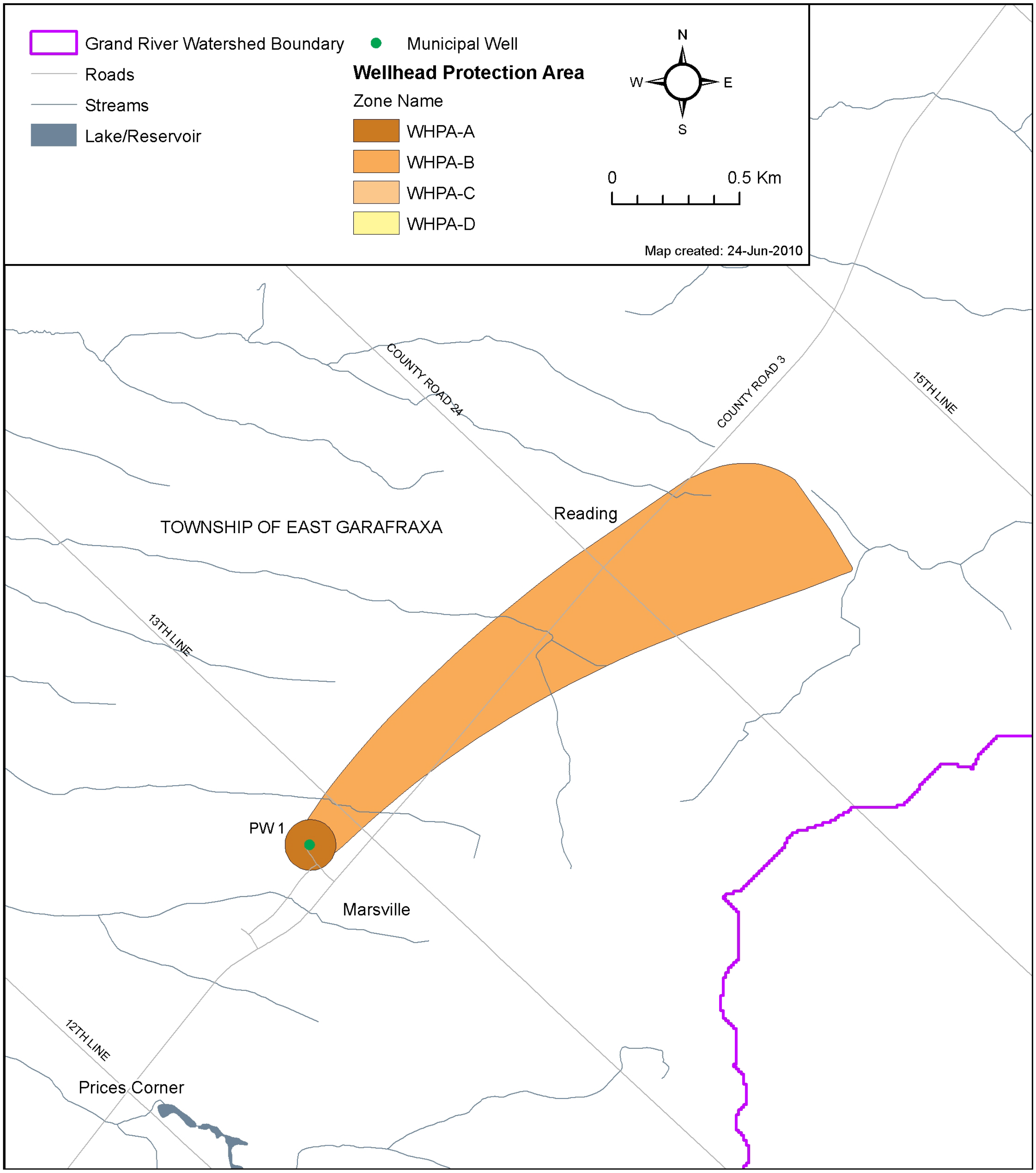
Delineation of WHPA-E and WHPA-F for the Marsville Well Supply

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

As part of the Engineer’s Report on Marsville Water Supply System (Burnside, 2000), PW1 was identified as not being impacted by surface water. The well is located in a confined aquifer at a depth of 91 m below surface. There were no microbiological Issues identified to suggest impacts from surface water.

Since the wells in this study have not been identified as GUDI, the delineation of a WHPA-E was not required. The Technical Rules also require that a WHPA-F be delineated for a well when the wells Wellhead Protection Area contains a WHPA-E and a drinking water issue is identified that originates outside of the areas WHPA-A through WHPA-E. Since a WHPA-E was not required for any of the wells, the delineation of a WHPA-F was also not required.

Map 5-20: Marsville Well Supply Wellhead Protection Area



Vulnerability Scoring in Wellhead Protection Areas

Most of the regional intrinsic vulnerability within the Grand River SPA was completed using the Surface to Aquifer Advective Time (SAAT) method (EarthFX, 2010) and modified at the municipal well scale to account for local conditions (Golder, 2010a). A map showing the unadjusted intrinsic vulnerability is shown on **Map 5-21.**

The vulnerability scoring for the current study was completed in accordance with Rule 82 of the Technical Rules. Vulnerability scores range from 10 for areas with the highest vulnerability to 2 for areas with low vulnerability. Scores were assigned as per Table 2(a) in Part VII of the Technical Rules (MOE, 2009b). A summary of the process used to define vulnerability scores is outlined in the **Table 5-22**.

Table 5-22: Wellhead Protection Area Vulnerability Scores – SAAT

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

Vulnerability Scoring for the Marsville Wellhead Protection Areas

Map 5-22 shows the vulnerability scores assigned to the Marsville Wellhead Protection Areas using the SAAT vulnerability mapping. The mapping illustrates that the entire study area is rated as low vulnerability. This low vulnerability is of the fine-grained till overburden that is extensively distributed throughout the area, providing protection for the aquifer from contaminants and also due to the thickness of the overburden cover over the bedrock aquifer.

For this study the delineated zone was scored as a 2 year time of travel zone since flow becomes vertical before a 2 year time of travel was established. The Wellhead Protection Area has a score of 6 since the vulnerability is low while the 100 m radius zone around the supply wells is scored as 10.

Transport Pathways in the Marsville Wellhead Protection Areas

The features discussed below were considered as transport pathways within the context of the current study.

Water Wells

A review of water well records from the MOE water well database and a field survey were conducted to identify wells within the Wellhead Protection Areas. The wells were then evaluated and ranked based on their risk to the supply aquifer. The risk evaluation process included an analysis of the age of the well and its likely condition and where possible a visual inspection of the well. The risk evaluation process as conducted for this study. The survey resulted in the identification of 12 water wells within the Wellhead Protection Areas and classified 7 of the wells as high risk wells.

Residential Septic Systems

In areas where no municipal sewerage systems exist, residences are assumed to be connected to individual septic systems. 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 from which the sewage discharge infiltrates 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 in question. Septic systems are assumed to be used by all residences in the study area as there is no wastewater servicing. The municipal aquifer for the Marsville water supply is a confined aquifer that is overlain by over 60 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.

Tile Drains

Tile drains are common in agricultural areas where fine-grained soils are known to occur. Tile drains tend to be located within the upper 1 m of the soil. A tile drain known as Brower Drainage Works is located in a field north of the supply wells and discharges within the Wellhead Protection Area at 13th Line. Since the aquifer used by the municipal supply wells is generally protected by over 60 m of fine grained sediments (an upper aquitard), the risk for transport pathways to be created due to tile drains is low.

Utilities

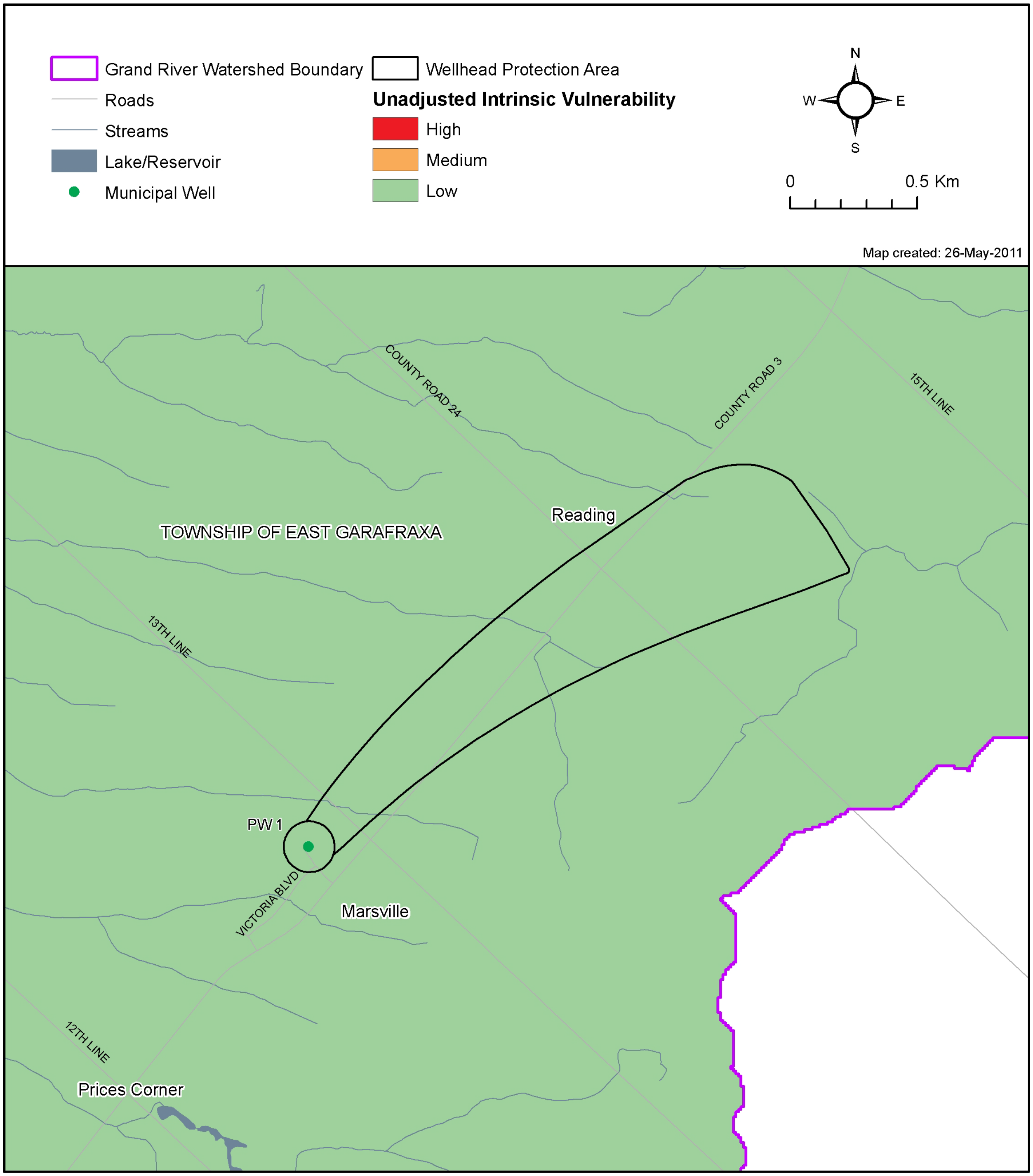
Utilities that are constructed in the sub-surface are potential transport pathways as the disturbed soil surrounding them can provide a pathway for contaminants to enter into the aquifer below. Utilities that may act as transport pathways include storm-water trunk sewers and sanitary infrastructure. The depth of excavation for the construction of utilities will determine the risk that the wells pose on the municipal supply aquifer. There is no infrastructure within the Wellhead Protection Areas that may act as transport pathways. 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.

Aggregate Operations

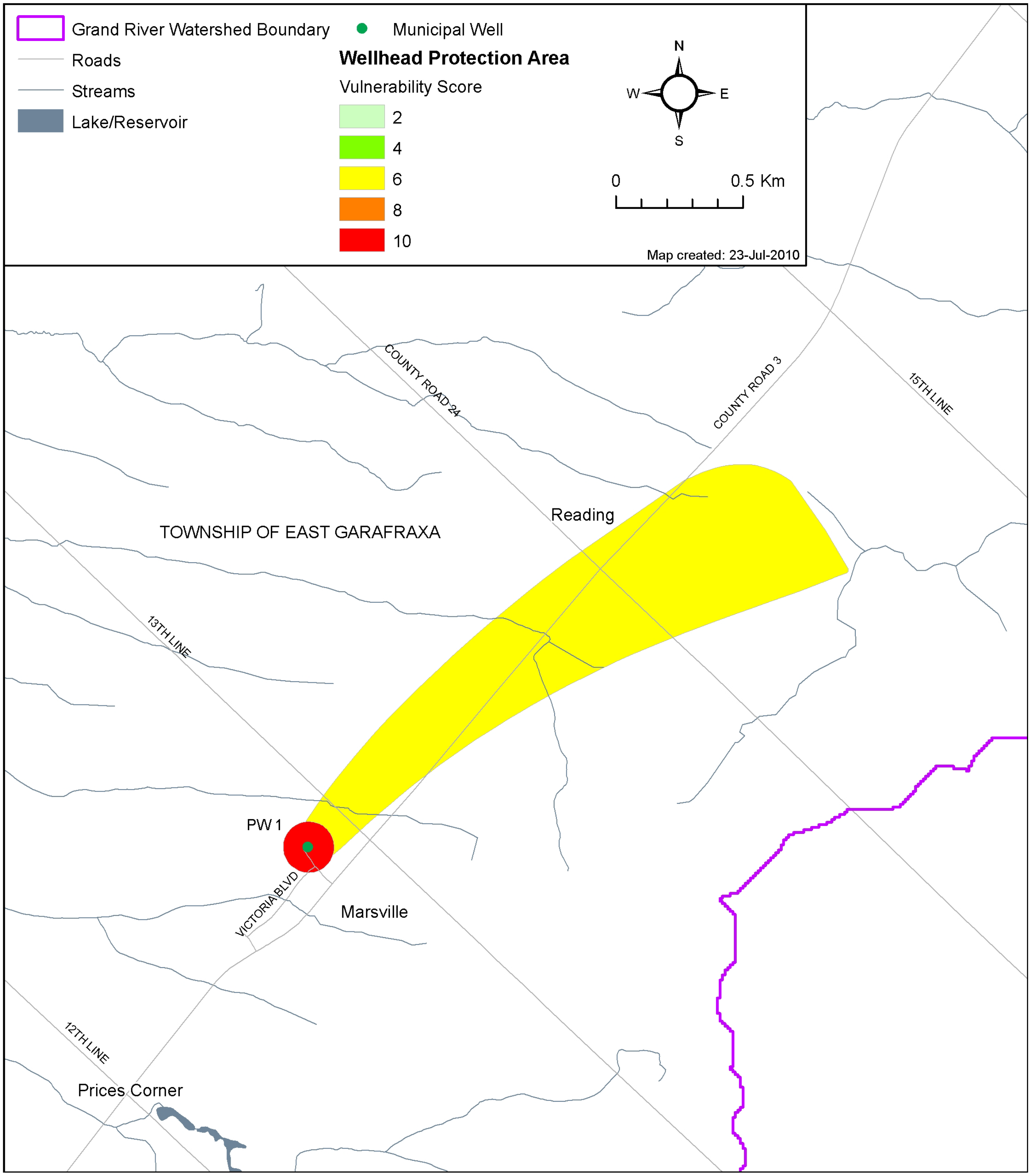
Aggregate operations are defined as activities that involve the extraction of material from the surface and in the current study include both pits and quarries. Pits and quarries present a transport pathway as their creation serves to remove a potential layer or layers of protection from the regional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

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

Map 5-21 Marsville Well Supply Unadjusted Intrinsic Vulnerability



Map 5-22: Marsville Well Supply Wellhead Protection Area Final Vulnerability



Adjusted Vulnerability Scoring for the Marsville Wellhead Protection Areas

Within the current study, to account for the presence of high risk wells as potential transport pathways, increases in vulnerability were applied in areas with a high density of high risk wells. For this evaluation a visual survey of high risk well locations was undertaken and where there was a significant concentration of well points the update was made.

The water well survey rated 7 out of 12 water wells as high risk wells. The high risk wells are distributed within the Wellhead Protection Area along County Road 3. There is a low density of wells identified within the Wellhead Protection Area and they are located outside of the serviced area of Marsville and are likely in use. As a result, the vulnerability was not increased due to transport pathways and the final vulnerability score is shown on **Map 5-22.**

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

The Technical Rules (MOE, 2009b) require an assessment of uncertainty as part of the vulnerability assessment. The uncertainty assessment seeks to provide a qualitative summary of data and analysis reliability as performed during the study. Uncertainty associated with a vulnerability assessment can be attributed to a number of factors including:

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

The delineation of the Wellhead Protection Areas was completed through the use of a FEFLOW groundwater model. The model was completed based on a number of simplifying assumptions that incorporate some level of uncertainty that is dependent on the nature, spatial distribution and density of available data.

The groundwater model was calibrated to represent steady state conditions in the aquifer using static water levels from 1061 points. The NRMS error for the calibration is reported as being 6.1% which is considered to be within the acceptable limits of less than 10% for numerical models. The model calibration results were compared to reported pumping tests at the wells and showed a reasonable fit to the observed groundwater conditions recorded in the tests. Stream flow data was also used for calibration. Through the calibration process it was found that the hydraulic conductivities of the geological units, simulated flow pattern within the bedrock aquifer and modeled baseflows are in good agreement with site specific information (Golder, 2010b).

Uncertainties within the model are associated with limitations in the availability of subsurface information and can be related to projected variability in the aquifer properties (e.g. hydraulic conductivity; porosity) or uncertainties with the conceptual model (e.g. groundwater-surface water interactions; location of flow boundaries; recharge rates; continuity in aquitards; direction of regional groundwater flow). To account for some of these uncertainties Golder has applied a factor of safety to the Wellhead Protection Areas. The factor of safety has been applied to two components of the Wellhead Protection Areas; the width and length of the capture zones were increased by 20% to account for uncertainty in the hydraulic characteristics of the aquifer system and the orientation of the capture zone was adjusted by 5 degrees (plus and minus) along its centre line to account for some uncertainty in the regional flow direction by increasing the width of the capture zones at increasing distances from the pumping well. This reflects the concept that the available data is typically concentrated around the pumping well and that the uncertainty in the hydrogeological understanding decreases at increasing distances from the supply wells (Golder, 2010b).

Based on known variations in hydraulic properties, the factor of safety approach is not considered to adequately address the issue of uncertainty. It is known that slight variations of aquifer properties may impact the shape and orientation of the capture zones. The safety factor while attempting to cover some of this likely variation does not give an indication of the likely impact of variations in actual model properties as there is no correlation between the factor of safety and the model parameters.
Although the calibration results were good, the lack of information on the impact of variations in model parameters on the resulting capture zones suggests that there has been inadequate work completed for the full evaluation of uncertainty.

The Vulnerability assessment was completed by Earthfx on behalf of the GRCA in 2008 and was based on the Surface to Aquifer Advection Time (SAAT). The SAAT calculation was based on a number of empirical formulae provided in MOE's Draft Guidance Modules (October 2006) that have not been incorporated into the Technical Rules (MOE, 2009b). Detailed descriptions of the methodology and associated assumptions for these calculations are included in the report *Aquifer Vulnerability mapping for Norfolk, Brant Counties, Catfish Creek and Kettle Creek watershed* (Earthfx, 2008).

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

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

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

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

The Earthfx team performed a comparative analysis of vulnerability methods using Intrinsic Susceptibility Index (ISI) to compare with the values for SAAT. It was indicated that the SAAT ranking compared 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.

Given the poor data distribution of wells used for the SAAT analysis within the Wellhead Protection Area and the noted variability of surficial geology in the study area, there is low certainty in the SAAT vulnerability mapping.

Managed Lands within the Marsville Wellhead Protection Area

Managed lands are lands that may receive agricultural source material (ASM), non-agricultural source material (NASM) or commercial fertilizer and can be divided into 2 categories of agricultural managed lands (AML) and non-agricultural managed lands. 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.

The managed land mapping was completed for areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats (a score of 6 or higher). Managed lands were completed using the methodology outlined in Chapter 3, with the results for the Marsville Wells are summarized **Table 5-23** and **Map 5-23.** The coding of N/A indicates that the vulnerability score in this area is 4 or less, and this area has not been assessed. Detailed methodology on managed lands is discussed in Chapter 3 of the Grand River Assessment Report.

Table 5-23: Managed Lands Percentage in the Marsville Wellhead Protection Areas

Township	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
East-Garafraxa	Marsville	Well 1	89.41%	92.22%	N/A	N/A

Livestock Density within the Marsville Wellhead Protection Area

Livestock density is used as a surrogate measure of the potential for generating, storing and land applying agricultural source material as a source of nutrients 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 generates enough manure to fertilize an area of land.

Livestock density is combined with the results of the computations for percentage agricultural managed land for the purposes of determining the circumstances related to the application of nutrients and the associated threats as defined by the MOE's Table of Drinking Water Threats. Detailed methodology on managed lands is discussed in Chapter 3 of the Grand River Assessment Report.

The results of the calculations for livestock density are provided in **Table 5-24** and **Map 5-24.**

Table 5-24: Livestock Density (NU/acre)

Township	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
East-Garafraxa	Marsville	Well 1	0	0.62	N/A	N/A

In **Table 5-24** 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

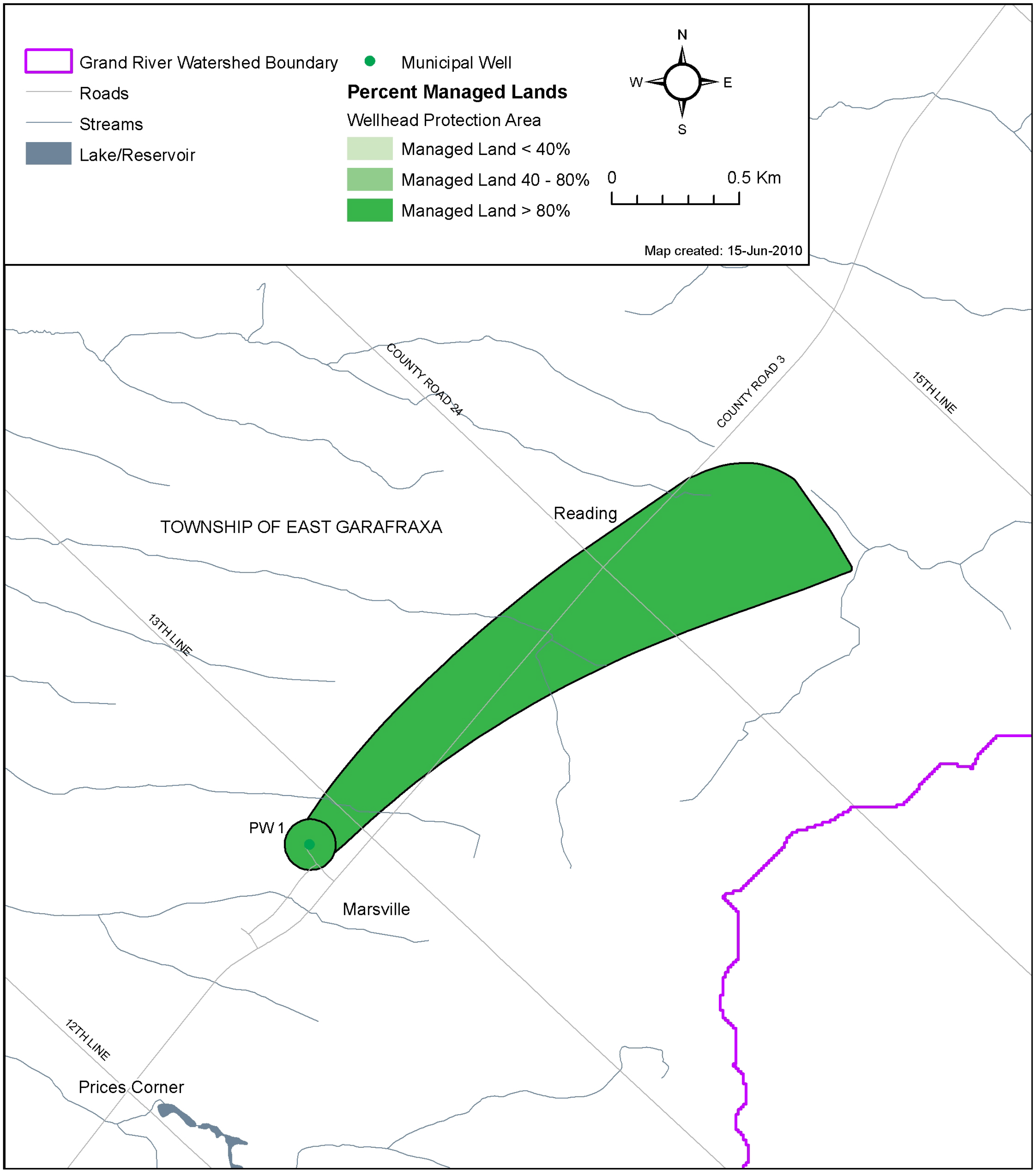
Some default values were used for estimating NAML based on the air photo interpretations and for ease of calculating. Roads generally had right-of-ways that were about 50% of the parcel size while the rest was the actual roadway, so most of these parcels were given NAML percentage of 50%. Parks or other 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 in Wellhead Protection Areas

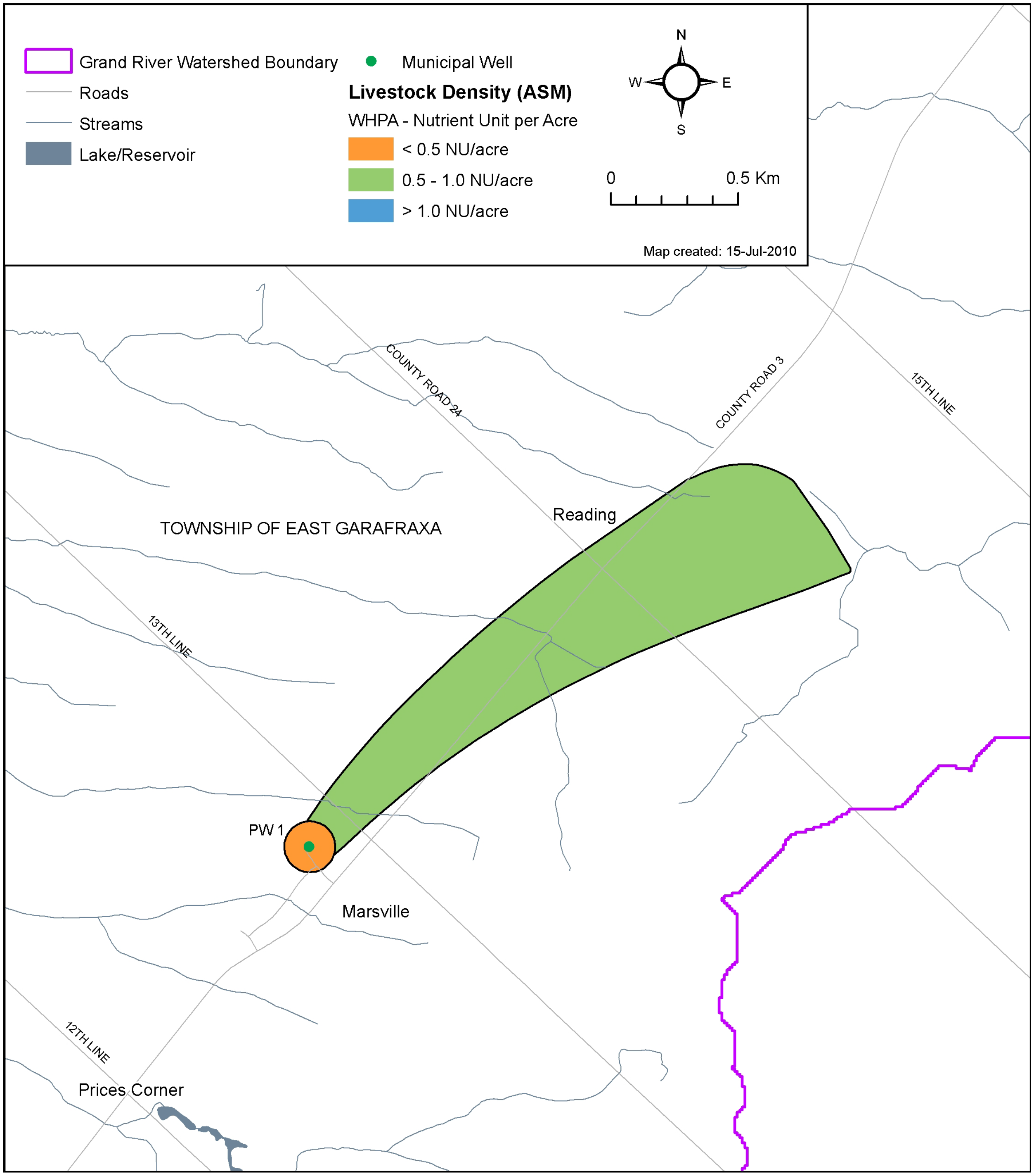
Road salt used during winter road maintenance is regarded as a threat. Generally road salts are applied depending on the amount of traffic a road receives and weather conditions.

Impervious surfaces are defined in the Technical Rules (MOE, 2009b) as areas that receive road salt application and include roads and parking lots. The areas were determined using road mapping from the National Road Network (Natural Resources Canada) and satellite air photography to identify large parking lots and paved areas. Using a 1 km x 1 km grid centered over each vulnerability area, the percentage of impermeable surfaces within each square kilometre was calculated. The percentage of total impervious surface areas within the Marsville Wellhead Protection Area is shown in **Map 5-25.** The percentage of impervious surfaces is an indicator for the potential for impacts due to road salts. In areas with high levels of impervious surfaces (roads) there is an increased likelihood that road salts would be applied.

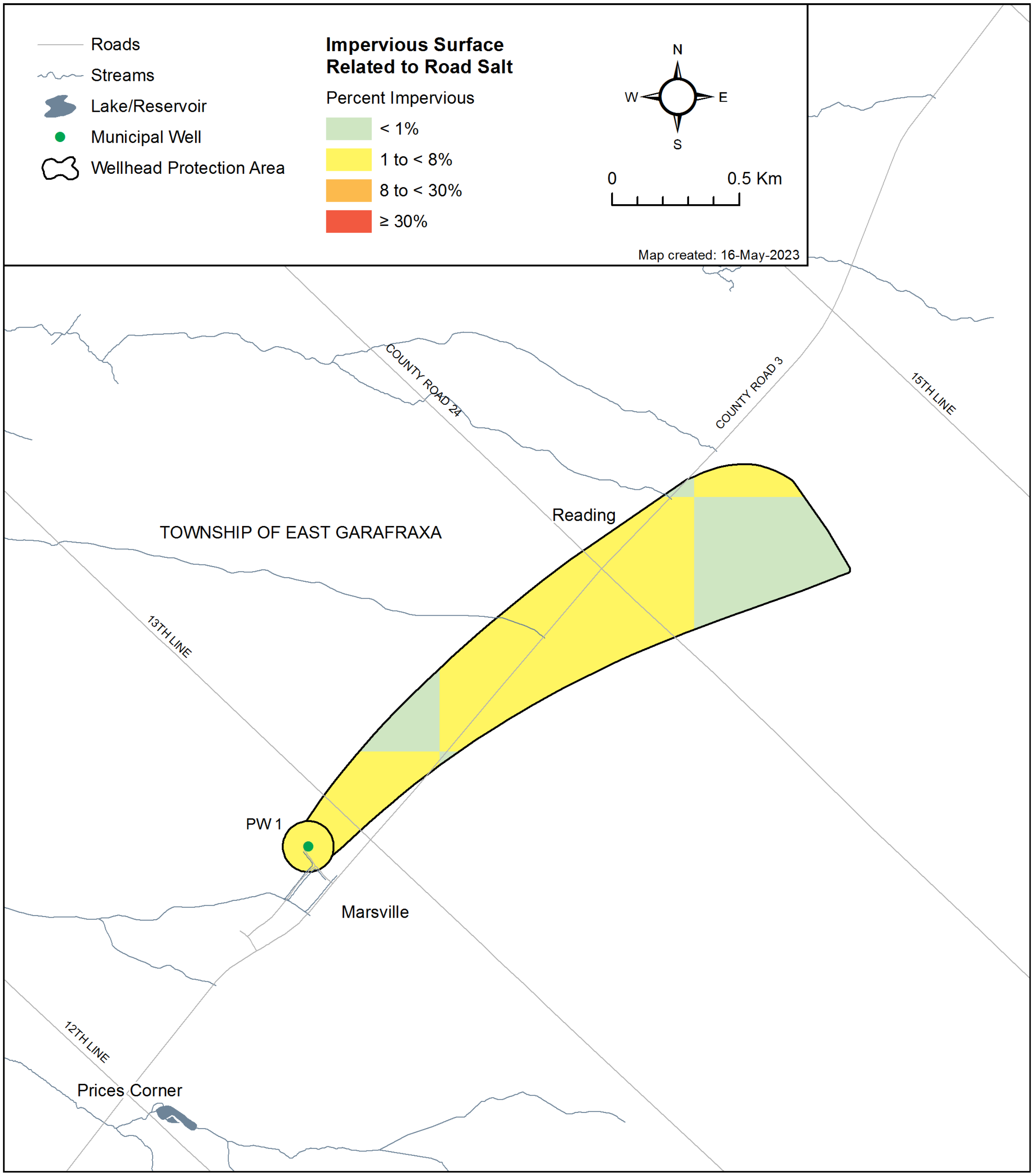
Map 5-23: Marsville Well Supply Percent Managed Lands



Map 5-24: Marsville Well Supply Livestock Density



Map 5-25: Marsville Well Supply Percent Impervious Surfaces



5.3.3 Drinking Water Threats Assessment

The *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 Marsville 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 2021 Director's Technical Rules, Clean Water Act, 2006. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool. The information above can be used with the vulnerability scores shown in **Map 5-22** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 5-25 provides a summary of the threat levels possible in the Marsville 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 5-22**.

Table 5-25: Identification of Drinking Water Quality Threats in the Marsville 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		✔	✔
Handling / Storage of DNAPLs	WHPA-A/B	Any Score	✔		
Pathogens	WHPA-A	10	✔	✔	
	WHPA-B	6			✔

5.3.4 Conditions Evaluation for Marsville Well Supply

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

One spill was recorded in the ORIS database as potentially being in the WHPA **Table 5-26** provides a summary of the potential condition 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. The SPC may choose to investigate the occurrence to evaluate if a condition exists.

Table 5-26: Summary of Potential Conditions in the East Garafraxa Wellhead Protection Areas

Source Database	Description	Location	Details
ORIS	Spill from Transformer	School at County Rd 3 and Regional Road 24 (former Highway 25)	9 L of non-PCB transformer oil spill to ground, confirmed impact (Spill ID 176187)

Based on the available data there were no conditions identified in the Marsville Wellhead Protection Areas.

5.3.5 Marsville 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 Marsville Water Supply System was conducted. 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.
- Preparation of concentrations of parameters over time plots to evaluate if there were any increasing trends.
- Operator Interview.

Data Sources for Water Quality Issues Evaluation for the Marsville Well Supply

All available water quality data for the Marsville water supply wells was collected and reviewed. This included engineering reports and MOE Annual reports for the water supply systems.

Water quality data collected in 2000 from Marsville Well showed an exceedance of the ODWQS for iron (Burnside, 2000).

The MOE Drinking Water Systems O. Reg. 170/03, 2005 and 2008 Annual Reports for the Marsville water supply system were reviewed to identify any water quality Issues.

Some elevated levels of arsenic were recorded in 2008. Arsenic was sampled at three different times during the year and levels ranged from 26 µg/L to 28 µg/L. The ODWQS standard for arsenic is 25 µg/L. An interview with the system operator, provided that the problems occurred during their routine lead sampling program. All of the samples in exceedance were taken from hydrants more than 30 years old and were not taken from in the pump house or homes. The problem is thought to be a result of the material used in the construction of the hydrants and that the problem is localized to these hydrants. Re-sampling at the hydrants resulted in acceptable results if the hydrants were flushed for longer periods of time before the sample was collected.

A review of the available microbiological data for the Marsville Water Supply wells for years 2000, 2005, 2007 and 2008 was completed. No Issues with total coliforms or *E.coli*. were been documented.

Water Operator Interview

The operator of the Marsville system was consulted to identify any Issues that may result in the deterioration of the water quality. No current water quality Issues at the Marsville Water Supply System were identified.

Water Quality Issues Evaluation for the Marsville Well Supply

The only parameter identified as a parameter of consideration is iron.

A sample collected from the Marsville well in 2001 had an iron concentration of 0.32 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.

Summary of Water Quality Issues Evaluation of the Marsville Well Supply

Upon review of available current drinking water quality data, there are no Issues for the Marsville wells. Iron was identified as having elevated concentrations, however is naturally occurring, therefore, does not reflect a deterioration of water quality.

There are no water quality Issues identified under Technical Rule 114 currently interfering or anticipated to interfere with the use of the groundwater as a source of drinking water.

Limitations and Uncertainty for the Water Quality Issues Evaluation for the Marsville Well Supply

The water quality data reviewed includes data from 2000 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 is designated for the water supply system.

5.3.6 Enumeration of Significant Drinking Water Threats

The Director’s 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 2009b version of the Director’s Technical Rules was used for the threats enumeration.

The threats inventory was compiled using the data from various sources that were reviewed as part of this study. Following the preliminary research, field assessments were conducted 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 inventory is high. It is through a re-evaluation of the prioritized threats that the level of uncertainty associated with the current results will be reduced.

Data Sources for the Activity Threats Assessment of the Marsville Well Supply

The threats inventory was compiled using the data and information sources outlined below. Following the preliminary research field assessments were completed to complete the threats inventory. All threats were recorded in a database provided by the MOE.

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 prescribed radius around the wells' 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

The only item identified by the Ecolog ERIS search was a Certificate of Approval for the Marsville Water Supply System issued in 2002 (Ecolog ERIS, 2006).

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 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 WHPAs. Current aerial photography of the WHPAs was obtained from the GRCA Watershed Ortho-imagery. 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

The land within the Marsville wellhead protection area is dominantly agricultural with some residential buildings. Some small shops, houses and institutional buildings exist along County Road 3. The Thunderbird Estates Subdivision is located west of the wells. No waste disposal sites, potential brownfields sites, gravel pits or quarries were noted in the photograph.

2000 Aerial Photography

The photographs from 2000 revealed that land use within the Marsville WHPA has remained largely unchanged since the 1978 photograph. The agricultural lands noted in the previous aerial photograph appear to remain unchanged.

Site Reconnaissance and Inspection

A drive-by roadside inspection of the WHPAs on June 26, 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 WHPA.

At the time of our inspection the predominant land uses included residential and agricultural activities. An elementary school was located along County Road 3. Residential homes along County Road 3 and 9th Line were noted to have wells and septic systems. Homes in the Thunderbird Estates subdivision utilize municipally supplied water and use individual in ground septic systems. Storm water ditches were located along the roads. No quarries, gravel pits or waste disposal sites were noted within the Wellhead Protection Area during the site inspection.

Significant Drinking Water Quality Threats for the Marsville Well Supply

As per the Technical Rules (MOE, 2009b), the enumeration of significant threats is required for the completion of the Assessment Report. **Table 5-27** summarizes the significant threats identified in the Marsville WHPAs.

Table 5-27: Marsville Well Supply Significant Drinking Water Quality Threats

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
2	Sewage System Or Sewage Works - Septic System	7	WHPA-A
3	Application Of Agricultural Source Material (ASM) To Land	1	WHPA-A
8	Application Of Commercial Fertilizer To Land	1	WHPA-A
10	Application Of Pesticide To Land	1	WHPA-A
Total Number of Properties		**8**	
Total Number of Activities		**10**	

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

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

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

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 Threats for the Marsville Well Supply

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, a field reconnaissance was completed to confirm the data and to decrease the error in the database information.

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.

5.4 Town of Shelburne

5.4.1 Shelburne Water Supply

The Town of Shelburne is situated at the headwaters of the Boyne River in the centre of Dufferin County and in the Nottawasaga Valley Source Protection Area. The Shelburne Water Supply System services a population of approximately 8,126 people (2022) and consists of six groundwater supply wells (PW 1, 3, 5, 6, 7, 8) and three pump houses. Wells PW 1, 3, 5, and 6 are located within the Nottawasaga Valley Source Protection Area and Wells PW7 and PW8 are within the Grand River Source Protection Area. Four of the wells are open hole in the shallow bedrock (Guelph Formation) and two are open hole in a deep confined bedrock aquifer (Gasport Formation). Portions of WHPA-D and/or C for Wells 1, 3, 5, and 6 cross into the Grand River Source Protection Area.

In 2012, PW7 was added to the Shelburne Water Supply System to address the projected increase in system demand. PW7 is a 305 mm diameter well drilled to a depth of 86.6 m bgs (meters below ground surface). As bedrock was encountered at 9.1 m bgs, the well was completed with a steel casing extending down to a depth of 47.2 m bgs, followed by 39.4 m of open hole.

In 2014, PW8 was installed approximately 10 m adjacent to PW7. PW8 is a 305 mm diameter well drilled to a depth of 86.6 m bgs. As bedrock was encountered, the well was completed with a steel casing extending down to a depth of 47.6 m bgs, followed by 39.0 m of open hole.

Both PW7 and PW8, draw water from the Gasport Formation, which is considered to have more desirable formation water chemistry than the shallower Guelph Formation, which contains naturally occurring arsenic (EarthFX, 2015). Both wells have been in service since 2016. Under Permit to Take Water No. 1814-7QVK7S, Shelburne wells PW7 and PW8 each have a permitted pumping rate of 1,634 m^3/day.

For further information on wells PW1, PW3, PW5 and PW6 of the Shelburne Water Supply System, see the Assessment Report for the Nottawasaga Valley Source Protection Area.

5.4.2 Shelburne Wellhead Protection Areas

Wellhead Protection Areas (WHPAs) for the Shelburne Water Supply System were delineated in 2022 using a revised version of the numerical groundwater flow model used in the 2015 WHPA delineations (EarthFX 2015) and the MECP 2021 Director's Technical Rules. Summarized updates to the groundwater model include:

- Interpretation of geologic layering in the Shelburne area resulting in structural changes to the groundwater model (i.e. representation of the deeper Goat Island and Gasport Formation and the confining properties of the Niagara Falls Member of the Goat Island Formation).
- Distribution of the average annual recharge was revised due to availability of additional information on land use in the model area.
- Pumping capacity of the Shelburne wellfield has been increased compared to 2015 (i.e. double the combined pumping rate at wells PW7 and PW8).

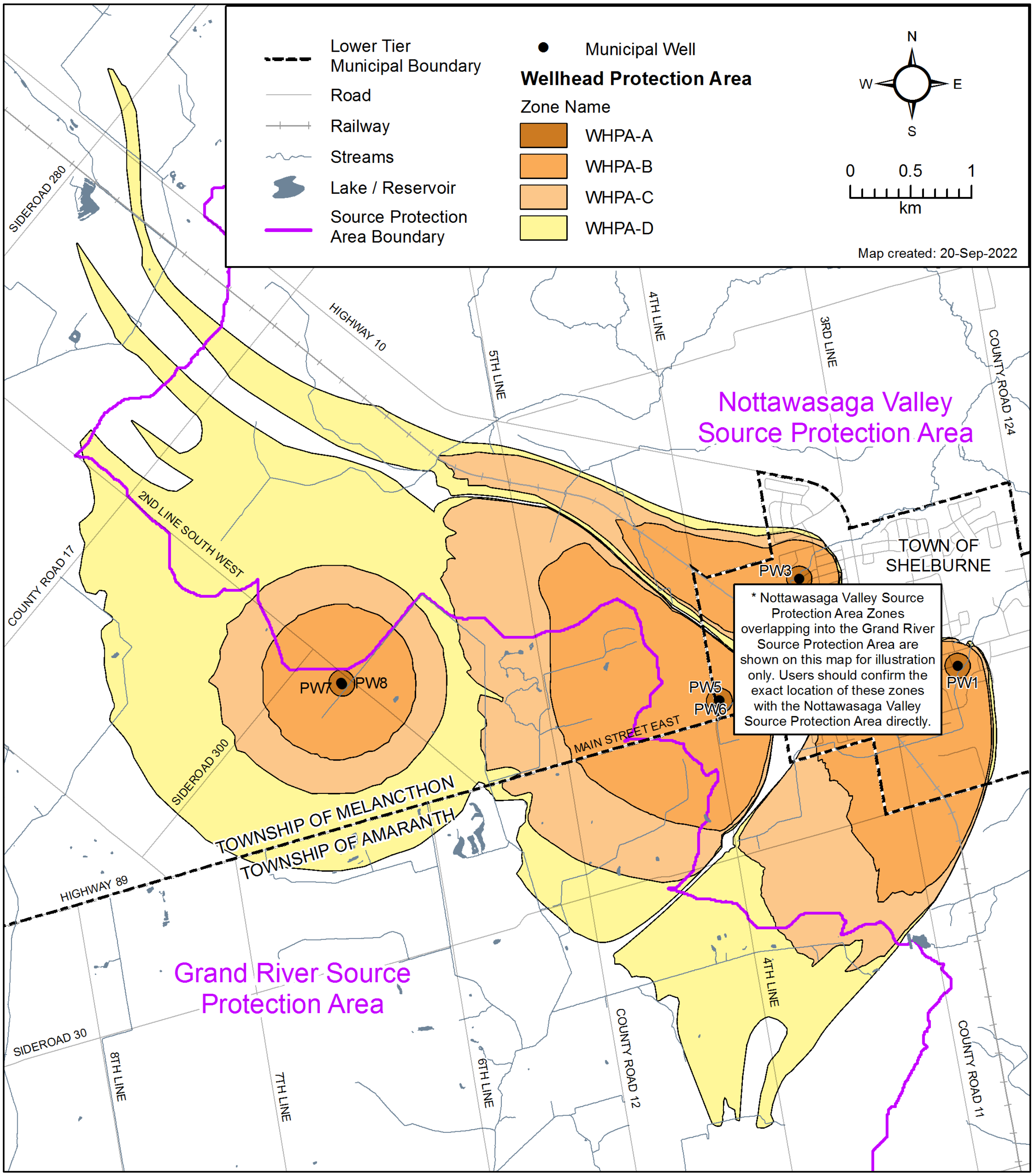
The simulated pumping rates for Shelburne wells PW7 and PW8 are based on the permitted pumping rate at PW7. The pumping rates used in developing the capture zones in the 2015 and 2022 capture zone delineation are presented in **Table 5-28.**

Table 5-28: Pumping Rates Used for the Shelburne Well Supply WHPA Delineation

Supply Wells	2015 Simulated Pumping Rate	2022 Simulated Pumping Rate
PW 1	1,030 m^3/day	1,642 m^3/day
PW 3	1,067 m^3/day	1,309 m^3/day
PW 5	982 m^3/day	982 m^3/day
PW 6	982 m^3/day	982 m^3/day
PW 7	1,635 m^3/day	1,634 m^3/day
PW8		1,634 m^3/day

Capture zones for the Shelburne wells were delineated for the WHPA-B, WHPA-C, and WHPA-D by encircling the pathlines at 2, 5, and 25 year travel times, respectively. The WHPA-A is defined by a 100 m radius zone around each well. WHPAs for PW7 and PW8 extend in a north-westerly direction and straddle the Grand River and Nottawasaga Valley watershed boundary. Portions of the WHPAs from Shelburne well PW1, PW3, PW5 and PW6 extend from Nottawasaga Valley watershed into the Grand River watershed. The location and orientation of the WHPAs for the Shelburne Water Supply System within the Grand River watershed are shown in **Map 5-26**.

Map 5-26: Shelburne Water Supply Wellhead Protection Area



Vulnerability Scoring in the Shelburne Wellhead Protection Area

Intrinsic aquifer vulnerability within the Shelburne WHPAs was mapped using the Surface to Well Advection Time (SWAT) method (EarthFX, 2022).

Surface to well advective travel time (SWAT) consists of two components: (1) the vertical travel time through the unsaturated zone above the water table (UZAT); and (2) the travel time from the water table to the well through the saturated zone (WWAT). Due to the uncertainties related to the estimation of unsaturated travel times, the unsaturated zone travel times (UZAT) were not factored into the calculation of SWAT values. This is considered to be a conservative assumption because assuming rapid flow through the unsaturated zone travel times will increase the vulnerability score. Areas of high, medium and low groundwater vulnerability were developed for the Shelburne supply wells based on the SWAT values and thresholds of 0 to 5 years (high), 5 to 25 years (medium), and greater than 25 years (low). The unadjusted intrinsic vulnerability (based on SWAT mapping) is shown on **Map 5-27**.

Transport Pathways in the Shelburne Wellhead Protection Area

Adjustments to the vulnerability scores can be made to account for the presence of transport pathways (i.e. constructed preferential pathways) that may bypass the natural protective geologic layers. Preferential pathways can include improperly constructed or decommissioned wells, pits and quarries, ditches, and pipeline bedding for storm and sanitary sewers. According to Drector's Technical Rule 39, the vulnerability of an area identified as low vulnerability can be increased to medium or high vulnerability because of the presence of a transport pathway that is anthropogenic in origin. Similarly, an area assigned a medium vulnerability can be increased to high vulnerability (Rule 40). The assessment of increased vulnerability considers:

- hydrogeological conditions;
- type and design of the transport pathways;
- cumulative impact of the transport pathways; and
- assumptions used in the assessment of groundwater vulnerability.

In the analysis of SWAT times, unsaturated zone travel times (UZAT) were set equal to zero. Therefore, constructed pathways that could possibly reduce unsaturated zone travel times, such as pipeline bedding and excavations above the water table, would not result in an increase in the vulnerability scores already assigned. The focus was on identifying those constructed pathways that could reduce travel times in the saturated zone. These included:

- deep wells that may leak or have been improperly abandoned;
- pits and quarries that breech the upper confining unit;
- landfills located in former pits or quarries that may breach the upper confining unit; or
- other deep excavations.

The potential for a water well to impact the Shelburne supply wells was assessed based on two main principles:

- whether the well is connected to the production aquifer, and
- the interpreted condition and quality of the well construction, with respect to preventing contaminants from reaching the aquifer.

To evaluate the potential connection between a well and the production aquifers, the screened interval listed for each well record was reviewed. Any well that was found to have an open interval or screen that penetrates an aquifer containing a Shelburne municipal supply well was considered to be connected to that aquifer.

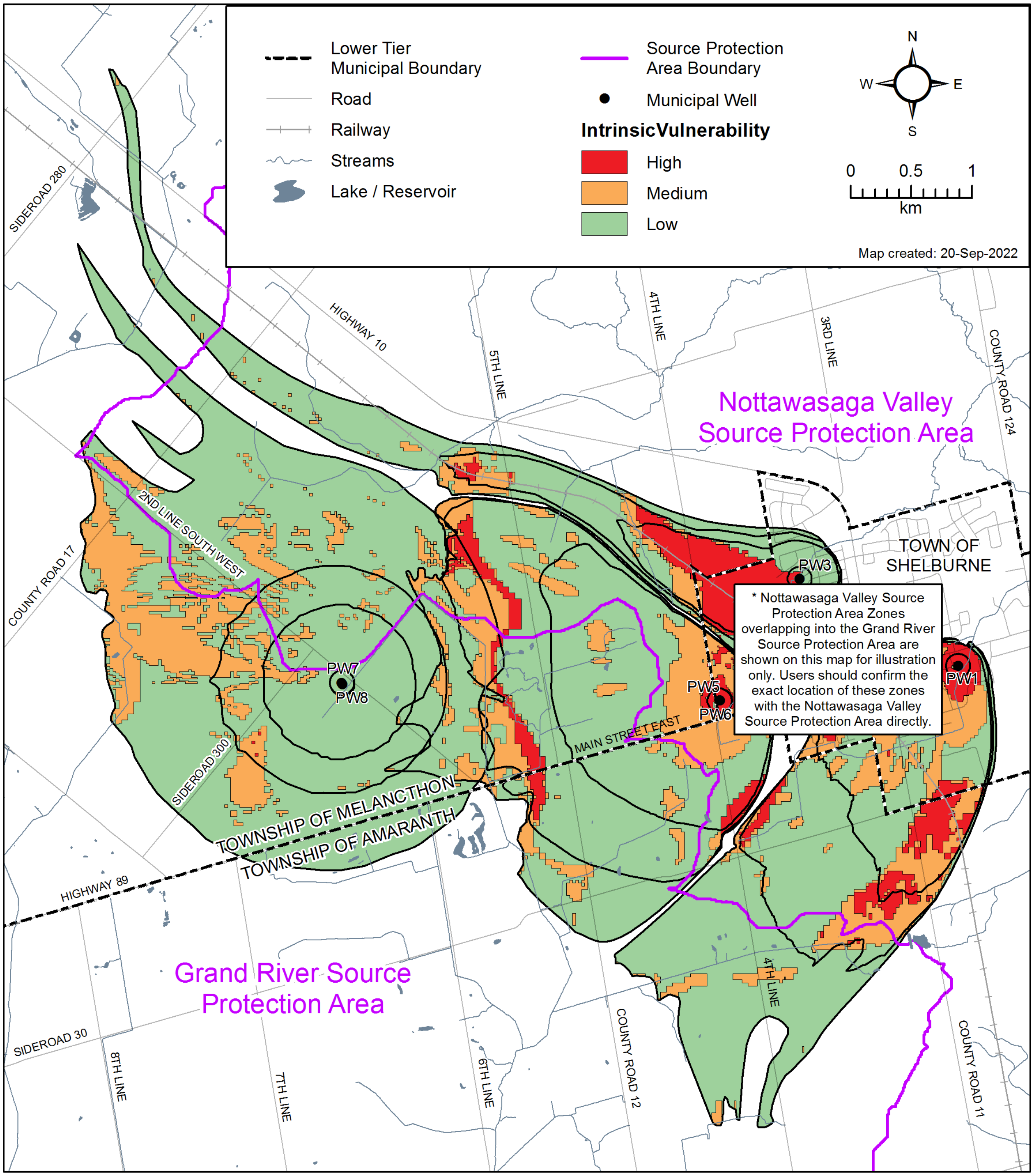
A total of 28 high-risk wells were identified which likely do not meet the current MECP well standards and may be in connection with the aquifer used for municipal water supply.

Existing and historical pit and quarry operations in the area were reviewed. Currently there are no active aggregate operation within the delineated WHPAs.

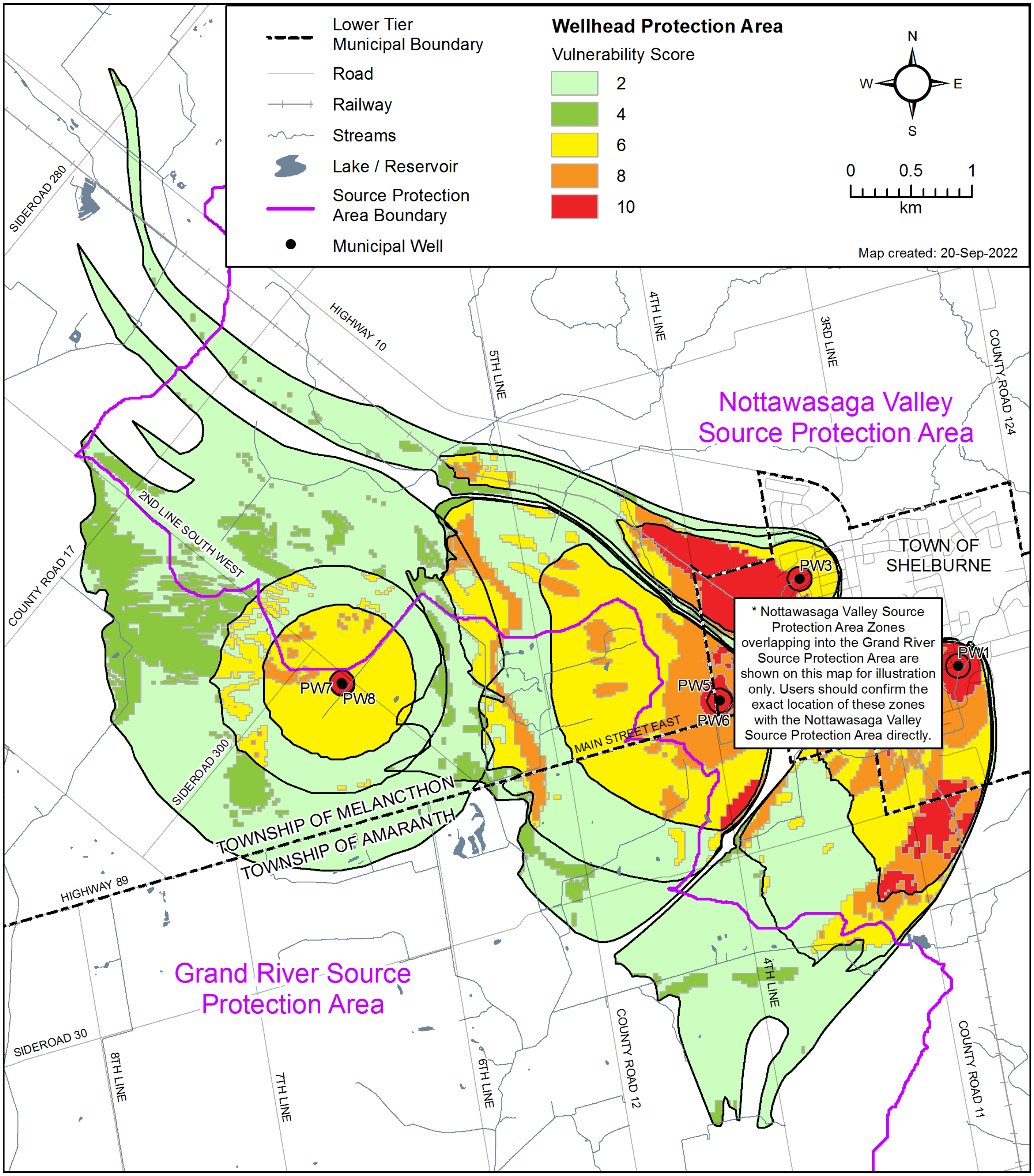
Adjusted Vulnerability Scoring for the Shelburne Wellhead Protection Area

In previous studies (Burnside, 2010 and EarthFX, 2015), the vulnerability index within a 30 m radius of each of the wells was adjusted based on the risk level assigned to each well. While this has been an accepted conservative approach, it becomes difficult to manage these isolated 30 m zones from a Source Water Protection standpoint, particularly when there are a large number of them. It is also worth noting that there are a number of decommissioning records in the vulnerable area, some of which could not be reconciled with previously active wells. In addition, the medium- and high-risk wells are generally older and their location accuracy tends to be inconsistent. For these reasons, the vulnerability levels were left un-adjusted. EarthFX (2022) recommended that these wells be investigated further before any adjustment to the vulnerability levels are made. Final vulnerability scoring for the Shelburne wells is presented on **Map 5-28**.

Map 5-28: Shelburne Water Supply Unadjusted Intrinsic Vulnerability



Map 5-29: Shelburne Water Supply Wellhead Protection Areas Final Vulnerability



Uncertainty in the Wellhead Protection Area Delineation and Vulnerability Scoring for the Shelburne Water Supply

The Director's Technical Rules require that an uncertainty rating of either high or low be assigned with each vulnerable area as outlined in Director's Technical Rules (MECP, 2021). There are two components for which an uncertainty rating is to be provided: the first is the WHPA delineation, and the second is the vulnerability assessment. It should be noted that a technical peer review consultant was retained to review the methodology, modelling, and results of the WHPA delineation and vulnerability assessment. The peer reviewers agreed with methodology, modelling, and results provided in the Earthfx 2015 report. Results of an uncertainty analysis indicated that there is a low uncertainty with the WHPA delineation and associated vulnerability scoring.

WHPA Delineation Uncertainty With all numerical modelling there are inherent variations in the level of confidence, including the quality of the input data as well as the uncertainty in the model output (due to computational assumptions within the model). The groundwater model was calibrated to thousands of static water level data points.

The geologic information provided by the MECP well records and oil and gas wells was sufficient to generate stratigraphic surfaces, which were used to constrain the geometry of the lower confidence surfaces. This in-turn helped to reduce the level of uncertainty in geologic model caused by the data quality issues. In addition, the new pump test data provided in September 2021 improved the understanding of the confinement of the Gasport aquifer.

A coordinated calibration was conducted to both steady state and transient aquifer testing events in the Shelburne PW7 and PW8 wells, but there was some uncertainty due to the need to reconcile data across the different scales of the calibration.

During the WHPA delineation analysis sources of uncertainty were introduced from both the groundwater model and the time-of–travel analysis itself. It is possible that subtle variations in flow directions near the wells caused by local variations in aquitard and aquifer hydraulic conductivity values, and/or recharge rates can lead to changes in flow paths of the particles. As a result, there is a chance that some of these subtleties may not be explained through the time-of- travel analysis.

Vulnerability Mapping Uncertainty

The WWAT component of the SWAT method is conservative as it is based on assessing travel times using locally determined hydraulic properties that have been adjusted and refined through model calibration. The model was calibrated to best match the observed directions of flow by carefully representing factors that influence flow patterns such as local variations in aquifer properties, recharge rates, aquifer and aquitard thickness, and continuity.

The use of WWAT zones to subdivide areas within the TOT zones adds uncertainty because the WWAT results cannot be field-verified or easily tested. The assignment of high vulnerability scores to the 100-m radius, regardless of actual travel times, is an implicit recognition that the level of uncertainty is unacceptable when it comes to potential sources of contamination in close proximity to the wells.

Managed Lands Within the Shelburne Wellhead Protection Area

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. Agricultural managed lands include cropland, fallow and improved pasture that may receive ASM. Non-agricultural managed landmay include golf courses, sports fields, residential lawns and other built-up grassed areas or turf that may have commercial fertilizers applied.

The managed land mapping was completed for those areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats (a score of 6 or higher). Managed lands were completed using the methodology outlined in Chapter 3, with the results for Shelburne wells summarized in **Table 5-29** and on **Map 5-30**. WHPA zones that are not within the Grand River Watershed are noted as '-'.

Table 5-29: Managed Lands Percentage in the Shelburne Wellhead Protection Areas (within Grand River Watershed)

Drinking Water System	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Shelburne	Grand River Watershed	PW7/PW8	80.9%	78.6%	89.1%	0.0%
Shelburne	Grand River Watershed	PW5/PW6	-	84.0%	68.8%	0.0%
Shelburne	Grand River Watershed	PW1	-	-	86.7%	82.7%

Livestock Density within the Shelburne Wellhead Protection Area

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. Similar to the managed land mapping, the livestock density for the Shelburne WHPAs was completed only in those areas where the vulnerability is high enough for related activities to be considered low, moderate or significant threats, using the methodology outlined in Chapter 3. Results are summarized in **Table 5-30** and **Map 5-31.**

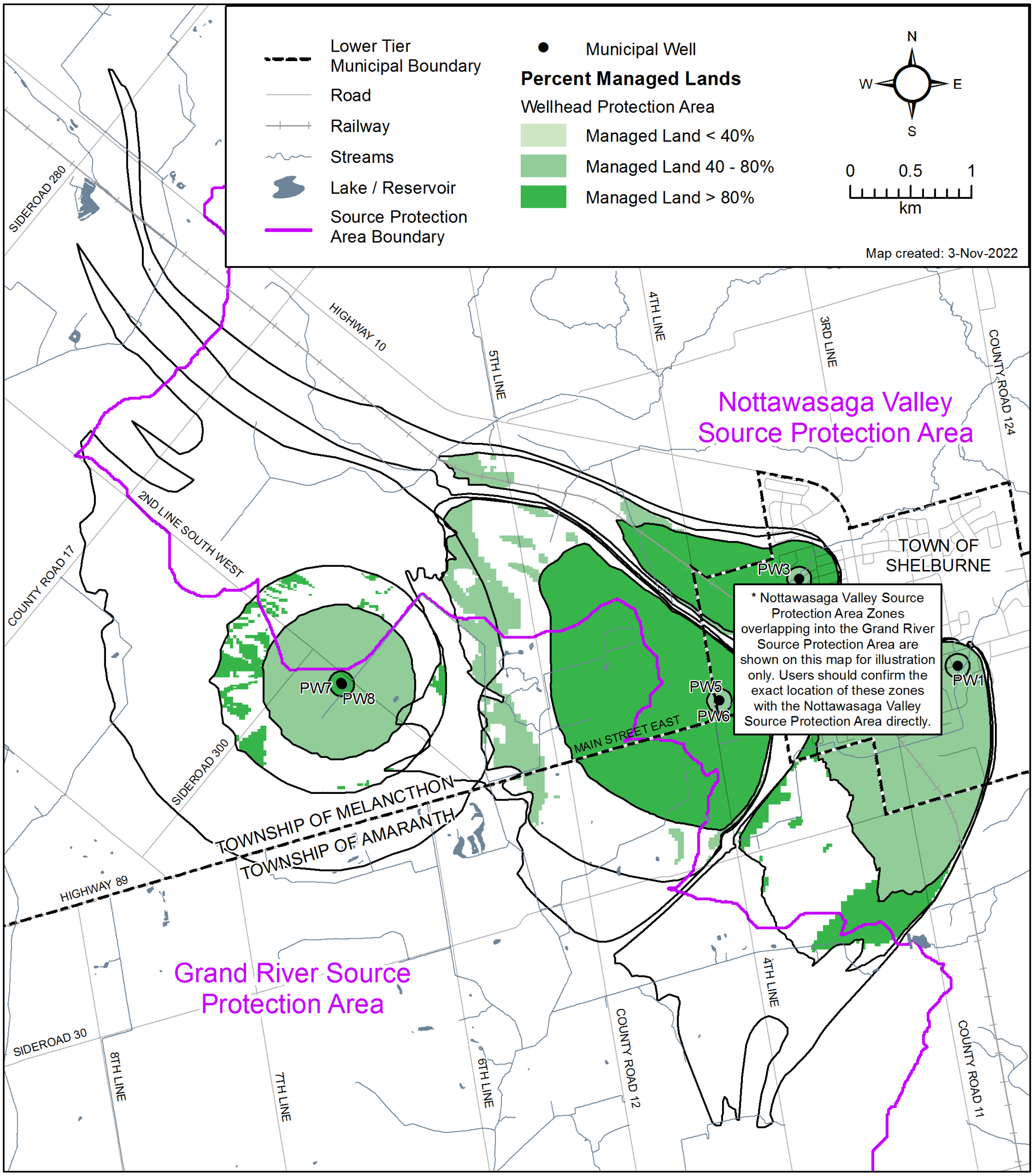
Table 5-30: Livestock Density (NU/acre) (within Grand River Watershed)

Drinking Water System	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Shelburne	Grand River Watershed	PW7/PW8	0.06	0.06	0.01	0
Shelburne	Grand River Watershed	PW5/PW6	-	0	0	0
Shelburne	Grand River Watershed	PW1	-	-	0.51	0.18

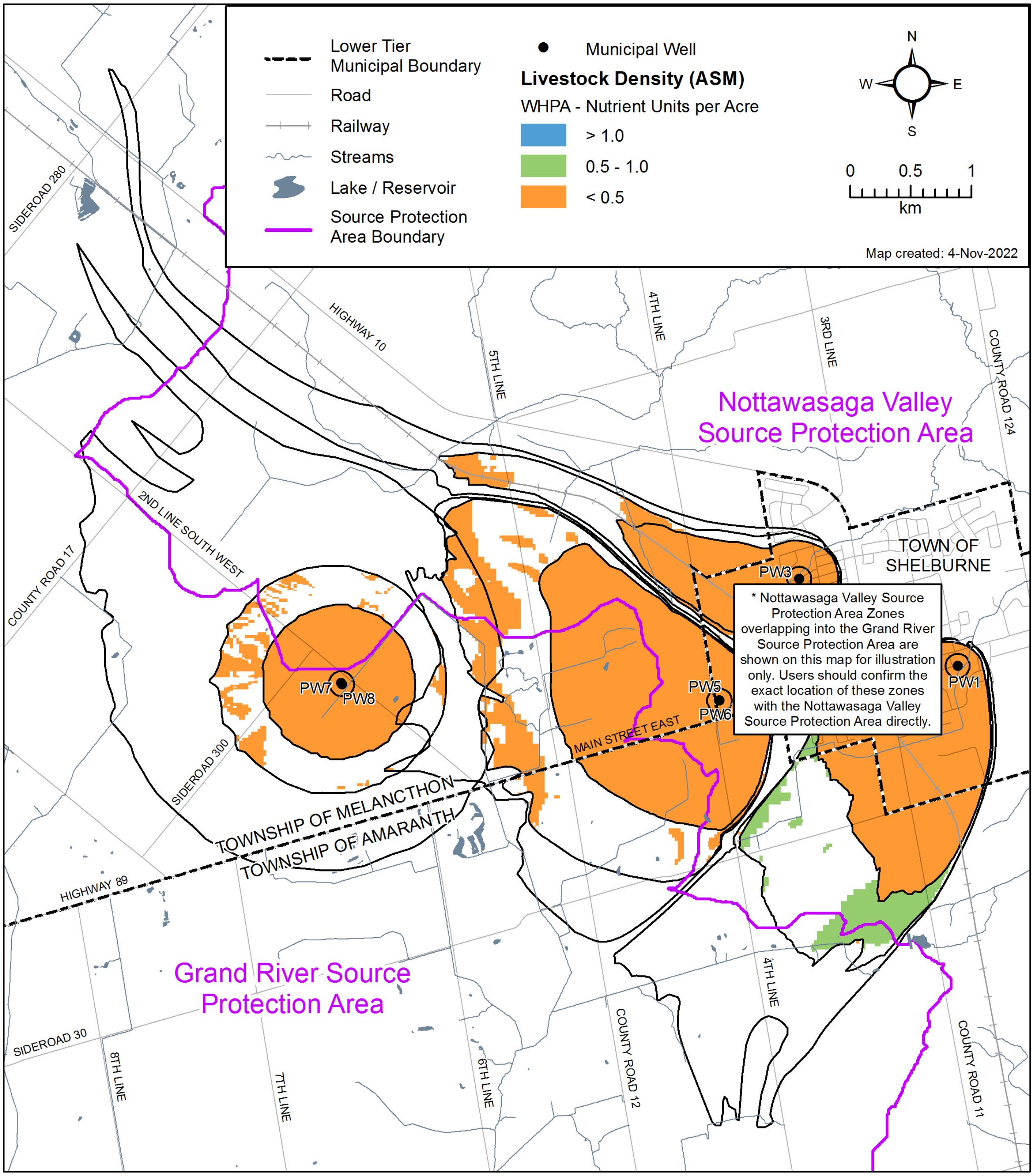
Percentage of Impervious Surface Area within the Shelburne Wellhead Protection Areas

Percent impervious surface is used to measure of the potential for the application of salt for the purposes of melting snow and ice. It measures the percentage of the study area covered by impervious surfaces where road salt would likely be applied (roads, sidewalks, and parking lots), but not those areas such as buildings, landscaped areas etc, where it would not be applied The percentage of impervious surface area was determined by using a 1 km square grid, draped over the vulnerability area and calculating the percentage of impervious area within each grid cell, as described in Chapter 3.The percentage of total impervious surface areas within the Shelburne Wells WHPAs is presented in **Map 5-32.**

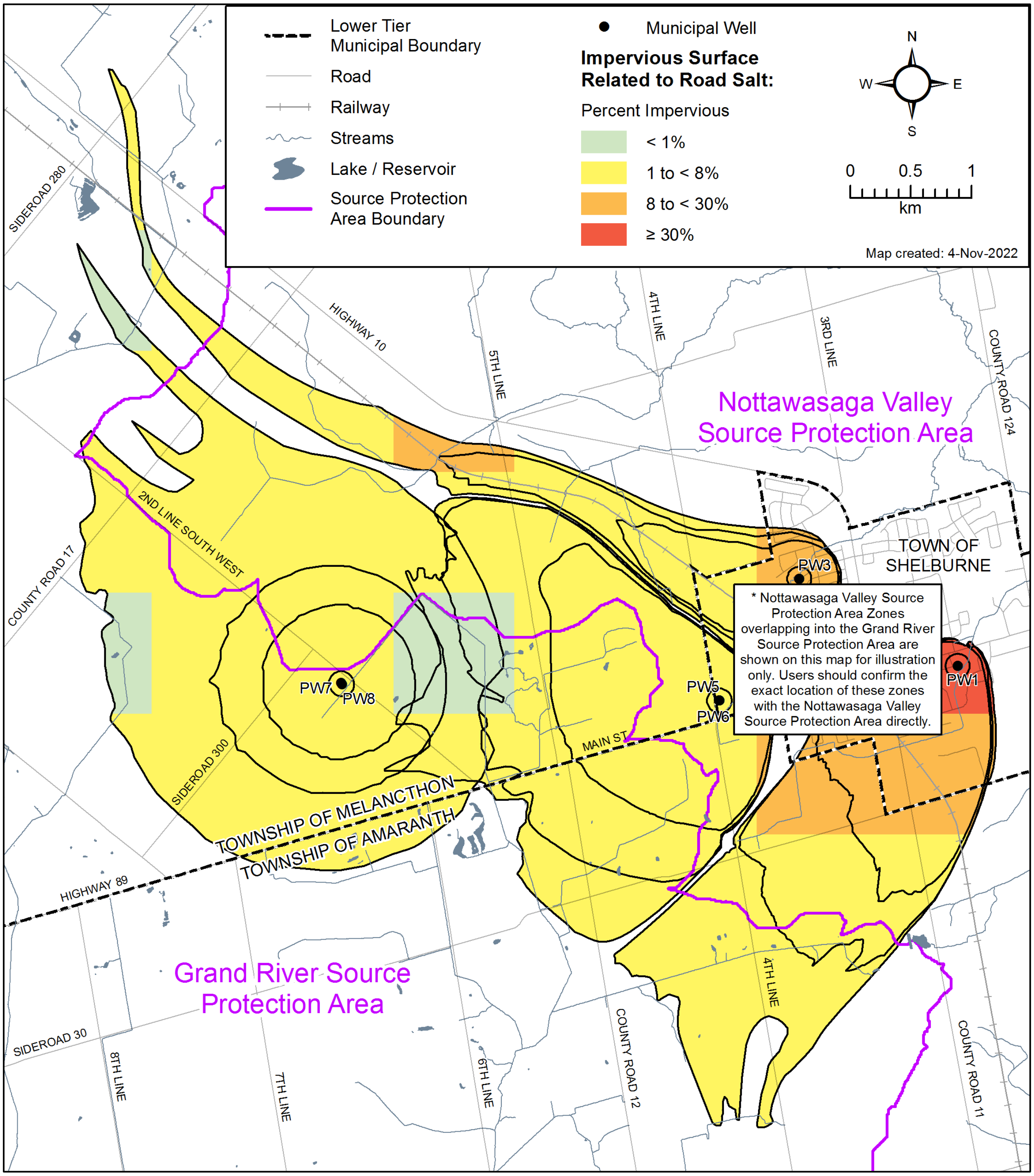
Map 5-30: Shelburne Wellhead Protection Areas Percent Managed Lands



Map 5-31: Shelburne Wellhead Protection Areas Livestock Density



Map 5-32: Shelburne Wellhead Protection Areas Percent Impervious Surface



5.4.3 Drinking Water Threats Assessment

The *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 Repot lists all possible drinking water threats.

Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Shelburne Water 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 Director's Technical Rules (2021) under the *Clean Water Act, 2006*. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool. The information above can be used with the vulnerability scores shown in **Map 5-28** to help determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 5-31 provides a summary of the threat levels possible in the Shelburne 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 5-28**.

Table 5-31: Identification of Drinking Water Quality Threats in the Shelburne Wells PW7/8 Wellhead Protection Area

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/C	8	✔	✔	✔
	WHPA-B/C/D	6		✔	✔
	WHPA-C/D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✔		
	WHPA-D	6			✔
	WHPA-D	2 & 4			
Pathogens	WHPA-A	10	✔	✔	
	WHPA-B	8		✔	✔
	WHPA-B	6			✔
	WHPA-C/D	Any Score			

5.4.4 Conditions Evaluation for the Shelburne Water Supply

Conditions that relate to past or historical activities have the potential to impact drinking water quality and are therefore reviewed when conducting an inventory of drinking water threats. A review of available data for the properties that intersect the updated WHPAs included the National Pollutant Release Inventory (NPRI), MECP Brownfields Site Registry, and MECP Waste Disposal Sites Inventory. The previous studies completed in the area by Burnside (2002, 2010) and Golder and Banks (2013) provided additional resources for screening for past and historical activities that could pose a threat to water quality. No conditions resulting from past or historical activities were identified within the PW7 or PW8 WHPAs based on the criteria established in Technical Rule 126 (EarthFX, 2015; EarthFX, 2022).

5.4.5 Shelburne Water Supply Drinking Water Quality Issues Evaluation

Drinking water issues for all of the Shelburne municipal wells were evaluated by reviewing the available water quality data reported in the 2016, 2017, 2018 and 2020 Drinking Water System Annual Reports prepared by OCWA (OCWA, 2017, 2018, 2019, 2021). Water quality data were compared to the ODWQS to identify the parameters that were in exceedance and data were assessed to identify any increasing trends in concentration.

Water Quality Issues Evaluation for the Shelburne Water Supply

All parameters analyzed were found to be below their respective ODWQS criteria, with the exception of sodium and total hardness. Sodium concentrations have been observed to exceed the ODWQS, however levels are generally low and likely natural, but they may be related to road salt application or water treatment using sodium hypochlorite. Sodium declined to below reporting limits in 2020.

Total hardness ranged from 234 to 325 mg/L as calcium carbonate. These levels exceeded the Operational Guideline range of 80-100mg/L, provided in the Technical Support Document for the Ontario Drinking Water Standards, Objectives and Guidelines. Elevated levels of total hardness are typical of groundwater sourced from bedrock aquifers, and have been persistent in the Town of Shelburne's drinking water supply. Total hardness is considered to be an operational guideline/aesthetic objective that is often treated using household water softening system, as such it has not been identified as an issue.

The wells have also been found to exhibit naturally high iron levels; however, these levels are reduced through iron sequestration in the treatment system. Low levels of fluoride were observed in 2020, but fluoride is known to be naturally occurring in bedrock aquifers that occur beneath Shelburne.

The construction of well PW7 and PW8 was motivated by reoccurring water quality problems related to arsenic in the other Town of Shelburne supply wells. The source of arsenic is assumed to be from naturally-occurring arsenopyrite in the Guelph Formation; PW7 and PW8 are screened in the deeper Gasport Formation in hopes that the intervening low conductivity units will prevent the transport of arsenic to the deeper aquifer. Water quality samples collected during testing of PW7 were found to range from 0.4 to 3.8 μg/L, which were less than ODWQS of 10 μg/L. However, it was noted that during the 72-hour pumping test arsenic concentrations increased from 0.9 to 3.6 μg/L.

Upon review of the available current drinking water quality data there are no identified Issues under Technical Rule 114 for Shelburne Well PW7 and PW8.

5.4.6 Enumeration of Significant Drinking Water Quality Threats

The use of land use classification as a basis for evaluating threats was considered to be adequate for most of the WHPA areas, considering that the properties within the WHPAs were mostly classified as rural residential and/or agricultural (with the exception of roadways and undeveloped parcels). There are limitations with the land use classification approach and, wherever possible, the analysis was supplemented with data from other sources.

The use of land use classification as a basis for evaluating threats is considered to be adequate, considering all of the properties within the Shelburne WHPAs are classified as rural residential and/or agricultural.

Significant Drinking Water Quality Threats for the Shelburne Water Supply

The 2021 version of the Technical Rules was used for the threats enumeration. **Table 5-32** summarizes the significant threats in the WHPAs in the Township of Melancthon based on existing land uses. A windshield survey was completed in the fall 2022, following the desktop study completed by EarthFX (2022). The windshield survey identified 3 properties and 8 potential significant drinking water threats, the majority of which werewithin the WHPA-A.

Table 5-32: Town of Shelburne Well Supply Significant Drinking Water Quality Threats located in the Township of Melancthon (current to September 2022)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
3	The application of agricultural source material to land.	2	WHPA-A
6	The application of non-agricultural source material to land.	2	WHPA-A
8	Application Of Commercial Fertilizer To Land	2	WHPA-A
10	Application Of Pesticide To Land	1	WHPA-A
15	The handling and storage of fuel.	1	WHPA-A
Total Number of Properties		**3**	
Total Number of Activities		**8**	

1. *Prescribed Drinking Water Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07s.1.1.(1).*
2. *Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category.*

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

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 Threats for the Shelburne Water Supply

To be consistent with other vulnerability and threat assessment studies for drinking water systems in the area, the technical document “Reducing Inconsistencies in Threat Subcategory Enumeration” (SGBLS, 2010) was used as reference. Because the available information for residential and agricultural lands rarely included storage or handling quantifies for chemicals or agricultural source materials, conservative assumptions were applied when evaluating the threat category (low, medium or significant) using the Tables of Circumstances. In some cases the SGBLS (2010) technical Bulletin provided more reasonable assumptions. Nevertheless, the use of land use classification for the evaluation of drinking water threats is associated with significant uncertainty and has been classified as high.

5.5 Town of Orangeville

5.5.1 Orangeville Water Supply

The Town of Orangeville is located in the headwaters of the Credit Valley River and in the Credit Valley Source Protection Area. Orangeville has 12 water supply wells in nine well fields that supply the town of approximately 29,000 people. The wells obtain water from a combination of overburden and bedrock aquifers (Burnside, 2010). Portions of WHPA-B, C and D for the Orangeville wells, with the exception of Well 10, cross into the Grand River Source Protection Area (**Map 5-32**).

For further information on the Orangeville Water Supply System, the physical settings, and the Vulnerability Assessment for the system, please see the Assessment Report for the Credit Valley Source Protection Area.

5.5.2 Drinking Water Quality 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 Threats for the Orangeville Supply System

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 Director’s Technical Rules (2021) under the *Clean Water Act, 2006*. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool. The information above can be used with the vulnerability scores delineated for the Orangeville Supply System to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.

Table 5-33 provides a summary of the threat levels possible for the Orangeville 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.

Table 5-33: Identification of Drinking Water Threats in the Orangeville Supply System 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	8	✔	✔	✔
	WHPA-B/C	6		✔	✔
	WHPA-C/D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✔		
	WHPA-D	2 & 4			

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Pathogens	WHPA-A/B	10	✔	✔	
	WHPA-B	8		✔	✔
	WHPA-B	6			✔
	WHPA-C/D	Any Score			

5.5.3 Orangeville Drinking Water Quality Issues Evaluation

As part of the issues evaluation, available water quality data was reviewed to assess whether any contaminants are impacting or have the potential to impact or interfere with the Town of Orangeville 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.

Drinking Water Quality Issues Evaluation for the Orangeville Water Supply

Microbiological testing is reported for the municipal wells on a biweekly basis. There were occasional non-zero counts for Total Coliforms and background bacterial counts; however, these results are typical of wells that are influenced by surface water (GUDI). All wells identified as GUDI in the Orangeville Water Supply System have been equipped with treatment systems equivalent to surface water treatment systems that can handle the occasional presence of pathogens. A pathogenic Issue was not identified for the Orangeville supply system.

Sodium concentrations are currently below the provincial standards in Well 2A, 5, 5A, 7, 9A and 9B. There is, however, a noted increasing trend at Well 2A, 5, 5A, 9A and 9B. Based on projections of these trends it is anticipated that sodium concentration at Well 9A and 9B will exceed the provincial standard by 2024. Although increasing, the concentration at Well 2A and Well 5 and 5A is not expected to exceed the ODWQS standards within the next 50 years.

The trends for Wells 6, 10 and 11 indicate that while the current concentrations are below the provincial standards, they are likely to exceed them by 2042 at Well 6 and by 2025 at Well 10. Based on the current trend there is no anticipated exceedance at Well 11. A similar analysis for Well 8B, 8C and 12 (TM) show that no increasing trend has developed at these wells.

Chloride concentrations reported between 1983 and 2008 show that chloride concentrations are increasing significantly in Well 2A, Well 5, 5A, 9A and 9B. Although currently below the provincial standards it is anticipated that chloride levels will exceed the provincial standards within the next 50 years if this trend were to continue. More detailed analysis shows that the exceedance is likely by about 2042 for Well 2A and 2052 for Well 5 and 5A. At Well 9A and 9B the exceedance is expected in 2014 - 2015 based on the projection of the current trend.

Concentrations for Well 6, Well 10 and Well 11 are currently below the provincial standards, but based on the observed trends are expected to exceed the standards by the year 2024 for Well 6 and 2044 for Well 11. At Well 10 a similar significant increase to that at Well 9A and 9B is anticipated based on the current trend and the provincial standards are likely to be exceeded at this well by 2015. Current chloride concentrations for Well 8B, 8C and 12 (TM) are well below the provincial standards with no indication of an increasing trend.

Nitrate concentrations in the Orangeville wells range from 0 mg/L to 5.5 mg/L. No significant increases in nitrates with time have been observed in the monitoring results for the majority of the wells. Well 5 and 5A have elevated nitrate concentrations ranging from 3.5 up to 6 mg/L and vary seasonally, but do not have a significant increasing trend. A projection of the current trend based on average values indicates that nitrate concentrations will not exceed the provincial standards in the next 50 years at this well.

Analysis of values observed for Well 2A and Well 9A and 9B indicate that there is no significant trend at these locations as the variations observed are within the historical ranges. It is interpreted that these results are due to the impact of seasonal variation on the nitrate values at these wells. The anticipated impact of development activities within the WHPA for these wells is the reduction in nitrate loading due to the change from agricultural to residential land use. Due to the anticipated reduction in nitrate loading and the small nature of the variations in nitrate at the wells, it is concluded that there is no issue with nitrates at these or any of the wells in the Orangeville supply system.

Summary of Drinking Water Quality Issues Evaluation for the Orangeville Water Supply

Based on the above water quality analysis, sodium, and chloride have been identified as Issues under Technical Rule 114 for the Orangeville supply system.

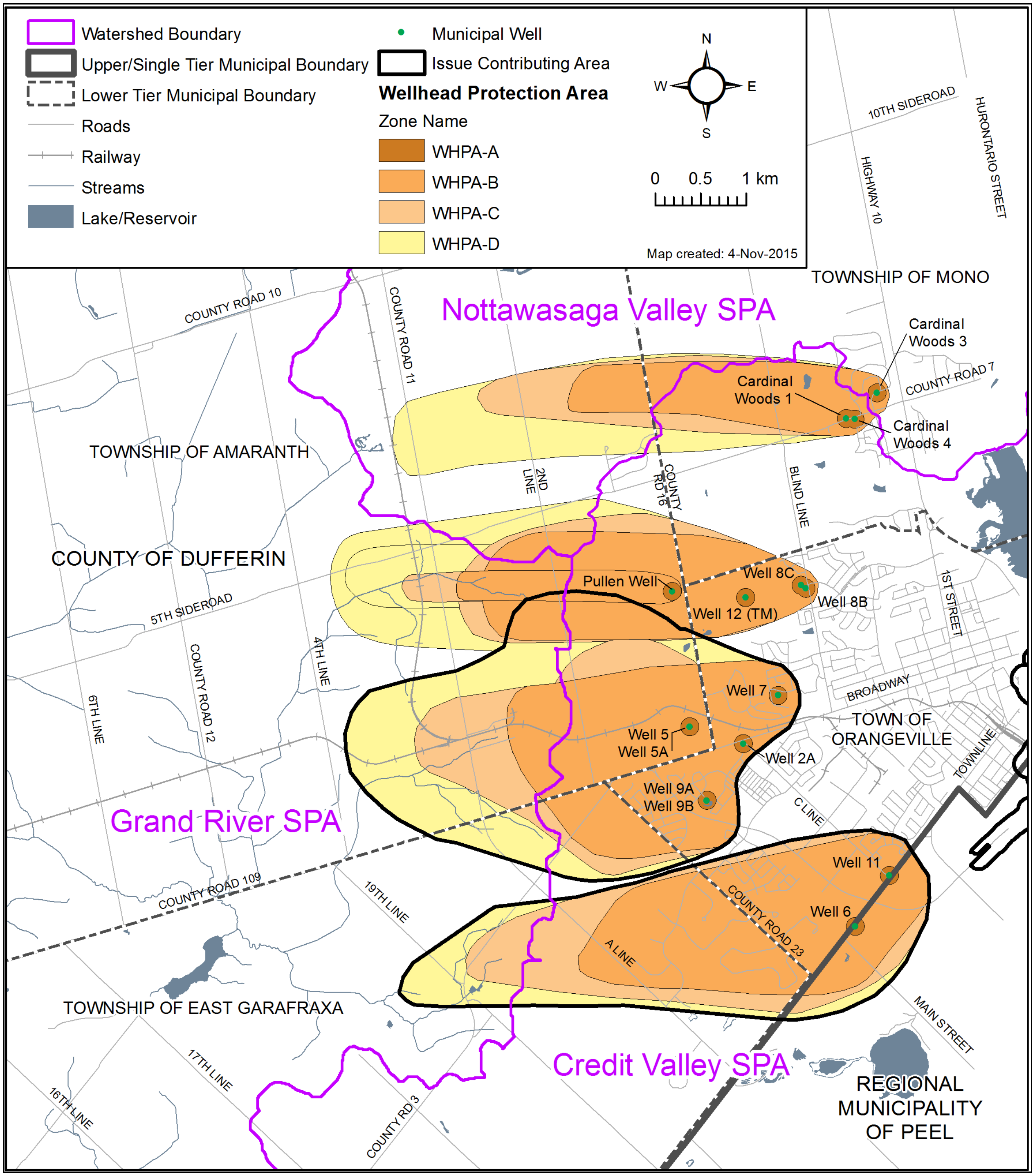
Issue Contributing Area - Sodium and Chloride

The WHPAs defined for Well 2A, 5, 5A, 9A and 9B overlap and have been mapped as a single WHPA. The Issue Contributing Area for the chloride (road salt) impact noted is interpreted as being the extent of the 25 year time-of-travel (WHPA A to D). Currently, the area within the WHPA sits at the west end of the Town of Orangeville and features a number of subdivision developments that have become established since 2000. Within these subdivisions, it is expected that winter road maintenance results in road salts being leached into the ground and the groundwater. The WHPA also features the main east west arterial road through the Town of Orangeville as well as the new bypass.

The 25 year time-of-travel defined for Well 6 and Well 11 is regarded as the Issue Contributing Area for the sodium and chloride levels noted at these wells. This WHPA encompasses an area on the western edge of the Town of Orangeville within which new subdivisions have also been developed. Alongside these developments are a number of major roadways including the existing Highway 9 (bypass for the Town of Orangeville) and Townline. It is anticipated that the winter maintenance of these roadways has contributed to the noted sodium and chloride impact.

The Technical Rules have identified septic systems as potential sources of sodium and or chloride in an Issue Contributing Area. In the Orangeville ICA the elevated concentrations of sodium and chloride are a result of the application of road salt and other winter maintenance practices. As such, septic systems and septic system holding tanks have not been identified as significant drinking water threats in the chloride Issue Contributing Area for Orangeville.

Map 5-33: Issue Contributing Areas for the Orangeville Water Supply located in the Grand River Watershed



5.5.4 Enumeration of Significant Drinking Water Threats

As per the Technical Rules; Assessment Report (Clean Water Act, 2006), the enumeration of significant threats is required for the completion of the Assessment Report. The 2017 version of the Director's Technical Rules was used for the threats enumeration. **Table 5-34** summarizes the significant threats for the Orangevillle Water Supply within the Grand River watershed as of 2018.

Table 5-34: Orangeville Water Supply Significant Drinking Water Threats within the Grand River Watershed

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
12	Application of Road Salt	11	ICA
13	Storage of Road Salt	7	ICA
14	Storage of Snow	5	ICA
16	Handling and Storage of a Dense Non Aqueous Phase Liquid (DNAPL)	9	WHPA-B WHPA-C
Total Number of Activities		**32**	
Total Number of Properties		**11**	

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

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

Note: Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

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