Assessment Report

Raisin Region Source Protection Area

Version 2.0.2

November 20, 2024

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Version Control

Version	Date	Editor	Note
Version 2.0.2	November 20, 2024	JS	Added Road Salt Enumeration to Significant Drinking Water Threat Activities tables where applicable.
Version 2.0.2	November 20, 2024	PMB	Implemented minor corrections based on review from Conservation and Source Protection Branch pre-consultation review.
Version 2.0.0	February 25, 2022	PMB	Amended to comply with Section 36 Order. Amended to comply with updated Technical Rules. Updated SGRA Mapping. Updated Managed Lands Mapping. Updated vulnerability scoring for the Long Sault municipal intake. Updated watershed characterization including population summaries, water quality assessment. Updated drinking water threats enumeration. Updated drinking water system information. Typographic corrections and minor layout corrections.
Version 1.0.0	December 10, 2012	PMB	Version 0.3.0 was approved by Ministry of the Environment in October 2011. Version 1.0.0 includes slightly updated threat assessments based on public consultation. The Map template has been updated to improve usability.
Version 0.3.0	July 21, 2011	PMB	Added Water Quantity Risk Assessment/ Tier-3 Water Budget for Town of Alexandria. Updated IPZ-1 shapes for consistency with Technical Rules. Updated managed land mapping. Additional minor edits and corrections.
Version 0.2.0	November 2, 2011	PMB	Incorporated additional edits from Public Consultation, and MOE Source Protection Programs Branch. Document, titled “Proposed Assessment Report”.
Version 0.1.0	September 10, 2010	PMB	Incorporated additional edits from Source Protection Committee. First posting for public inspection.

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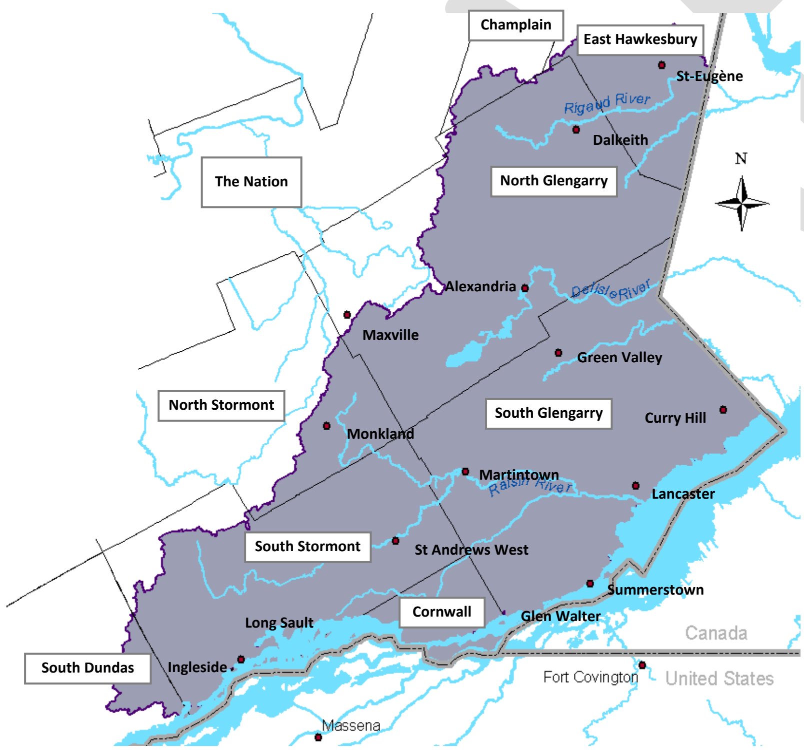
Executive Summary

The **Clean Water Act** helps protect drinking water at the source, as part of an overall commitment from the Province of Ontario to safeguard human health and the environment. A key focus of this legislation is the preparation of **locally developed, science-based assessment reports and source protection plans**.

An assessment report includes:

- Characterization of the area, including physical geography, human geography and water quality;
- Conceptual understanding of where the water is in the area and how it moves between watershed elements;
- Water quantity threats assessment;
- Water quality threats assessment.



Raisin Region Source Protection Area

The Raisin Region Source Protection Area accounts for nearly 2,000 km² and is comprised of the Raisin Region Conservation Authority's jurisdiction, plus some additional watershed-based area to the south-east and north. The total population of the area is approximately 84,000 and includes all of or portions of the following municipalities:

- The Nation Municipality
- Township of Champlain
- Township of East Hawkesbury
- City of Cornwall
- Township of North Glengarry
- Township of North Stormont
- Township of South Dundas
- Township of South Glengarry
- Township of South Stormont

In the Raisin Region Source Protection Area, seven (7) municipal drinking water sources, supplying water to 57,000 residents, were studied for water quantity and quality threats assessment. These include:

- Redwood Estates (Township of South Glengarry), 1 groundwater well
- Glen Robertson (Township of North Glengarry), 1 groundwater well
- Long Sault (Township of South Stormont), 1 surface water intake
- Cornwall (City of Cornwall), 1 surface water intake
- Glen Walter (Township of South Glengarry), 1 surface water intake
- Lancaster (Township of South Glengarry), 1 surface water intake
- Alexandria (Township of North Glengarry), 1 surface water intake

The following activities, defined by the Clean Water Act Regulations are prescribed as drinking water threats:

1. The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.
2. The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.

6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.
15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid.
17. The handling and storage of an organic solvent.
18. The management of runoff that contains chemicals used in the de-icing of aircraft.
19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.
20. An activity that reduces the recharge of an aquifer.
21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.
22. The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.

A significant drinking water threat exists if the activity meets certain circumstances. One location (i.e., municipal parcel) may be associated with multiple activities.

Activities that are or would be significant drinking water **quality** threats have been identified near three drinking water systems.

The following table lists the number of activities that may pose a significant threat to the municipal drinking water systems listed.

System	Source water	Total Significant Activities	Locations of Activities
Redwood Estates	Groundwater	7	5
Glen Robertson	Groundwater	22	19
Long Sault	Surface Water (St. Lawrence River)	0	0
Cornwall	Surface Water (St. Lawrence River)	0	0
Glen Walter	Surface Water (St. Lawrence River)	0	0
Lancaster	Surface Water (St. Lawrence River)	0	0
Alexandria	Mill Pond, Garry River	12	12

Totals for 7 Drinking Water Systems	**41**	**36**

The information will be used to prepare a Source Protection Plan, which will describe the actions required to address threats to drinking water sources.

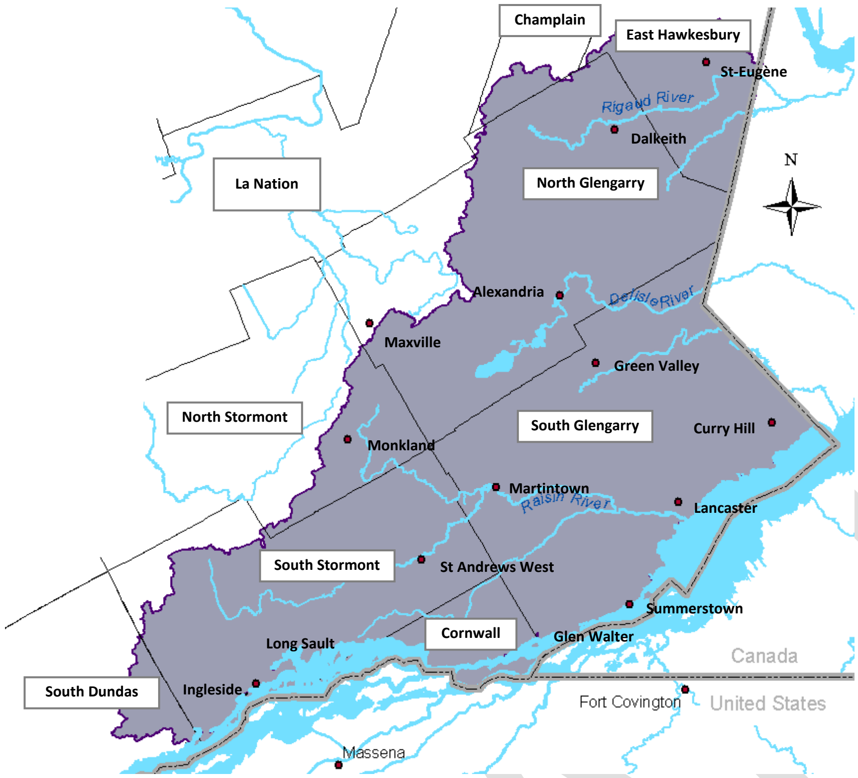
This assessment report has been prepared by the Raisin-South Nation Source Protection Committee.

Sommaire Exécutif

Dans le cadre d’un engagement global de la part du gouvernement de l’Ontario envers la protection de la santé humaine et de l’environnement, la **Loi sur l’eau saine** assure la protection de l’eau potable municipale à la source. Un des volets clés de cette loi comporte la **préparation de rapports d’évaluation technique et l’élaboration de plans de protection des sources à l’échelle locale**.

Un rapport d’évaluation inclut :

- Une caractérisation d’une région, y compris la géographie physique et humaine et la qualité de l’eau;
- Une compréhension conceptuelle de la localisation de l’eau dans une région et de la façon dont elle circule entre les divers éléments du bassin hydrographique;
- Une évaluation des menaces visant la quantité de l’eau;
- Une évaluation des menaces visant la qualité de l’eau.



La zone de protection des sources de la région Raisin

La zone de protection des sources de la région Raisin s'étend sur environ 2 000 km² et comprend le territoire de compétence de l'Office de protection de la nature de la région Raisin et une autre région du bassin hydrographique située au sud-est et au nord. Cette région a une population approximative de 84 000 et elle est composée des municipalités suivantes, en entier ou en partie:

- Municipalité de la Nation
- Canton de Champlain
- Canton d'Hawkesbury Est
- Cité de Cornwall
- Canton de Glengarry Nord
- Canton de Stormont Nord
- Canton de Dundas Sud
- Canton de Glengarry Sud
- Canton de Stormont Sud

Dans la zone de protection des sources de la région Raisin, sept (7) sources d'eau potable municipales, qui alimentent en eau 57 000 habitants, ont été étudiées dans le but d'évaluer les menaces visant la qualité et la quantité de l'eau. Incluses sont les sources suivantes:

- Redwood Estates (Canton de Glengarry Sud), 1 puits d'eaux souterraines
- Glen Robertson (Canton de Glengarry Nord), 1 puits d'eaux souterraines
- Long Sault (Canton de Stormont Sud), 1 prise d'eaux de surface
- Cornwall (Cité de Cornwall), 1 prise d'eaux de surface
- Glen Walter (Canton de Glengarry Sud), 1 prise d'eaux de surface
- Lancaster (Canton de Glengarry Sud), 1 prise d'eau de surface
- Alexandria (Canton de Glengarry Nord), 1 prise d'eaux de surface

Les activités suivantes, telles que définies dans les règlements de la Loi sur l'eau saine, ont été déterminées comme étant des menaces pour l'eau potable:

1. La création, l'exploitation ou l'entretien d'un lieu d'élimination des déchets au sens de la partie V de la Loi sur la protection de l'environnement.
2. La création, l'exploitation ou l'entretien d'un système qui capte, stocke, achemine, traite ou élimine les eaux d'égout.
3. L'épandage de matières de source agricole sur les terres.
4. Le stockage de matières de source agricole.
5. La gestion de matières de source agricole.
6. L'épandage de matières de source non agricole sur les terres.
7. La manutention et le stockage de matières de source non agricole.
8. L'épandage d'engrais commerciaux sur les terres.
9. La manutention et le stockage d'engrais commerciaux.
10. L'épandage de pesticides sur les terres.
11. La manutention et le stockage de pesticides.
12. L'épandage de sel de voirie.
13. La manutention et le stockage de sel de voirie.
14. Le stockage de neige.
15. La manutention et le stockage de carburants.
16. La manutention et le stockage d'un liquide non aqueux dense.
17. La manutention et le stockage d'un solvant organique.
18. La gestion d'eaux de ruissellement contenant des produits chimiques utilisés pour dégivrer les aéronefs.
19. Une activité qui retire de l'eau d'un aquifère ou d'une étendue d'eau de surface sans la retourner au même aquifère ou à la même étendue d'eau.
20. Une activité qui réduit l'alimentation d'un aquifère.

21. L’utilisation des terres comme pâturage pour le bétail, zone de confinement extérieure ou cour d’animaux d’élevage. Règl. de l’Ont. 386/08, art. 1
22. La création et l’exploitation d’un pipeline de transport d’hydrocarbures liquides. Règl. de l’Ont. 386/08, art. 1; Règl. de l’Ont. 206/18, art. 1

Une menace importante à l’eau potable existe si l’activité se déroule dans des conditions particulières. Un emplacement (parcelle municipale) peut être associé à plusieurs activités.

Les études techniques ont révélé la possibilité d’une menace importante à la **quantité** d’eau de la réserve d’eau de la ville d’Alexandria. Des études subséquentes, dont les résultats seront inclus dans la mise à jour du rapport d’évaluation, pourraient confirmer cette menace. Aussi, on a identifié certaines activités qui pourraient présenter des menaces importantes ou des menaces potentielles à la **qualité** de l’eau.

Le tableau suivant énumère les activités qui pourraient poser une menace importante aux systèmes d’eau potable municipale indiqués.

Système	Source d'eau	No total d'activités importantes	Localisations de ces activités
Redwood Estates	Eaux souterraines	7	5
Glen Robertson	Eaux souterraines	22	19
Long Sault	Eaux de surface (Fleuve Saint-Laurent)	0	0
Cornwall	Eaux de surface (Fleuve Saint-Laurent)	0	0
Glen Walter	Eaux de surface (Fleuve Saint-Laurent)	0	0
Lancaster	Eaux de surface (Fleuve Saint-Laurent)	0	0
Alexandria	Mill Pond, Rivière Garry	12	12
Total pour les 7 systèmes d'eau potable		**41**	**36**

Cette information sera utilisée lors de l'élaboration d'un Plan de protection des sources dans lequel les actions nécessaires pour contrer les menaces visant les sources d'eau potable seront décrites.

Ce rapport d'évaluation a été préparé par le Comité de protection des sources de la région Raisin-Nation Sud.

Table of Contents

List of Tables

List of Figures

Map List

1 Introduction

"The first barrier to the contamination of drinking water involves protecting the sources of drinking water."

- Justice Dennis O'Connor

1.1 Drinking Water Source Protection and the Clean Water Act

As a result of Justice O'Connor's Report recommendations from the Walkerton Inquiry, the province developed a program for protecting water at its source as part of a multi-barrier approach for ensuring clean safe drinking water.

Among many other strategic measures taken to respond to recommendations, Ontario passed the Clean Water Act, 2006 (Bill 43). The Clean Water Act provides the legislative framework for drinking water Source Protection Planning in Ontario. The goal of the Act is to make certain that Ontario's drinking water is safeguarded from contamination or depletion.

The Ontario Ministry of the Environment (MOE) is the lead agency for drinking water source protection activities throughout the province. The Ontario Ministry of Natural Resources (MNR) is assisting with project management as well as aspects related to protecting quantities of water from being depleted.

Formally enacted in 2007, Ontario Regulation 287/07 formalized the partnerships between watershed based Conservation Authorities to create nineteen Source Protection Regions and subsequently nineteen Source Protection Committees province-wide. Each Source Protection Committee was charged with preparing a Drinking Water Source Water Protection strategy for their respective region. This approach included creating a Terms of Reference, Assessment Report(s) and Source Protection Plan(s) for their region. Chairs of the Committees were provincially appointed and given a five-year timeframe to complete the preparation of the aforementioned documents. Committee members were locally appointed to comply with Clean Water Act regulations. Since the introduction of the Act, the Source Protection Committees, staff and municipalities have been working together to ensure that the studies being prepared for the Assessment Report meet Clean Water Act regulation requirements. The results of these studies are the foundation for this report.

1.2 Scope and Purpose of the Assessment Report

The scope of this Assessment Report is framed by the legislation contained in the Clean Water Act 2006. Ontario Regulation 287/07 (*the Regulations*) specifies what information is to be contained in an Assessment Report. The Clean Water Act declared that the head of the Ministry of the Environment's Source Protection Programs Branch, *the Director*, may make rules establishing requirements relating to risk assessments, risk management plans and any matter that is authorized or required to be included in an assessment report. The Director's Rules (*the Rules*) are compiled in a document, "Technical Rules: Assessment Report", and may be amended from time to time. The content of the Assessment Report is further defined in the Terms of Reference submitted to the MOE by the Raisin Region Source Protection Authority in May 2009. The focus is on the municipal drinking water systems within the Raisin Region Source Protection Area. This report is a summary of general watershed characteristics, a summary of various technical studies identifying vulnerable areas as well as a list of the water quantity and quality threats with respect to municipal drinking water systems.

1.3 Raisin Region Source Protection Area

A Source Protection Area, for the purposes of the Clean Water Act, is established as the area over which a Conservation Authority has jurisdiction under the Conservation Authorities Act. The Raisin Region Source Protection Area therefore comprises the jurisdiction of the Raisin Region Conservation Authority (RRCA). As Source Protection Areas are watershed based, the boundary is slightly expanded beyond the Conservation Authority's jurisdiction to encompass additional watershed-based areas, to the southwest (Hoasic Creek) and north (Rigaud River).

The Source Protection Area is shown in *Map* 1.1. The total area of the Raisin Region Source Protection Area is approximately 2,000 km^2. Area types are tabulated in *Table 0.1*.

Table 0.1: Area types within the Raisin Region Source Protection Area

Area Type	Comment	Area (km^2)
Watershed	Main land area	1,856.4
Lake/River Jurisdiction	Area extending to International Boundary	128.6
Shoreline or Island	Includes the island chain of the Long Sault Parkway	4.3
Total Area		**1,989.3**

A municipality is designated as part of a Source Protection Area if any part of that municipality is within the Source Protection Area boundary. The following municipalities are therefore within the Raisin Region Source Protection Area:

- The Nation Municipality
- Township of Champlain
- Township of East Hawkesbury
- City of Cornwall
- Township of North Glengarry
- Township of North Stormont
- Township of South Dundas
- Township of South Glengarry
- Township of South Stormont.

A municipality may belong to one or more source protection areas.

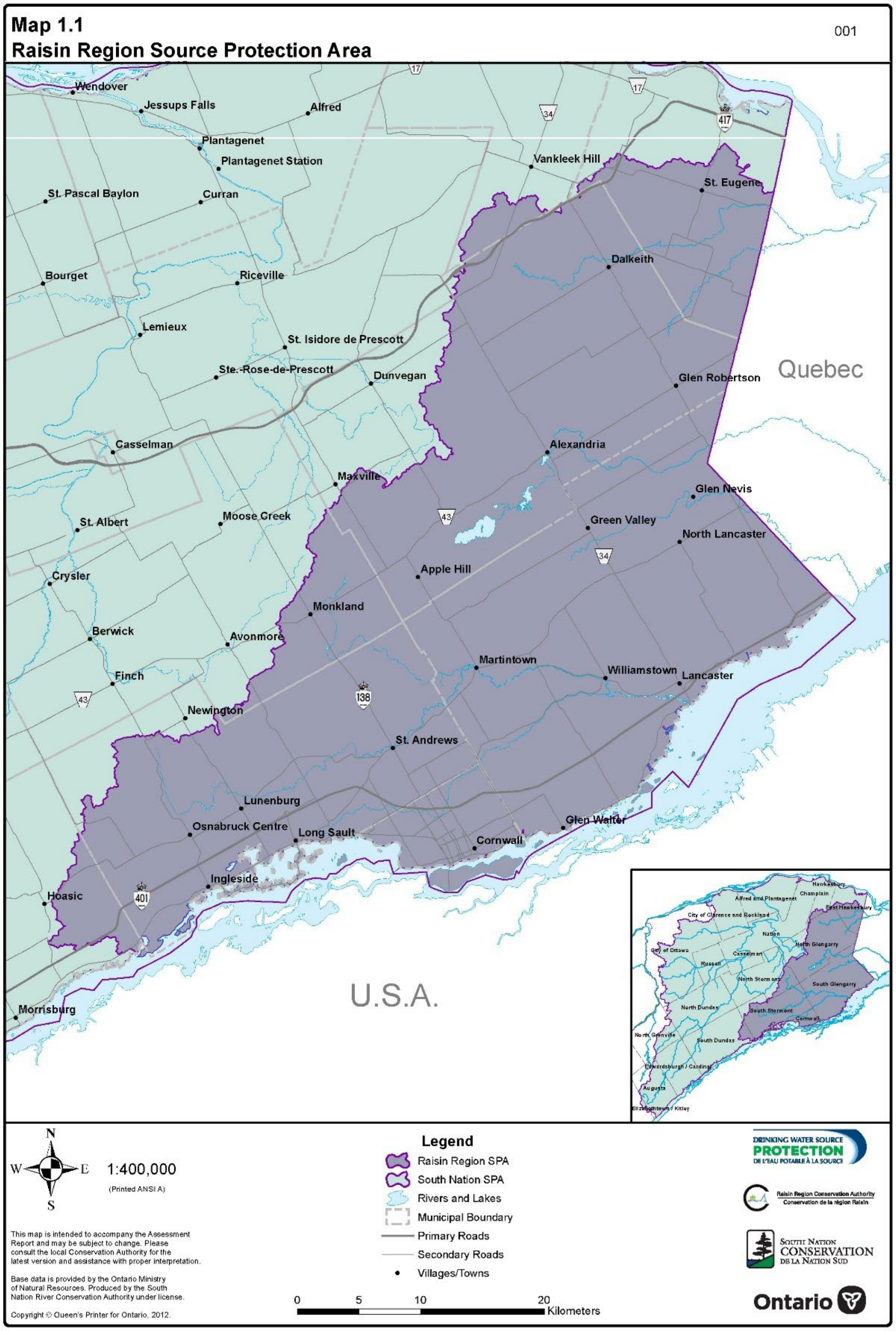
The Raisin Region Source Protection Area combined with the South Nation Source Protection Area form the Raisin-South Nation Source Protection Region. A Source Protection Region is a grouping of two or more neighbouring Source Protection Areas which generally share a similar geographic and physical setting. Source Protection Regions are established by the province to facilitate efficiencies in scale with respect to the administration of technical studies, communications initiatives, stake-holder engagement and support to Source Protection Committees. The Source Protection Region is shown on *Map 1.2*.

A Source Protection Authority is the designated authority to fulfill the obligations of the Clean Water Act for a specified Source Protection Area. The Raisin Region Source Protection Area is represented by the Raisin Region Source Protection Authority. The Raisin Region Source Protection Authority is comprised of the Board of Directors of the RRCA plus an additional member representing the Township of East Hawkesbury. The Raisin Region Source Protection Authority has been designated the lead authority for the Raisin-South Nation Source Protection Region.

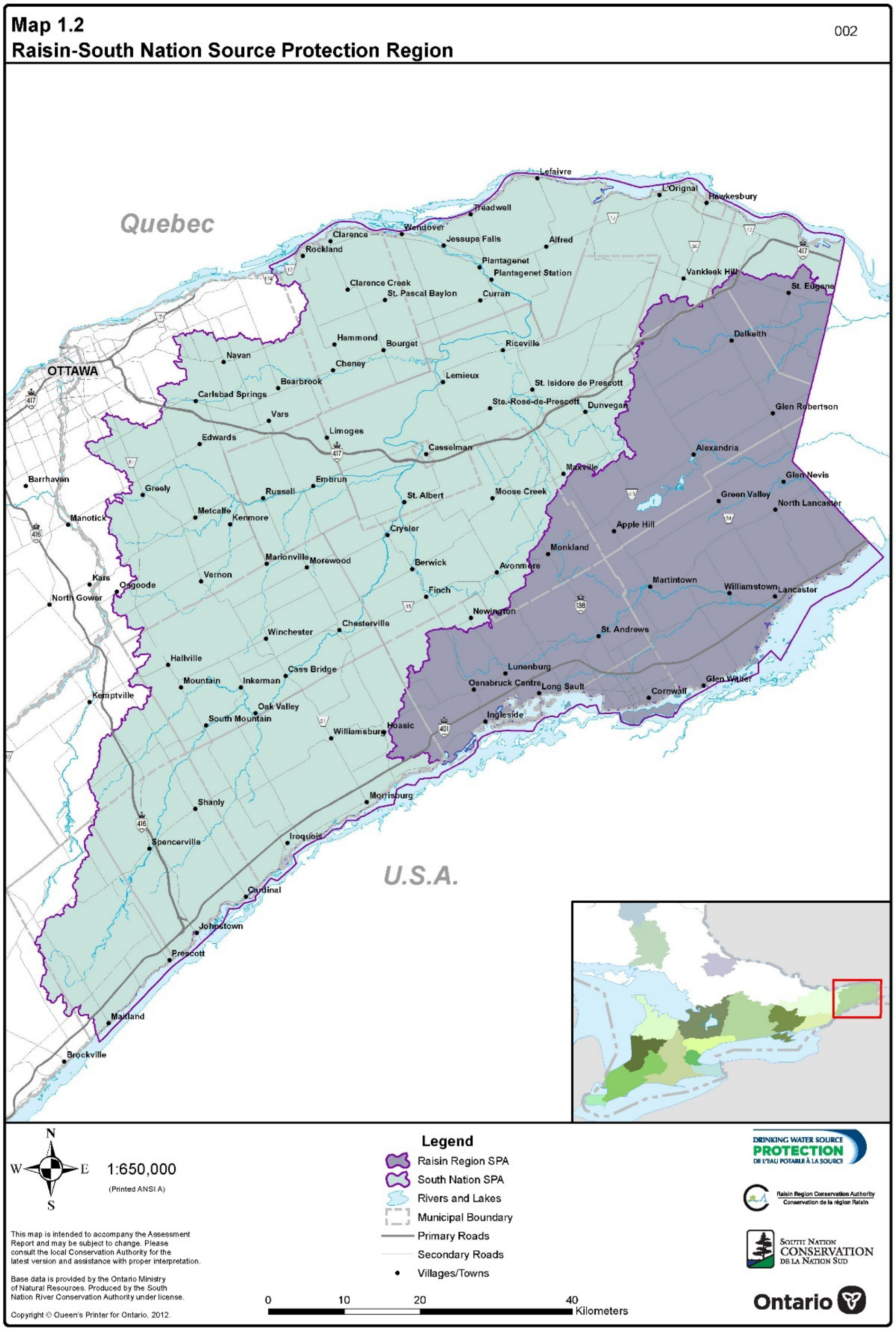
1.4 Neighbouring Source Protection Areas and Regions

The Raisin Region Source Protection Area is the eastern-most Source Protection Area in the province. The eastern boundary abuts the Province of Quebec. The southern boundary abuts the St. Lawrence River. The western and northern boundaries border the South Nation Source Protection Area. The Raisin-South Nation Source Protection Region shares boundaries with the Mississippi-Rideau Source Protection Region to the west, and a portion of the Cataraqui Source Protection Area to the southwest.

Map 1.1: Raisin Region Source Protection Area



Map 1.2: Raisin-South Nation Source Protection Region



2 Watershed Characterization

A watershed, also known as a catchment basin or drainage area, includes all of the land that is drained by a watercourse and its tributaries. Watersheds are used in many types of landscape analysis. They are the fundamental unit in which we can understand water in our landscape, including water quantity (flows, levels, etc.) and quality (contamination, source protection, etc).

The Raisin-South Nation Source Protection Region produced an initial watershed characterization report in 2007, “Raisin-South Nation Source Protection Watershed Characterization”. The report was based upon available knowledge at the time. Some data gaps which were identified have since been filled through subsequent studies. This section of the Assessment Report presents the current understanding of the Source Protection Area.

2.1 Watersheds in the Source Protection Area

The Water Survey of Canada (WSC) developed a Water Resources Index Inventory as a convenient and logical system for recording and filing water resources data. The WSC delineations involved the division, sub-division and sub-sub-division of Canada into suitably sized areas based on drainage, for administrative purposes.

Within the Province of Ontario, there are three primary watersheds. These primary watersheds are sub-divided into seventeen secondary watersheds, which are further subdivided into 147 tertiary watersheds. Tertiary watersheds have also been subdivided into over 1000 quaternary divisions. Conservation Authorities sometimes delineate additional watershed areas based on their local program requirements.

The Ministry of Natural Resources (MNR) through its Land Information Ontario (LIO) program manages geographic information for use in maps and Geographic Information Systems (GIS). The MNR in conjunction with various other provincial ministries, municipalities and conservation authorities manages the Water Resources Information Program (WRIP). This program ensures that information about Ontario’s water resources is accessible, accurate and useable.

The entire Raisin-South Nation Source Protection Region belongs to the *Great Lakes* primary watershed (WRIP identifier, ‘02’). The majority of the Raisin Region Source Protection Area drains to the *Upper St. Lawrence* secondary watershed (WRIP identifier, ‘02M’), with a portion to the north contributing to the *Lower Ottawa* secondary watershed (WRIP identifier, ‘02L’). Furthermore, the Raisin Region Source Protection Area includes the majority of the tertiary watershed, *Upper St. Lawrence – Raisin* (WRIP identifier, ‘02MC’) plus a portion of the *Lower Ottawa – South Nation* (WRIP identifier, ‘02LB’).

2.1.1 Watershed Boundaries

Watershed boundaries are delineated through analysis of topographic mapping data. The basic principle is that water runs downhill. Watershed boundaries generally represent the high-points in the regional terrain. The primary watershed divide in the source protection region is the watershed boundary between the Raisin Region Source Protection Area and the South Nation Source Protection Area to the west. This boundary represents for the most part a definitive and characteristic split between the two Source Protection Areas. The majority of the Raisin Region Source Protection Area ultimately drains south towards the St. Lawrence River. The majority of the South Nation Source Protection Area drains north towards the Ottawa River.

As they are based on topography, watershed boundaries do not necessarily align with political boundaries. Several townships in the region therefore belong to more than one watershed. The larger watershed boundaries in the region extend beyond provincial borders. This is the case with the Rigaud, Delisle and Beaudette subwatersheds which originate in Ontario but cross over into Quebec.

2.1.2 Subwatershed Areas

The RRCA's jurisdiction encompasses five locally significant watersheds: Rigaud River (flowing east into Quebec), Delisle River (flowing east into Quebec), Rivière Beaudette (flowing east into Quebec), Raisin River (flowing south-east into St. Lawrence River) and an interior lake system comprising three connected lakes (Loch Garry, Middle Lake and Mill Pond) connected by the Garry River (flowing east into Delisle). Several smaller subwatersheds drain to the St. Lawrence through short local creeks. These subwatersheds are shown on *Map 2.1*, and detailed in *Table 0.2*.

Table 0.2: Subwatershed areas of the Raisin Region Source Protection Area

Subwatershed	Drainage Area (ha)	Outlet	Intersecting Municipalities
Rigaud River	30,888	Ottawa River (via Quebec)	North Glengarry, East Hawkesbury
Delisle River	19,103	St. Lawrence River (Via Quebec)	North Glengarry, South Glengarry
Garry River	3,428	Delisle River	North Glengarry
Rivière Beaudette	15,421	St. Lawrence River (Via Quebec)	South Glengarry
Wood Creek	3,087	St. Lawrence River	South Glengarry
Gunn Creek	1,039	St. Lawrence River	South Glengarry
Sutherland Creek	7,922	St. Lawrence River	South Glengarry
Westley's Creek	3,175	St. Lawrence River	South Glengarry
Pattingale Creek	900	St. Lawrence River	South Glengarry
Finney Creek	3,191	St. Lawrence River	South Glengarry

Subwatershed	Drainage Area (ha)	Outlet	Intersecting Municipalities
Fraser Creek	4,621	St. Lawrence River	South Glengarry
Grey's Creek	4,449	St. Lawrence River	Cornwall, South Glengarry
Raisin River	57,982	St. Lawrence River	North Stormont, South Stormont, Cornwall, South Glengarry
Hoople Creek	9,714	St. Lawrence River	South Stormont
Hoasic Creek	3,157	St. Lawrence River	South Stormont, South Dundas

2.2 Physical Geography

Physical geography pertains to the natural features of the earth's surface. The bedrock and overlying sediments are the foundations of our modern landscape.

2.2.1 Physiographic Units

Physiographic units identify regions with distinct and unique plains, flats, highlands and fields. Six representative geologic terrains have been identified for the purpose of understanding how groundwater flows throughout the region:

1. Ottawa Valley Clay Plains
2. Prescott and Russell Sand Plain
3. Winchester Clay Plain
4. Glengarry Till Plain
5. Lancaster Clay Plain
6. Edwardsburgh Sand Plain

The extents of physiographic units are shown in *Map 2.2*.

2.2.2 Bedrock Topography

Bedrock topography is the elevation of the bedrock as if the cover of unconsolidated deposits was removed. The position and function of present-day rivers are strongly influenced by historic valley systems and reflected in bedrock surface topography. Sedimentary formations are generally flat lying with bedrock elevation ranging from 40 to 120 metres above sea level.

Exposures of bedrock are not common in the watershed; they occur mainly in the western and southwestern parts of the basin and in the bottom of river valleys. Bedrock is exposed at surface over less than 1% of the region.

Several east-southeast trending, steeply-dipping, normal faults transect the region. In the southern parts of the region the fault zones have a different orientation, more often running northwest to southeast. Faults zones in the area are generally intensely fractured, commonly 5 to 20 m wide and form linear negative relief features on the bedrock surface. The extensive networks of faulting in the region are potentially zones of high water transmissivity since fault zones are kilometres to tens of kilometres long and very deep, with their origin well into the basement rock. Additionally, fault zones may play a role in interrupting the direction of groundwater flow between more transmissive formations (i.e., the Nepean Sandstone) when these formations are interrupted by displacement of the unit along the fault.

The region's bedrock topography is shown in *Map 2.3*.

2.2.3 Ground Surface Topography

The Source Protection Region is located in the *Ottawa - St. Lawrence Lowland* physiographic region of Eastern Ontario. The area is characterized by subdued topography with relief generally less than 90 metres. Overall, the ground surface topography mirrors the bedrock topography.

The region's ground surface topography is shown in *Map 2.4*.

2.2.4 Hummocky Topography

Till is the major surface unit in a large triangular area bounded roughly by the St. Lawrence River, a line between Prescott and Hawkesbury, and a line running due south from Hawkesbury, and is common as a surface material in the west central and southwestern parts of the region. To the east, the till forms numerous drumlins, oriented slightly west of north and what appear to be east-northeasterly trending ridges formed of coalescing drumlins or with superimposed north-south drumlins.

Based on descriptions from MOE Well Records, it appears there is a correlation between the till unit and deposits that were described as more permeable materials (sands, gravels, etc.). This hummocky pattern could play a significant role in ground water – surface water interaction, as the larger streams located in the clay lowlands would be relatively isolated from the groundwater system, however where they cross till or other surface materials they might preferentially pick up or lose water to the underlying ground water system.

2.2.5 Bedrock Geology

The bedrock geology of the Source Protection Region consists of Precambrian igneous and metamorphic rocks overlain by a series of Paleozoic sedimentary rocks of Cambrian-Ordovician age. Although the sedimentary units are generally flat lying, considerable faulting has resulted in a complex and irregular vertical stacking.

In general, conglomerates and sandstones of the Covey Hill Formation and sandstones of the Nepean Formation lie unconformably above the Precambrian lower layer (i.e., the Nepean Sandstone does not succeed the Precambrian bedrock in immediate order of age; a period of erosion existed between the deposition of the two units). The Nepean Formation is conformably overlain (i.e., strata were deposited in continuous succession) by sandstone-dolostones of the March Formation and dolostones of the Oxford Formation. Above these deposits are sandstones of the Rockcliffe Formation and limestones of the Ottawa Group, which include the Gull River Formation (limestone/dolostone/shale), the Bobcaygeon Formation (limestone/shale), the Verulam Formation (limestone/shale) and the Lindsay Formation (limestone/shale). Younger rocks are also found north and east of the study area; these include the Billings Formation (shale/limestone), the Carlsbad Formation (shale/siltstone/limestone) and the Queenston Formation (shale/limestone/siltstone).

The unique bedrock formations are illustrated on *Map 2.5*.

2.2.6 Surficial Geology

The surficial geology consists of unconsolidated Pleistocene and recent deposits. These deposits include: glacial deposits made up of tills and moraines deposited during the advance and retreat of the Laurentide Ice Sheet, glaciofluvial deposits produced by meltwater streams escaping from the glacier, shallow water (sand and gravel with minor silt and clay) and deep water (silt and clay) glaciomarine deposits, deltaic and fluvial deposits from early phases of the Ottawa River and recent alluvium, colluvium and organic deposits.

Surficial Geology is shown in *Map 2.6*.

2.2.7 Glaciofluvial Deposits (Esker and Subglacial Fan Deposits)

Other key physiographic features within the Source Protection Region are the esker and outwash fan deposits. The esker and fan deposits extend in a north-south orientation across the study area for a distance of greater than 30 km generally located in the western and central areas of the region. Although these coarse-grained deposits cover a limited aerial extent, they comprise a notable groundwater resource.

The distribution of these glaciofluvial deposits however is minimal in the Raisin Region Source Protection Area as shown in *Map 2.7*.

2.2.8 Overburden Thickness

Overburden relates to the unconsolidated surficial deposits atop the bedrock. The overburden generally ranges in thickness from less than 10 metres to greater than 50 metres. Significant thickness of overburden occurs within the Prescott and Russell Sand Plains where the thickness is generally greater than 30 metres and along the St. Lawrence River where the thickness of the overburden increases to more than 35 metres.

Overburden thickness is illustrated in *Map 2.8.*

2.2.9 Soils

Soil type is a key factor in determining groundwater recharge. Soil types have various recharge factors. Clay has a low permeability, whereas sand is highly permeable. Land use in the Source Protection Region is generally correlated to soil types since the agricultural capability of the land is controlled by soil conditions. The north of the Source Protection Region is dominated by fine sandy loam and silt loam, the southeastern part of the region is dominated by loam with minor sandy loam and the south and central parts of the region are predominantly clay loam. A high proportion of these soils are suitable for agricultural production. Most of the high capability soils correspond to the Ottawa Valley Clay Plain, the Winchester Clay Plains and the Lancaster Clay Plain; these soils are suitable for agricultural use but tend to be poorly drained. The widespread nature of poorly drained soils has led to the development of extensive tile drainage networks throughout the region; approximately 40% of the soils have a drainage problem to some degree.

Soil types within the region are shown on *Map 2.9*.

2.2.10 Natural Vegetative Cover

Natural vegetative cover relates to wetlands; woodlands; vegetated riparian areas. The location and types of natural vegetative cover is shown in *Map 2.10*.

2.2.10.1 Wetlands

Wetlands are lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens. Periodically soaked or wet lands being used for agricultural purposes, which no longer exhibit wetland characteristics, are not considered to be wetlands for the purposes of this definition. Wetlands act as temporary water storage facilities and aid in filtration of nutrients, sediments and toxins.

Across the region, construction of roads, pipelines and hydro transmission corridors have fragmented the wetland habitats. Increased human disturbances have altered vegetation communities, water levels and water movement. The current wetland coverage (Provincially Significant, Locally Significant and Undefined) in the Raisin Region Source Protection Area is 149.1 km², representing 7.5% of the total area.

2.2.10.2 Woodlands

Woodlands are treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as: erosion prevention; hydrological and nutrient cycling; provision of clean air and the long-term storage of carbon; provision of wildlife habitat; outdoor recreational opportunities; and the sustainable harvest of a wide range of woodland products. Woodlands include treed areas, woodlots or forested areas and vary in their level of significance at the local, regional and provincial levels. Woodlands affect water quantity and quality in a number of ways: they reduce the intensity and volume of stormwater runoff, thereby decreasing soil erosion and flooding; they act as a semi-conductor or regulator for water movement between its percolation into the ground and its release into the atmosphere; they act as a soil stabilizer, filtering system and control water temperatures along stream courses.

The current woodlands coverage in the Raisin Region Source Protection Area is 246.8 km^2, representing 12.4% of the total area.

2.2.10.3 Vegetated Riparian Areas

Vegetated riparian areas are the areas where land and water meet. The area along a stream, river, creek, lake or other water body is the "riparian zone". These areas do not necessarily meet the requirements for wetlands classification. Vegetated riparian areas act as natural filters for contaminants, control erosion from overland flow and limit sedimentation.

In the Raisin Region Source Protection Area, vegetated riparian areas span 712 km of streams, representing 23% of all stream courses.

2.2.11 Aquatic Habitat

Aquatic ecology and fish classification studies have been conducted by the RRCA on behalf of the Department of Fisheries and Oceans. Municipal drain classifications were developed through local sampling of species. The classifications assist municipal drainage superintendents to determine the type of maintenance that may be applied to drains. Fish habitat is shown on *Map 2.11* and summarized in *Table 0.3*.

Table 0.3: Stream Classification in the Raisin Region Source Protection Area

Stream Classification	Stream Length (km)
A – Permanent Cold/Cool, No Trout or Salmon	28
B – Permanent Warm, Top Predators	160
C – Permanent Warm, Baitfish	939
D – Permanent Cold/Cool, Trout and/or Salmon	0
E – Permanent Warm, Top Predators	926
F – Intermittent Stream	549
U/N – Unclassified	96
Outside of DFO Classification	369
Total Stream Length	**3,067**

Macroinvertebrates are the spineless insects, worms and mollusks that live on the bottom of streams, rivers and lakes. They have been utilized for years as indicators of water quality conditions. The composition of macroinvertebrate populations adapt quickly to changing water conditions and thus some macroinvertebrate species can provide an integrative index of nutrient loading and declining water quality conditions.

The RRCA has recently undertaken benthic sampling of local tributaries to supplement existing water quality data. The preliminary findings indicate that the benthic sampling results tend to follow the trends seen in water quality sampling.

2.2.12 Anthropogenic Impacts on Aquatic Habitat

The RRCA has documented various anthropogenic impacts on aquatic habitat through the development of a *Fish Habitat Management Plan*. The following activities were identified as impacting aquatic habitat in the area: dredging, channelization, filling, water control structures, shoreline development and introduction of invasive species. In general, all of these activities alter the natural environment. The alterations change stream dynamics, disturbs habitat and puts outside stresses on fish populations. This results in decreased productivity of the aquatic ecosystem, a reduction in habitat heterogeneity, and negative effects on fish and benthic communities.

As part of the Remedial Action Program (RAP), Beneficial Use Impairments (BUI) were identified for the Cornwall Area of Concern (AOC) (*Section 2.3.3*). A BUI is the inability of an AOC to provide for a particular beneficial use of the aquatic ecosystem. Fourteen BUI's are listed in the Great Lakes Water Quality Agreement. The 7 identified BUI’s that were degraded in the AOC are:

1. Restrictions on Fish and Wildlife Consumption
2. Degradation of Fish and Wildlife Populations

3. Degradation of Benthos
4. Restrictions on Dredging Activities
5. Eutrophication or undesirable Algae
6. Beach Closings/Water Contact Sports
7. Loss of Fish and Wildlife Habitat

2.2.13 Species and Habitats at Risk

The Raisin Region Conservation Authority (RRCA) has developed a Natural Heritage Strategy. A natural heritage strategy is a document that provides direction in the design and management of natural heritage systems. It can be used to define conservation and protection objectives in land-use, watershed and resource planning. One component of the Strategy, titled, "Significant Habitat of Rare and Threatened Species, 2009", presents a table of Rare or Threatened species.

Species have been evaluated by their classification with respect to the following rating systems:

- Committee on the Status of Endangered Wildlife in Canada (COSEWIC)
- Ministry of Natural Resources (MNR)
- Natural Heritage Information Centre, Provincial Rank (SRANK)
- Global Consensus Ranking, (GRANK)

Species that were identified as rare or threatened are listed in *Table 0.4*. Classification codes are defined in

Table 0.5.

Table 0.4: Rare and Threatened Species, as identified by Natural Heritage Strategy

Taxon	Scientific Name	Common Name	Classification			
			COSEWIC	MNR	SRANK	GRANK
Birds	Coturnicops noveboracensis	Yellow Rail	SC	SC	S4B	G4
Birds	Larus marinus	Great Black-backed Gull			S2B	G5
Birds	Chlidonias niger	Black Tern	NAR	SC	S3B	G4
Birds	Lanius ludovicianus	Loggerhead Shrike	END	END	S2B	G4
Birds	Dendroica palmarum hypochrysea	Yellow Palm Warbler			S1B	G5TU
Birds	Ammodramus henslowii	Henslow's Sparrow	END	END	S1B	G4
Fish	Exoglossum maxillingua	Cutlip Minnow	NAR	THR	S1S2	G5
Fish	Moxostoma valenciennesi	Greater Redhorse			S3	G4
Fish	Moxostoma carinatum	River Redhorse	SC		S2	
Fish	Notropis bifrenatus	Bridle Shiner	SC		S2	
Fish	Esox americanus vermiculatus	Grass Pickerel	SC		S3	
Fish	Anguilla rostrata	American Eel	SC		S1	
Mammals	Myotis septentrionalis	Northern Long-eared Bat			S3?	G4
Mammals	Urocyon cinereoargenteus	Common Gray Fox	THR	THR	SNA	G5
Insects	Callophrys lanoraieensis	Bog Elfin			S1	G3G4
Insects	Aeshna verticalis	Green-striped Darner			S3	G5
Insects	Somatochlora williamsoni	Williamson's Emerald			S4	G5
Insects	Williamsonia fletcheri	Ebony Boghaunter			S2	G4
Plants	Astomum muehlenbergianum	A Moss			S2	G5
Plants	Rhododendron canadense	Rhodora			S1	G5
Plants	Monarda didyma	Bee-balm			S3	G5
Plants	Persicaria arifolia	Halberd-leaved Tear-thumb			S3	G5
Plants	Crataegus brainerdii	Brainerd's Hawthorn			S2	G5
Plants	Crataegus corusca	A Hawthorn			SNA	G3G5
Plants	Alisma gramineum	Grass-leaved Water-plantain			S4	G5
Plants	Carex atlantica	Prickly Bog Sedge			S1	G5
Plants	Carex folliculata	Long Sedge			S3	G4G5

Taxon	Scientific Name	Common Name	Classification			
			COSEWIC	MNR	SRANK	GRANK
Plants	Schoenoplectus heterochaetus	Pale Great Club-rush			S3	G5
Plants	Schoenoplectus smithii	Smith's Club-rush			S3	G5?
Plants	Aplectrum hyemale	Puttyroot			S2	G5
Plants	Cypripedium arietinum	Ram's-head Lady's-slipper			S3	G3
Plants	Platanthera leucophaea	Eastern Prairie Fringed-orchid	END	END	S2	G3
Plants	Thelypteris simulata	Bog Fern			S1	G4G5

Table 0.5: Species and Habitats at Risk Classifications

System	Code	Definition
COSEWIC / MNR	SC	Special Concern
	THR	Threatened
	NAR	Not at Risk
	END	Endangered
SRANK	SX	Presumed Extirpated—Species or community is believed to be extirpated from the nation or state/province. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
	SH	Possibly Extirpated (Historical)—Species or community occurred historically in the nation or state/province, and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years. A species or community could become NH or SH without such a 20-40 year delay if the only known occurrences in a nation or state/province were destroyed or if it had been extensively and unsuccessfully looked for. The NH or SH rank is reserved for species or communities for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant occurrences.
	S1	Critically Imperiled—Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
	S2	Imperiled—Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
	S3	Vulnerable—Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
	S4	Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
	S5	Secure—Common, widespread, and abundant in the nation or state/province.
	SNR	Unranked—Nation or state/province conservation status not yet assessed.
	SU	Unrankable—Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
	SNA	Not Applicable —A conservation status rank is not applicable because the species is not a suitable target for conservation activities.
	S#S#	Range Rank —A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU is used rather than S1S4).

System	Code	Definition
GRANK	G1	Extremely rare; usually 5 or fewer occurrences in the overall range or very few remaining individuals; or because of some factor(s) making it especially vulnerable to extinction.
	G2	Very rare; usually between 5 and 20 occurrences in the overall range or with many individuals in fewer occurrences; or because of some factor(s) making it vulnerable to extinction.
	G3	Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
	G4	Common; usually more than 100 occurrences; usually not susceptible to immediate threats.
	G5	Very common; demonstrably secure under present conditions.
	GH	Historic, no records in the past 20 years.
	GU	Status uncertain, often because of low search effort or cryptic nature of the species; more data needed.
	GX	Globally extinct. No recent records despite specific searches.
	?	Denotes inexact numeric rank (i.e., G4?).
	G	A "G" (or "T") followed by a blank space means that the NHIC has not yet obtained the Global Rank from The Nature Conservancy.
	G?	Unranked, or, if following a ranking, rank tentatively assigned (e.g., G3?).
	Q	Denotes that the taxonomic status of the species, subspecies, or variety is questionable.
	T	Denotes that the rank applies to a subspecies or variety.

2.3 Water Quality

Water quality across the Source Protection Area has been assessed based on regional land use patterns with respect to Provincial Water Quality Objectives (PWQO) and Ontario Drinking Water Standards (ODWS). These are numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level of quality for surface waters.

2.3.1 Surface Water Quality

The Provincial Water Quality Monitoring Network (PWQMN) measures water quality in rivers and streams across Ontario. The dataset provides stream water quality monitoring data for several parameters. There are nine (9) long term stations within the Raisin Source Protection Area.

The following parameters were chosen to assess the surface water quality as they are indicators of potential adverse impacts from agricultural sources, rural residences, small communities and emerging development:

- **Total Phosphorus (TP)**: a limiting nutrient for aquatic vegetation and a major contributor to eutrophication of water bodies (PWQO Guideline - 30µg/L);
- **Nitrate**: can pose a health risk in elevated concentrations to children, livestock and aquatic habitats (ODWS Maximum Allowable Concentration 10mg/L);
- **Turbidity**: a strong indicator of runoff from anthropogenic activities, high turbidity can affect the disinfection process for drinking water treatment (ODWS Aesthetic Objective 5NTU);
- **Escherichia coli (E. coli)**: primary indicators of recent fecal contamination (PWQO – 100 counts/100mL);
- **Chloride**: an indicator of development through runoff from the excessive application of road salt (ODWS Aesthetic Objective 250mg/L).

The dataset analyzed includes data up to 2018. The sampling station locations are listed in *Table 0.6* and shown on *Map 2.12*.

Table 0.6: Surface Water Quality Sampling Stations

Station	River	Location	Number of Years of Data				
			TP	Nitrate	Turbidity	E. coli	Chloride
12007300302	Raisin River	Williamstown	42	24	42	2	40
12007300802	Raisin River	Downstream of St. Andrews	42	24	42	2	40
12007301102	North Raisin River	Cemetery Rd, Upstream of Martintown	42	24	42	2	40
12007301502	South Raisin River	Cashions Rd	42	24	42	2	40
12008600102	Delisle River	Glen Robertson Rd, Downstream Alexandria	39	32	39	2	37
12008600202	Delisle River	McCormick Rd	39	24	39	2	37
12008600402	Garry River	Lochiel St, upstream Alexandria	39	24	39	2	37
12008600302	Garry River	CNR trestle, Alexandria	32	17	32	2	32
12008000102	Beaudette River	West of Glen Nevis	23	17	23	2	23
12007301002	Raisin River	County Road 18, East of Lunenburg	16	0	16	0	16
12007300102	Raisin River	Highway 401, Lancaster	7	0	7	0	7
12008000302	Beaudette River	4th Line Rd, East of Glen Nevis	7	7	7	0	5
12008601102	Garry River	Sandfield Ave, Alexandria	7	7	7	0	5

Water quality analyses are shown in *Figure 0.1*, *Figure 0.2*, *Figure 0.3*, *Figure 0.4* and *Figure 0.5*. In general, Total Phosphorus regularly exceeds the PWQO; Nitrate concentrations are below ODWS' maximum allowable concentration; Turbidity levels in tributaries mostly exceed aesthetic objectives of ODWS; E. coli counts, with some exceptions are slightly higher than PWQO; and Chloride concentrations are well below the ODWS aesthetic objective.

High phosphorus concentrations and turbidity are often attributed to erosion, natural weathering and agricultural land use. Phosphorus is also a component of wastewater and septic discharge. E. coli is an indicator of fecal waste from mammals, and could be attributed to wildlife (e.g., muskrat, geese populations), human wastewater and septic discharge or agricultural runoff.

Figure 0.1: Surface Water Quality, Phosphorus

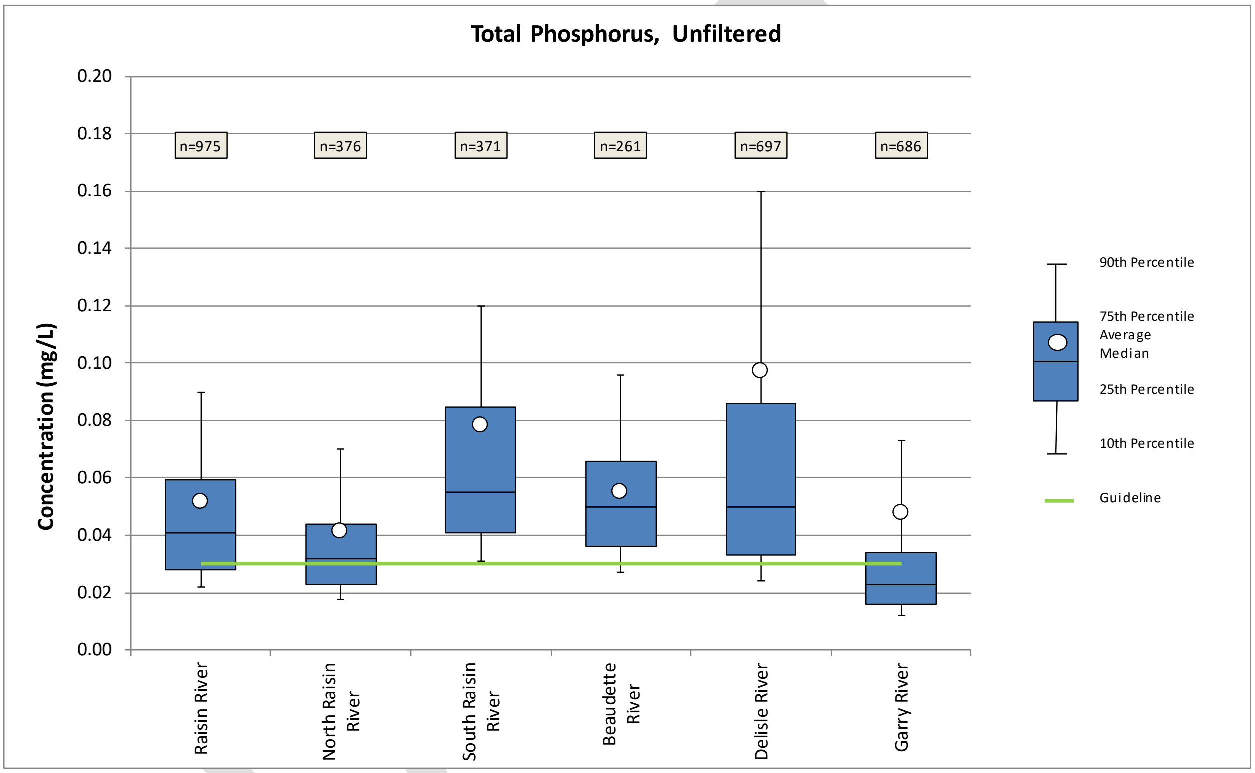


Figure 0.2: Surface Water Quality, Nitrates

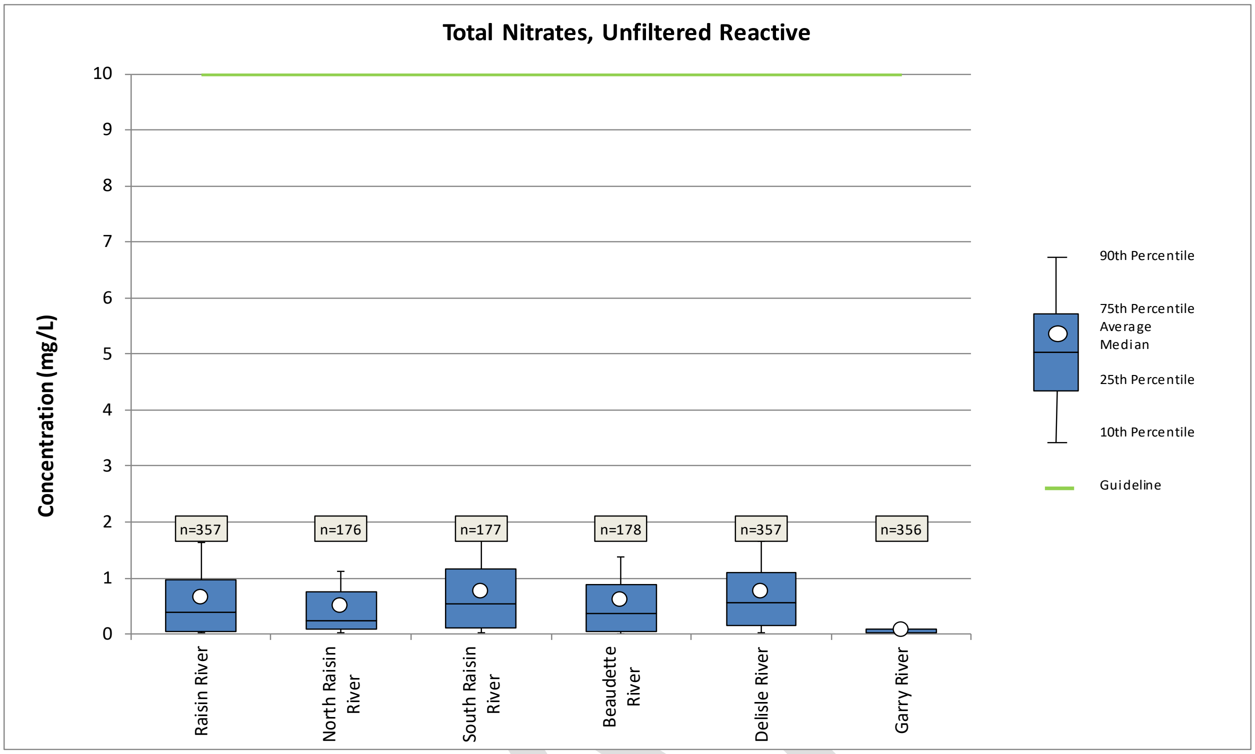


Figure 0.3: Surface Water Quality, Turbidity

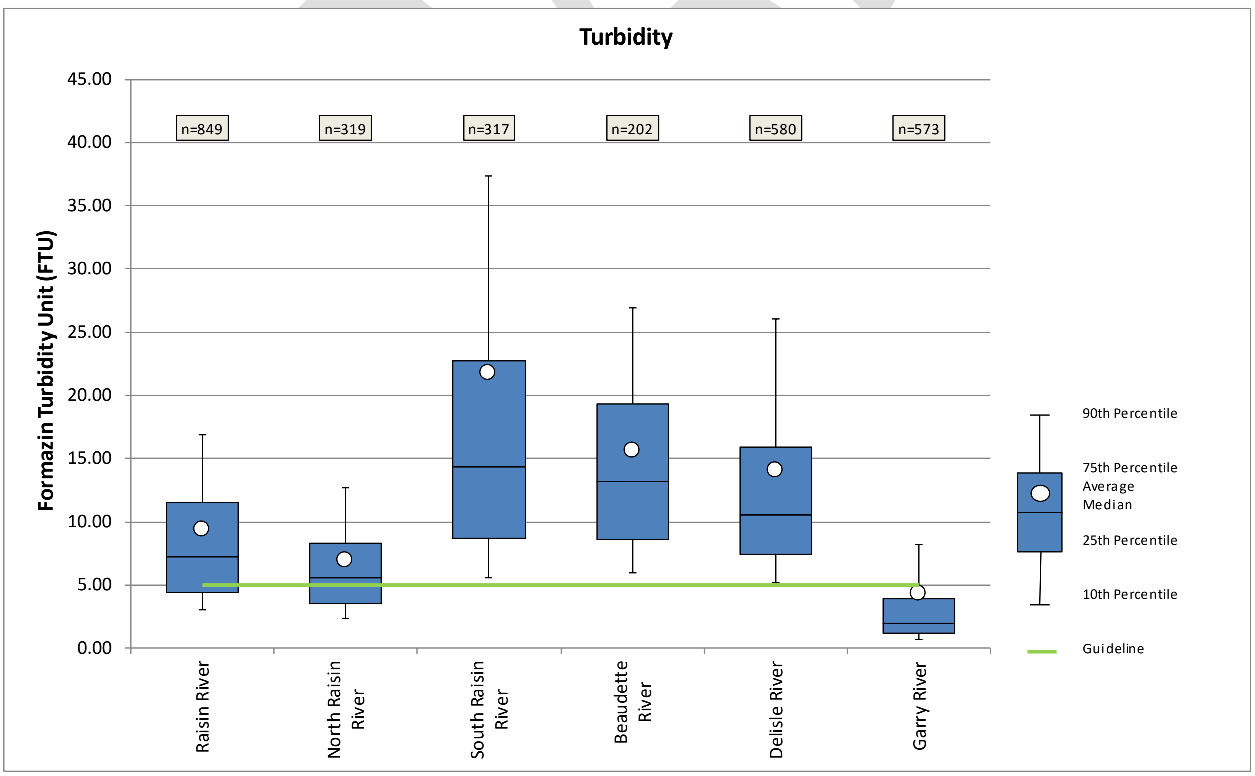


Figure 0.4: Surface Water Quality, Escherichia Coli

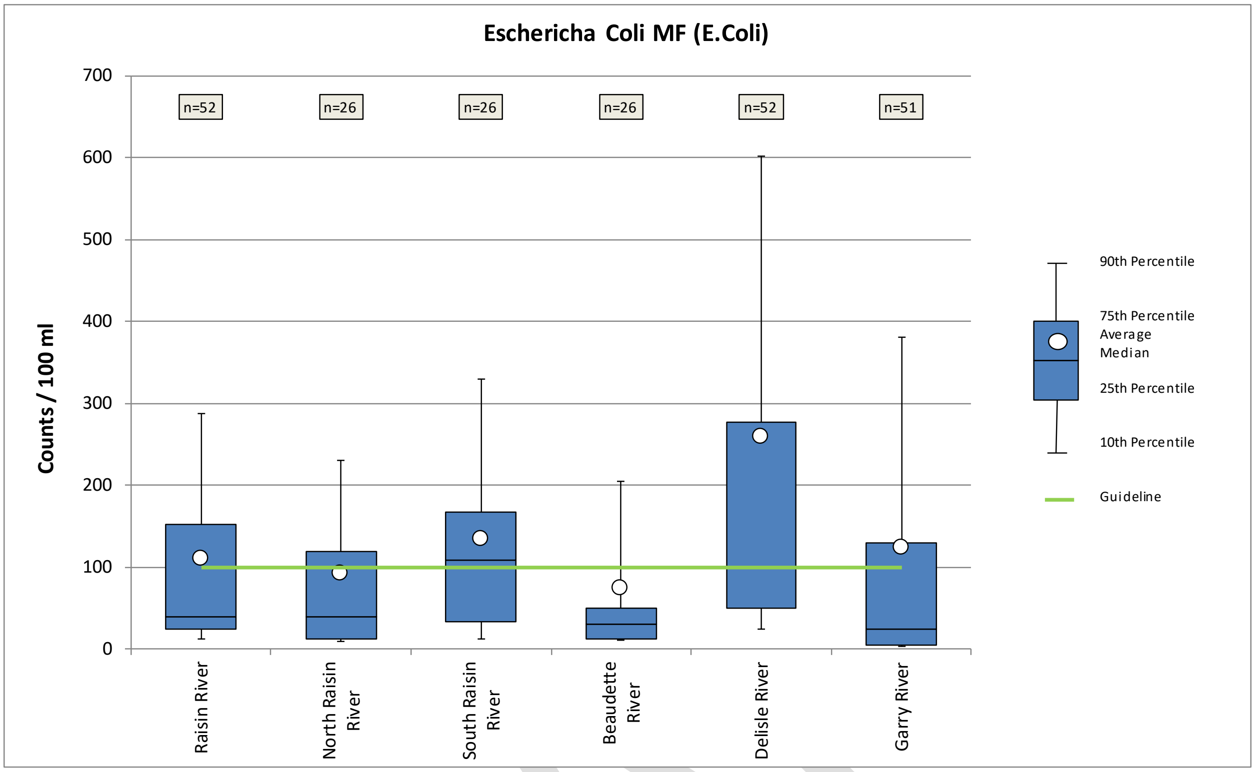
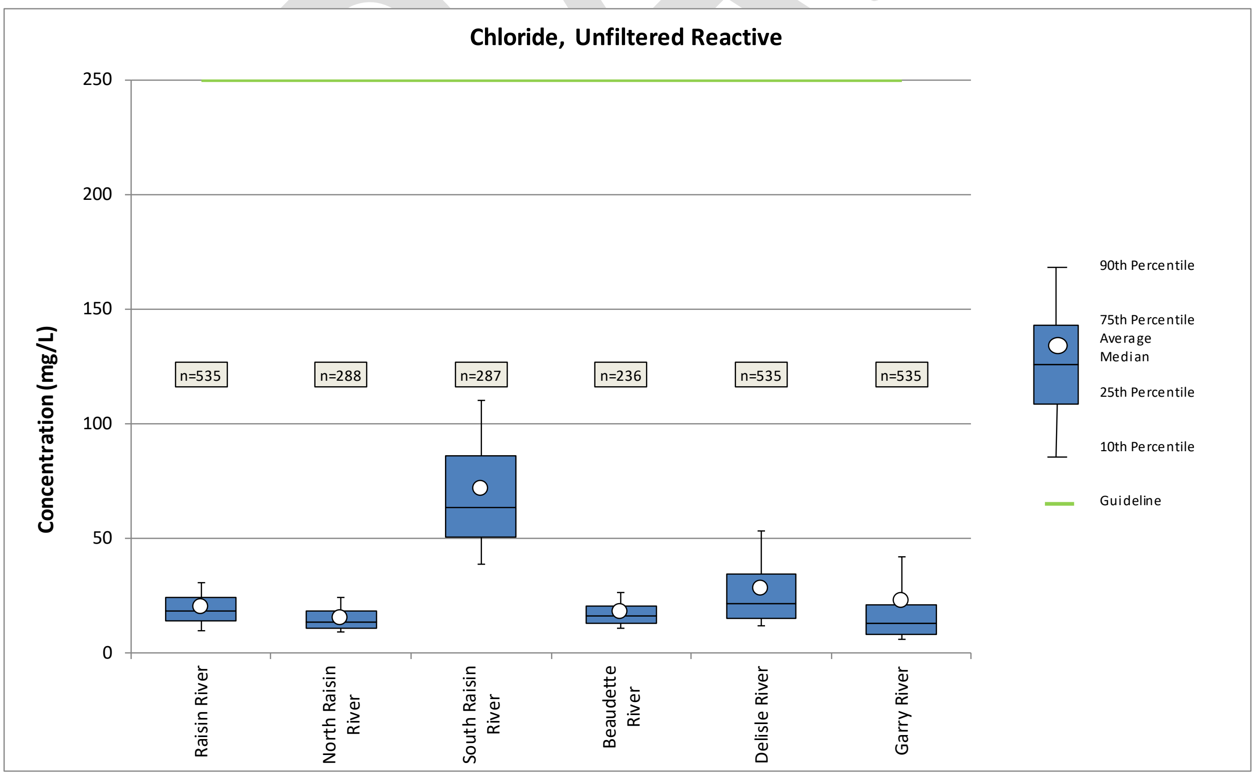


Figure 0.5: Surface Water Quality, Chloride



2.3.2 Groundwater Quality

Regional groundwater quality sampling has been initiated through the Provincial Groundwater Monitoring Network (PGMN). Nine PGMN monitoring wells are located throughout the Source Protection Area and are shown on *Map 2.13*.Long term data does not exist to determine historical trends in groundwater quality. Almost all sampled wells showed some exceedance of the ODWS aesthetic objectives for aluminum, chloride, iron, manganese or hardness. Initial samples (2003-2004) and notable exceedances with respect to ODWS are listed in *Table 0.7*.

Table 0.7: Groundwater Quality Monitoring Stations, Raisin Region Source Protection Area

PGMN Casing ID	Well Location Description	Parameter	Number of Samples	Average Sampled Concentration (mg/L)	ODWS (mg/L)
W0000089-1	2302990	None	1	---	---
W0000091-1	Roger	Hardness	1	294	80-100
W0000092-1	2300848	Iron	1	0.35	0.3
		Manganese	1	0.074	0.05
		Hardness	1	276	80-100
W0000093-1	TW1 - Norman	Hardness	1	293	80-100
W0000186-1	Glengarry	Hardness	1	151	80-100
W0000187-2	Cooper (a)	Iron	1	1.0	0.3
		Manganese	1	0.227	0.05
		Hardness	1	394	80-100
W0000187-3	Cooper (b)	Iron	1	1.0	0.3
		Manganese	1	0.07	0.05
		Hardness	1	411	80-100
W0000216-2	Glen Nevis	Hardness	2	328	80-100
W0000404-1	Rigaud River	Chloride	1	1450	250
		Fluoride	1	2.61	1.5
		Hardness	1	219	80-100

2.3.3 St. Lawrence River (Cornwall) Area of Concern

An Area of Concern (AOC) is defined as a geographic area that fails to meet the objectives of the Canada - U.S. Great Lakes Water Quality Agreement, meaning it has beneficial use impairments and the area’s ability to support aquatic life could be impaired. There is a total of 43 Areas of Concern in the US and Canada. Of the 17 Canadian Areas of Concern, two have been officially delisted (Collingwood Harbour and Severn Sound), and another is in the state of Natural Recovery (Spanish Harbour).

The St. Lawrence River (Cornwall) AOC is approximately 80 kilometres in length and stretches from the Moses-Saunders power dam to the eastern outlet of Lake St. Francis. This is a Bi-National and transboundary AOC with similar restoration efforts in both Quebec and the United States (St. Lawrence River (Massena) Area of Concern).

Over decades of industrial activity at Cornwall, since the turn of the 20th century, contaminants such as mercury were directly discharged into the St. Lawrence River. The river also received contamination from urban runoff, rural surface runoff, atmospheric deposition, and sources upstream of Cornwall.

Seven major environmental issues of concern in the Cornwall/Massena section of the St. Lawrence River were identified in the Stage 1 Report of the Cornwall Remedial Action Plan:

1. Mercury contamination
2. PCB contamination
3. Presence of other Contaminants
4. Bacterial (fecal) contamination
5. Habitat Destruction and Degradation
6. Excessive Growth of Nuisance Aquatic Plants
7. Exotic Species
8. Fish and Wildlife Health Problem Related Contaminants

The *Cornwall Sediment Strategy* is a long-term management plan for historically contaminated sediments. Continued natural recovery, administrative controls and long-term environmental monitoring are all part of this strategy.

The sediment is considered to be “capped” and is therefore not bio-available to the environment. Thirty years of environmental data and recent studies on biomagnifications show sediments along the Cornwall waterfront:

- Are not toxic to sediment-dwelling organisms, or to fish;
- Are not a major source of mercury to fish in the area through the food chain;
- Do not pose a risk to people or the environment;
- Do not pose a risk to swimmers along the waterfront;
- Are not the cause of elevated levels of mercury in walleye in the Lake St. Francis and Cornwall area.

2.4 Human Geography

The Source Protection Region includes the United Counties of Stormont, Dundas and Glengarry; the United Counties of Prescott and Russell; a portion of the United Counties of Leeds and Grenville, a portion of the City of Ottawa; the City of Cornwall and the Town of Prescott.

2.4.1 Municipal Boundaries

The Source Protection Region encompasses all of or parts of 24 various upper, lower or single tier municipalities. Of the municipalities in the region, 9 are within a portion of the Raisin Region Source Protection Area. A listing of municipalities within the Source Protection Region and Raisin Region Source Protection Area is shown in *Table 0.8*.

Table 0.8: Municipalities of the Source Protection Region

Municipality	Municipal Status	Geographic Area	Part of SPA?
Leeds and Grenville, United Counties of	Upper Tier	Leeds and Grenville	No
Augusta, Township of	Lower Tier	Leeds and Grenville	No
Edwardsburgh/Cardinal, Township of	Lower Tier	Leeds and Grenville	No
Elizabethtown-Kitley, Township of	Lower Tier	Leeds and Grenville	No
North Grenville, Municipality of	Lower Tier	Leeds and Grenville	No
Prescott and Russell, United Counties of	Upper Tier	Prescott and Russell	Yes
Alfred and Plantagenet, Township of	Lower Tier	Prescott and Russell	No
Casselman, Village of	Lower Tier	Prescott and Russell	No
Champlain, Township of	Lower Tier	Prescott and Russell	Yes
Clarence-Rockland, City of	Lower Tier	Prescott and Russell	No
East Hawkesbury, Township of	Lower Tier	Prescott and Russell	Yes
Hawkesbury, Town of	Lower Tier	Prescott and Russell	No
Russell, Township of	Lower Tier	Prescott and Russell	No
The Nation, Municipality of	Lower Tier	Prescott and Russell	Yes
Stormont, Dundas and Glengarry, United Counties of	Upper Tier	Stormont, Dundas and Glengarry	No
North Dundas, Township of	Lower Tier	Stormont, Dundas and Glengarry	No
North Glengarry, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
North Stormont, Township of	Lower Tier	Stormont, Dundas and Glengarry	No
South Dundas, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
South Glengarry, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
South Stormont, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
Cornwall, City of	Single Tier	Stormont, Dundas and Glengarry	Yes
Prescott, Town of	Single Tier	Leeds and Grenville	No
Ottawa, City of	Single Tier	Ottawa	No

2.4.2 Settlement Areas

The urban and rural settlements designated by municipal official plan are listed in *Table 0.9* and shown on *Map 2.14*.

Table 0.9: Designated Settlement Areas within the Source Protection Area

Municipality	Designated Urban Settlement Areas within Source Protection Area Boundary	Designated Rural Settlement Areas within Source Protection Area Boundary
The Nation Municipality	n.a.	n.a.
Township of Champlain	n.a.	n.a.
Township of East Hawkesbury	n.a.	Ste-Anne-de-Prescott[1] St-Eugène[1]
City of Cornwall	Cornwall	n.a.
Township of North Glengarry	Alexandria Maxville	Apple Hill Dominionville Dalkeith Greenfield Glen Robertson Glen Sandfield Laggan Lochiel
Township of South Glengarry	Glen Walter Green Valley Lancaster South Lancaster	Bainsville Brown House Corners Dalhousie Mills Glen Nevis Glen Norman Martintown North Lancaster St. Raphael's Summerstown Summerstown Station Williamstown
Township of South Stormont	Ingleside Long Sault Rosedale Terrace/Eamer's Corners St. Andrew's West	Beaver Glen Bonville Harrison's Corners Lunenburg Northfield Osnabruck Centre

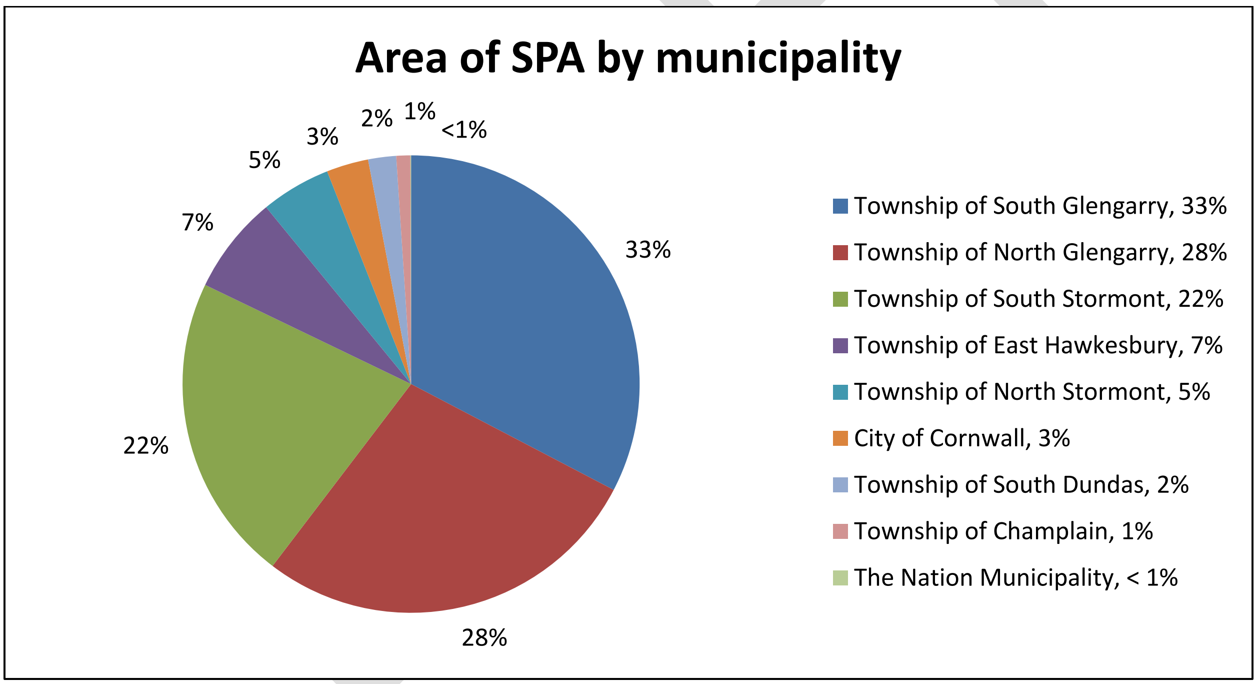
Notes: 1) Designated as "Community Policy Area, under the Official Plan for the United Counties of Prescott-Russell

The percentage of each municipality within the Source Protection Area, and the percentage of Source Protection Area by municipality is summarized in *Table 0.10* and displayed graphically in *Figure 0.6*.

Table 0.10: Municipalities within the Source Protection Area

Municipality	Total Area (km²)	Area within SPA (km²)	Percentage of Municipality	Percentage of SPA
City of Cornwall	61.5	61.5	100%	3%
The Nation Municipality	667.4	< 0.1	0%	< 1%
Township of Champlain	216	17.3	8%	1%
Township of East Hawkesbury	236.3	130.6	55%	7%
Township of North Glengarry	647.3	525.3	81%	28%
Township of North Stormont	518.5	84.3	16%	5%
Township of South Dundas	522.1	35.3	7%	2%
Township of South Glengarry	607.7	607.7	100%	33%
Township of South Stormont	452.3	401.6	89%	22%
Totals	**3,929.1**	**1,863.6**	**47%**	**100%**

Figure 0.6: Total Area of the Source Protection Area by Municipality



2.4.3 Federal Lands

The Federal government, through the Directory of Federal Real Property (DFRP) lists numerous properties of varying interests within the Source Protection Area. Crown owned property (i.e., the property is under the administration and control of the custodian) is referenced by DFRP identifier in *Table 0.11*. Non-Federal owned (i.e., the property is under the administration of a non-agent Crown Corporation) is referenced by DFRP identifier in *Table 0.12*. Federal Lands are shown on *Map 2.15*.

Table 0.11: Crown Owned Property within the Source Protection Area

DFRP ID	Property	Custodian	Municipality	Land Area (ha)
8493	Seaway International Bridge	Federal Bridge Corporation Limited	Akwesasne	58.0
56538	Glengarry Cairn National Historic Site of Canada	Parks Canada Agency	Akwesasne	0.4
8474	4th Street Armory	National Defence	Cornwall	1.6
8477	Cornwall Wharf Site	Transport Canada	Cornwall	7.9
8482	Water Street Park	Public Works and Government Services Canada	Cornwall	8.4
8490	Cornwall Headquarters Bldg.	Transport Canada	Cornwall	0.1
8491	Cornwall Canal	Transport Canada	Cornwall	136.2
23933	Sir Lionel Chevrier (Land)	Public Works and Government Services Canada	Cornwall	1.2
31510	Cornwall - Marina	Fisheries and Oceans	Cornwall	2.5
54103	Cornwall - Marina	Fisheries and Oceans	Cornwall	1.9
56477	Inverarden House National Historical Site of Canada	Parks Canada Agency	Cornwall	1.0
57719	CBOF-6-FM, CBOC-FM	Canadian Broadcasting Corporation	Cornwall	3.1
61366	St. Eugene Post Office	Canada Post Corporation	East Hawkesbury	0.1
61092	Alexandria Post Office	Canada Post Corporation	North Glengarry	0.1
61097	Apple Hill Post Office	Canada Post Corporation	North Glengarry	0.2
56478	Sir John Johnson House National Historic Site	Parks Canada Agency	South Glengarry	3.3
56556	Glengarry House National Historic Site	Parks Canada Agency	South Glengarry	0.0
61241	Lancaster Post Office	Canada Post Corporation	South Glengarry	0.1
61411	Williamstown Post Office	Canada Post Corporation	South Glengarry	0.1
61218	Ingleside Post Office	Canada Post Corporation	South Stormont	0.0
61250	Long Sault Post Office	Canada Post Corporation	South Stormont	0.0
Total Land Area				226.5

Table 0.12: Non-agent Crown Corporation Owned Land in the Source Protection Area

DFRP ID	Property	Custodian	Municipality	Land Area (ha)
73017	Marleau Avenue and Glenview Boulevard	Canada Lands Company CLC Limited	Cornwall	2.4
7821	Alexandria Subdivision	VIA Rail Canada Inc.	North Glengarry	331.2
73748	Alexandria Station	VIA Rail Canada Inc.	North Glengarry	0.2
Total Land Area				**333.8**

2.4.4 First Nation Reserves

First Nation Reserve refers to “tracts of land, the legal title to which is vested in Her Majesty that have been set apart for the use and benefit of a band”. Akwesasne borders the countries of Canada and the United States of America; the Canadian Provinces of Ontario and Quebec; and the American State of New York.

Mohawks of Akwesasne

The portion of Akwesasne within the Source Protection Region is approximately 11.1 km² and consists of several islands mostly within the Raisin Region Source Protection Area between Cornwall and Lancaster, the largest being Cornwall Island. The territory also includes islands between Prescott and Cardinal in the South Nation Source Protection Area. First Nation Reserves within the Source Protection Area are shown on *Map 2.17*.

Registered population on the Reserve is approximately 9000. Based on land area of 11.1 km², the population density is 810 persons per km².

Drinking water is partly supplied through a new water treatment plant. Kawehnoke Water Treatment Plant opened on Cornwall Island in August 2006, with a capacity to service 3000 residents. It services homes from the west end of Cornwall Island to the Arena road. It also, provides fire hydrants for its users in its coverage area. Currently most homes are hooked up within this section including the Anowarakowa Arena, Kawehnoke Day Care, and Cornwall Island Administration Buildings.

2.4.5 Population

Population counts are provided by Statistics Canada census. The census provides a statistical portrait of Canada and its people. Census data from 2001 and 2016 have been analysed; the populations and resulting population densities of the municipalities within the SPA are shown in *Table 0.13*.

Table 0.13: Municipal populations and population densities

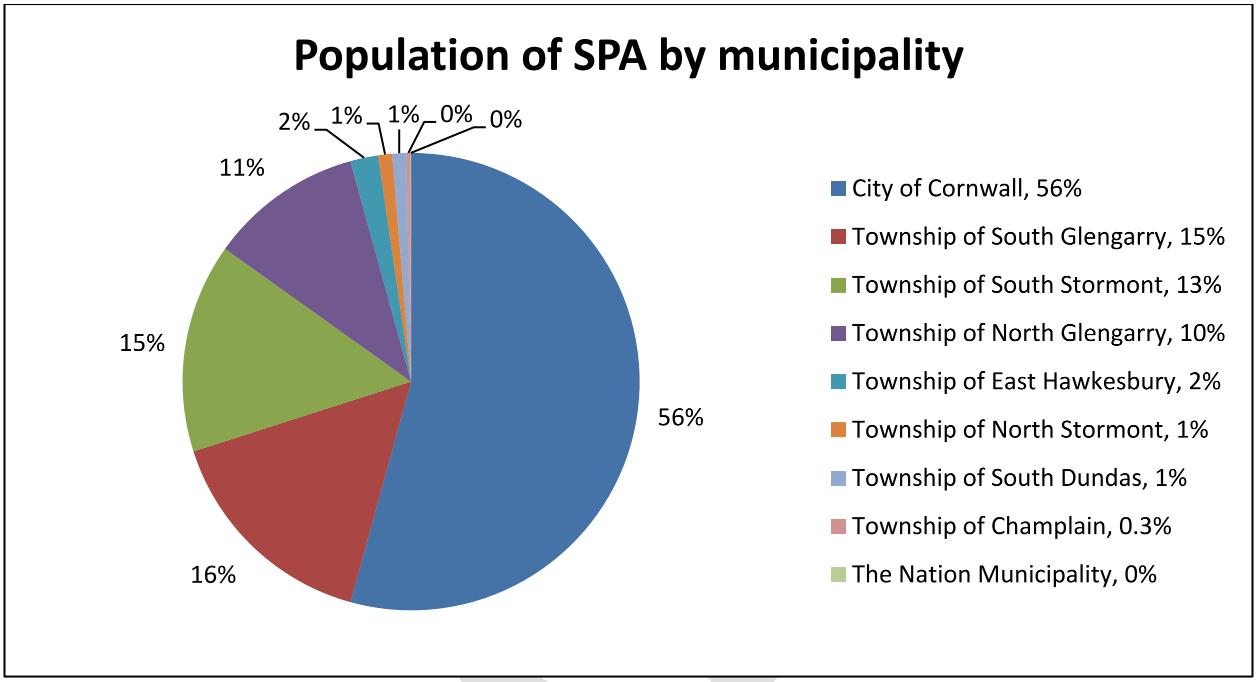
Municipality	Population 2001	Population 2016	Percent Change	Total Area (km²)	Population Density (/km²)
City of Cornwall	45,640	46,589	2.1%	61.5	758
The Nation Municipality	10,599	12,808	20.8%	667.4	19
Township of Champlain	8,586	8,706	1.4%	216	40
Township of East Hawkesbury	3,415	3,296	-3.5%	236.3	14
Township of North Glengarry	10,589	10,109	-4.5%	647.3	16
Township of North Stormont	6,855	6,873	0.3%	518.5	13
Township of South Dundas	10,783	10,833	0.5%	522.1	21
Township of South Glengarry	12,700	13,150	3.5%	607.7	22
Township of South Stormont	11,941	13,110	9.8%	452.3	29
Totals, Average Density	**121,108**	**125,474**	**3.6%**	**3,929.1**	**32**

The total population of the Source Protection Area (SPA) can be estimated by determining the pro-weighted land area of each municipality within the SPA and summing the corresponding population of each census dissemination area. The results are shown in *Table 0.14* and *Figure 0.7*.

Table 0.14: Population Estimates of the Source Protection Area

Municipality	Population 2016	Pro-weighted land-based area within SPA (km²)	Approximate population within Source Protection Area	Percentage of Source Protection Area
City of Cornwall	46,589	61.6	46,589	55%
The Nation Municipality	12,808	< 0.0	0	0%
Township of Champlain	8,706	17.2	252	0%
Township of East Hawkesbury	3,296	130.4	1,478	2%
Township of North Glengarry	10,109	521.8	8,926	11%
Township of North Stormont	6,873	82.3	1,037	1%
Township of South Dundas	10,833	35.5	434	1%
Township of South Glengarry	13,150	605.4	13,150	16%
Township of South Stormont	13,110	396.8	12,561	15%
Totals	**125,474**	**1,851.0**	**84,427**	**100%**

Figure 0.7: Population of the Source Protection Area by Municipality



2.4.5.1 Growth

The Official Plans for the municipalities within the Source Protection Area provide insight into growth expectations and planning implications as such:

City of Cornwall

The Official Plan makes the following basic assumptions concerning future conditions in the City during the planning period. The City of Cornwall will continue its role as the major urban centre of the Seaway Valley Region. It is assumed that the population of the City will continue to grow to reach approximately 50,900 persons in the twenty-year time horizon to 2036.

United Counties of Stormont, Dundas and Glengarry

The County is expected to grow by 2,300 residents over the twenty-year planning period to a 2036 Census population of 67,400 residents. The housing unit forecast is for 28,900 occupied units in 2036, representing an increase of 2,300 units over the next twenty years. Employment is expected to decline overall between 2016 and 2036 by 2,400 jobs, to a 2036 total employment of 18,000.

The forecasts assume that housing growth will outpace population growth due to continued aging of the population. An aging population comprises more widows and empty nesters; over time average household size declines, both in the existing base and in new units. As a result, more housing units will be required to house fewer residents overall. An aging population also results in a smaller labour force, a factor in the declining employment forecast.

United Counties of Prescott and Russell

The United Counties of Prescott and Russell have experienced tremendous growth over the last three decades. The County's population, housing unit and employment growth forecasts are based on a 2012 report which provides information on population, housing unit and employment growth and associated land needs within the 20-year 2011 to 2031 and 24-year 2011 to 2035 planning horizon. It is anticipated that migration from the City of Ottawa will continue to be a key driver of growth both in terms of the overall amount and its distribution within the County. The total population of the County is forecast to grow by 27,126 to approximately 115,720 by 2035.

2.5 Interactions between Physical and Human Geography

The Source Protection Region consists mainly of private land at approximately 95% of the total land area. The City of Cornwall accounts for approximately half the population of the Raisin Region Source Protection Area. It is the largest urban area, followed by the Town of Alexandria, accounting for approximately one eighth of the population. The remaining population is mostly rural settlement. Outside of the urban areas, similar to the South Nation Source Protection Area, the economy is rural based with agriculture being the main rural land use.

Urban municipalities within the Source Protection Region rely on a combination of municipal surface water and groundwater for drinking water. The majority of the Source Protection Region's rural population relies on private wells to supply their drinking water.

2.6 Drinking Water Systems

The Safe Drinking Water Act, 2002; through O. Reg. 170/03 defines eight classifications of drinking water systems:

1. Large municipal residential system (LMRS)
2. Small municipal residential system (SMRS)
3. Large municipal non-residential system (LMNRS)
4. Small municipal non-residential system (SMNRS)
5. Non-municipal year-round residential system (NMYRRS)
6. Non-municipal seasonal residential system (NMSRS)
7. Large non-municipal non-residential system (LNMNRS)
8. Small non-municipal non-residential system (SNMNRS)

In addition, O. Reg. 417/09 (amending O. Reg. 243/07) includes schools, private schools and day nurseries. Drinking water systems within the Raisin Region Source Protection Area which have been classified through the Safe Drinking Water Act are shown on *Map 2.16* and cross-referenced in *Table 0.15*. System capacity, average taking rate and population served are listed where known.

Table 0.15: Drinking Water Systems, Raisin Region Source Protection Area

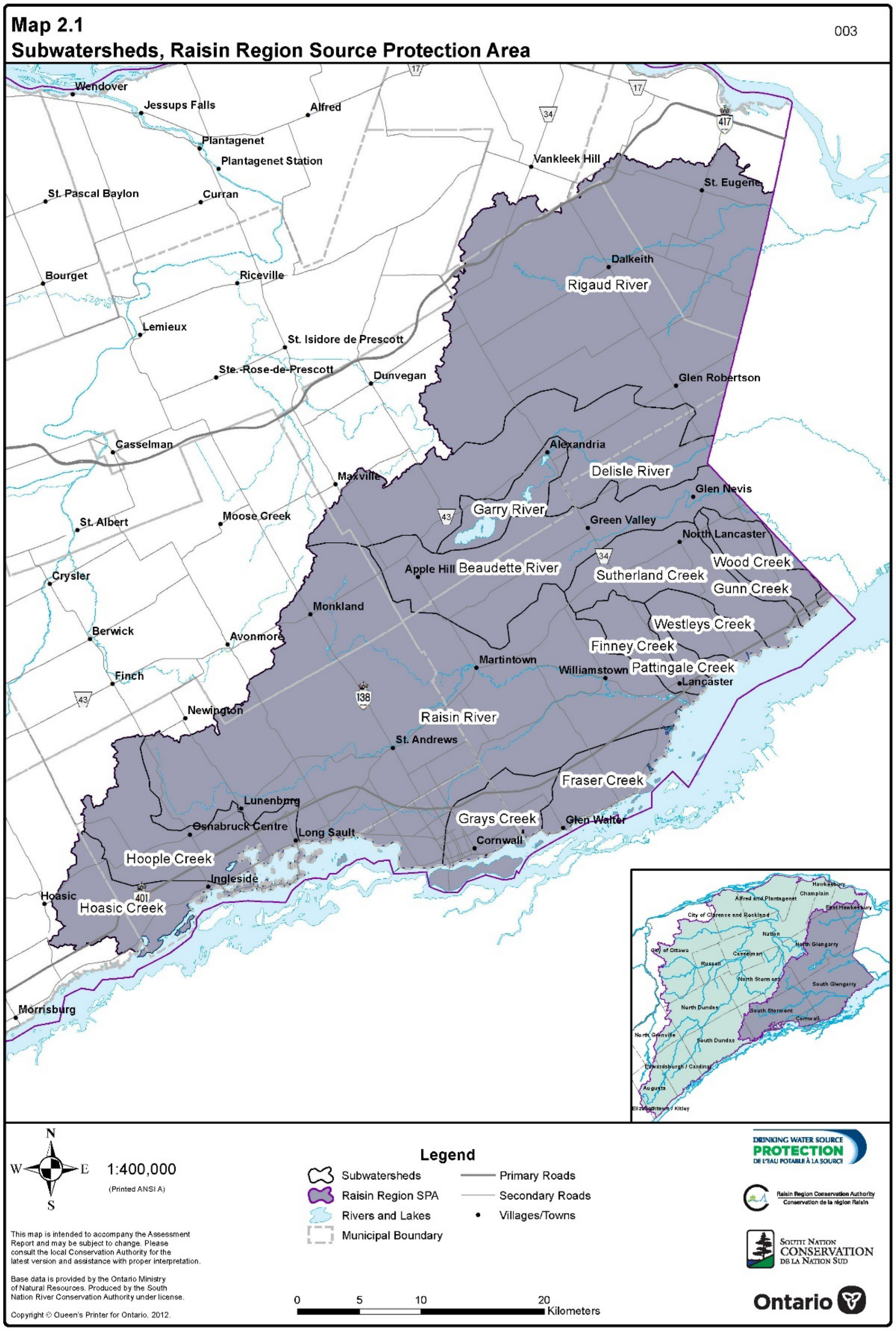
Map Id	Dwis Number	Drinking Water System	Classification	Capacity (M^3/Day)	Average Taking (M^3/Day)	Population Served	Residences Served	Source
R1	260074581	Markell Mobile Homes	Nmyrrs			70	26	Gw
R2	260012935	Elma Ps	School	Closed June 26, 2009				Gw
R3	260066417	Long Sault Water Treatment Plant	Lmrs	12,800	5,320	3500		Sw
R4	220001049	Cornwall Water Treatment Plant	Lmrs	100,000	35,000	47,000	16500	Sw
R5	260060814	Freehousemontessori school	Day Nursery	End Dated January, 2008				Gw
R6	210001861	Glen Walter Water Treatment Plant	Lmrs	995	360	675		Sw
R7	260075413	Senior Country Living	Snmnrs			30		Gw
R8	260038766	Milles Roches	Snmnrs	End Dated January 2011				Gw
R9	260012896	Child And Family Treatment Centre	Snmnrs	End Dated Nov 25,2008				
R10	260046241	Immaculate Conception Apostolic School	Snmnrs	130	< 5		12	Sw[2]
R11	260022893	Children First Group Home	Snmnrs	Closed				
R12	260001250	St. Andrews/Rosedale Terrace [1]	Lmrs	900		1,850		Sw[1]
R13	260042211	Campkagama	Snmnrs				7	Gw
R14	260074659	Menard's Mobile Home Centre	Nmyrrs	End Dated August 1,2008				Gw
R15	260006867	Lancaster Water Treatment Plant	Lmrs	1,440	313	1,032		Sw
R16	260012883	Charlottenburg Andlancasterhigh School	School					Gw
R17	260013416	Williamstown Ps	School					Gw
R18	260013091	Martintown Ps	School	26		144		Gw
R19	220008943	Creg Quay	Nmyrrs	490	95	182	96	Gw
R20	250002311	Redwood Estates	Smrs	450	12	150		Gw
R21	260013325	S J Mcleod Ps	School					Gw
R22	260014911	Ecole Elementaire Catholique L'ange Gardien	School					Gw
R23	260078013	4459 County Road 34	Nmyrrs			16	7	Gw
R24	260008232	Green Valley Residence	Snmnrs					Gw
R25	260014833	La Source, E. Sep.	School					Gw

Map Id	Dwis Number	Drinking Water System	Classification	Capacity (M^3/Day)	Average Taking (M^3/Day)	Population Served	Residences Served	Source
R26	220001030	Alexandria Water Treatment Plant	Lmrs	8,000	3,400	3,500		Sw
R27	260048425	Glengarry Memorial Hospital[3]	Snmnrs					Sw[3]
R28	250002233	Club Naturist Richard Brunet	Nmyrrs			100		Gw
R29	260076076	Maxville Fire Department	Smnrs					Gw
R30	220008408	Glen Robertson	Smrs	225	40	100		Gw
R31	260024622	Glen Robertson Residence	Snmnrs					Gw
R32	260014807	Cure-Labrosse, E	School	69.12				Gw
R33	260014430	Ionaacademy	School			250		Gw
R34	260048867	Cameron's Point Campsite	Nmsrs					Gw
R35	260001591	Osnabruckcenter[4]	Smnrs	56	5		7	Sw[4]

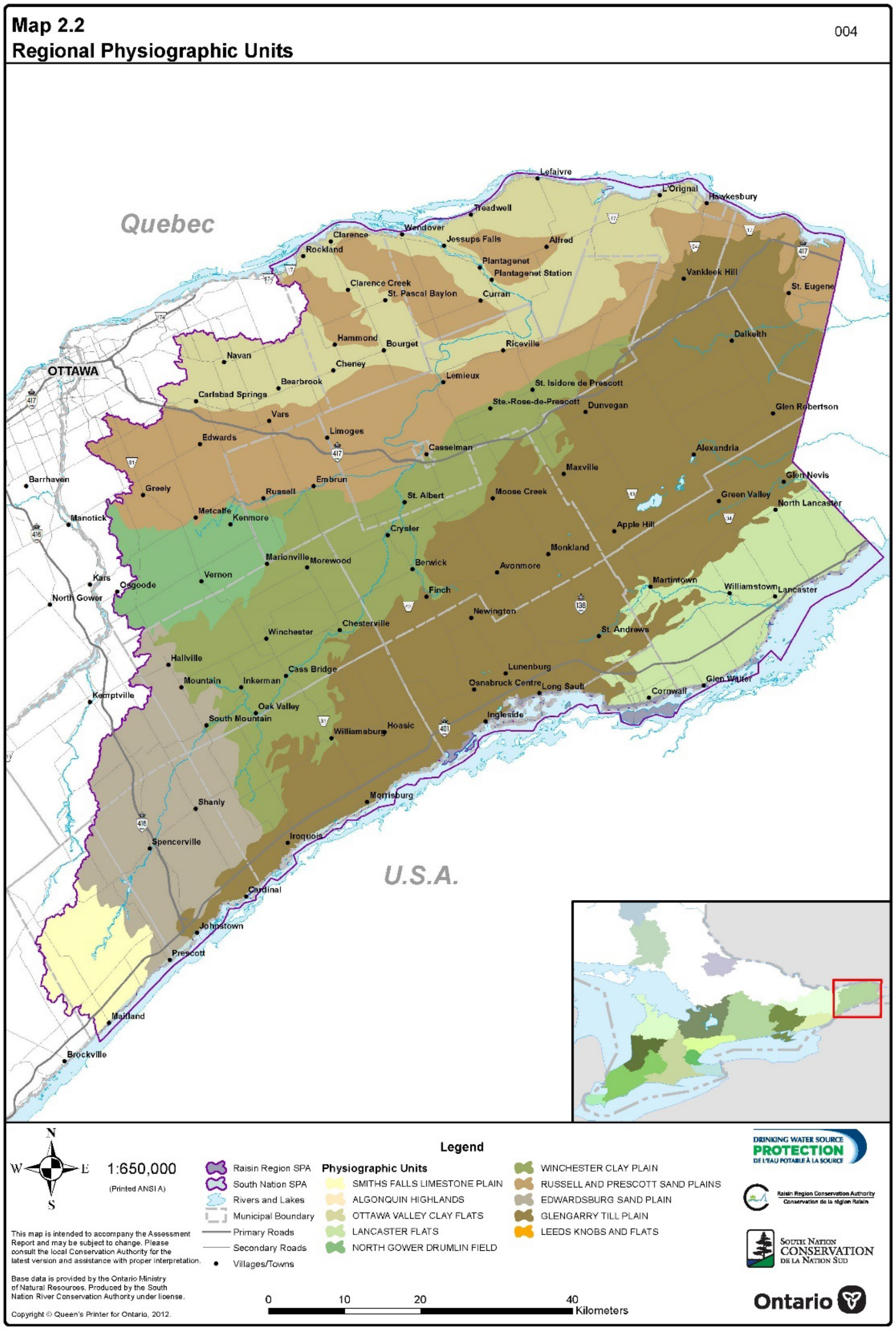
Note: This List Is Based On Active Dwis Identifiers, As Provided By Ministry Of Environment In 2008. Some Facilities (E.G., Schools) May Since Have Closed. It Is The Facility Owner's Responsibility To Contact The Ministry To Delist Any Inactive Drinking Water System.

1) St. Andrews / Rosedale Is A Distribution System Only, And Receives Treated Water From Cornwall Treatment Plant
2) Immaculate Conception School's Water Supply Is Via A Dug "Shore-Well" Where The Source Is The St. Lawrence River
3) Glengarry Hospital The Source Is The Alexandria Wtp
4) Osnabruck Center Water Supply Is Long Sault Wtp Connected To South Stormont

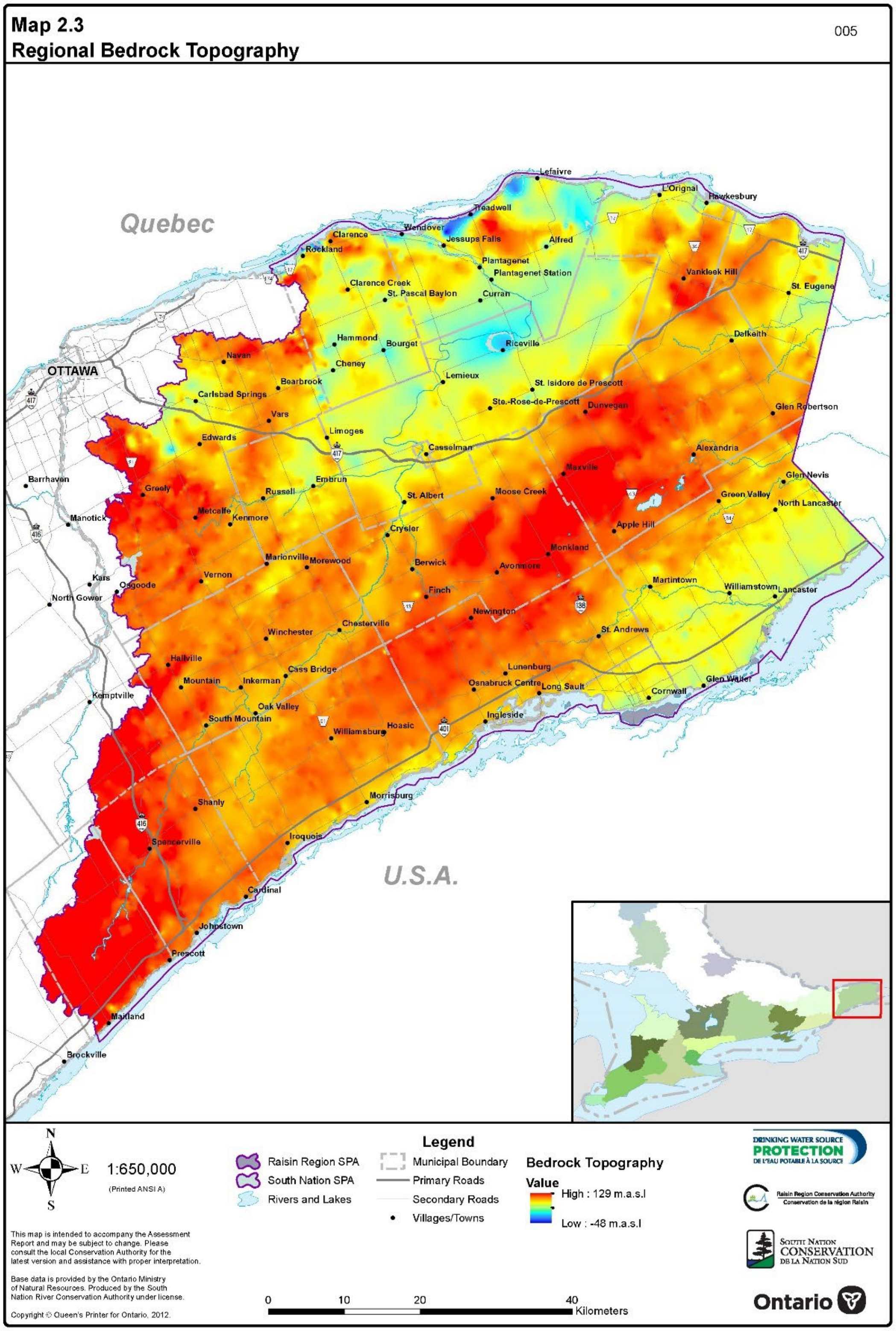
Map 2.1: Subwatersheds, Raisin Region Source Protection Area



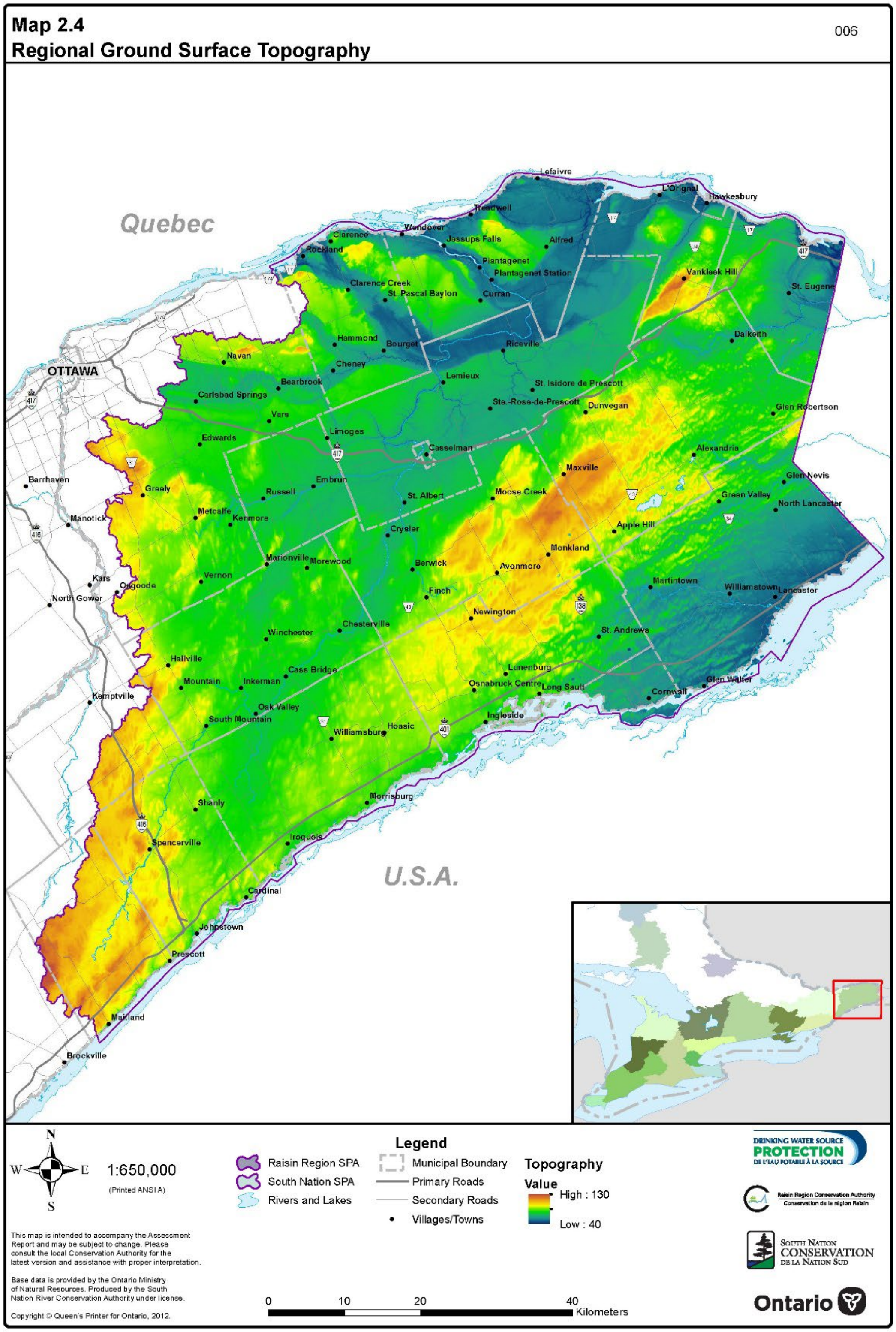
Map 2.2: Physiographic Units of the Source Protection Region



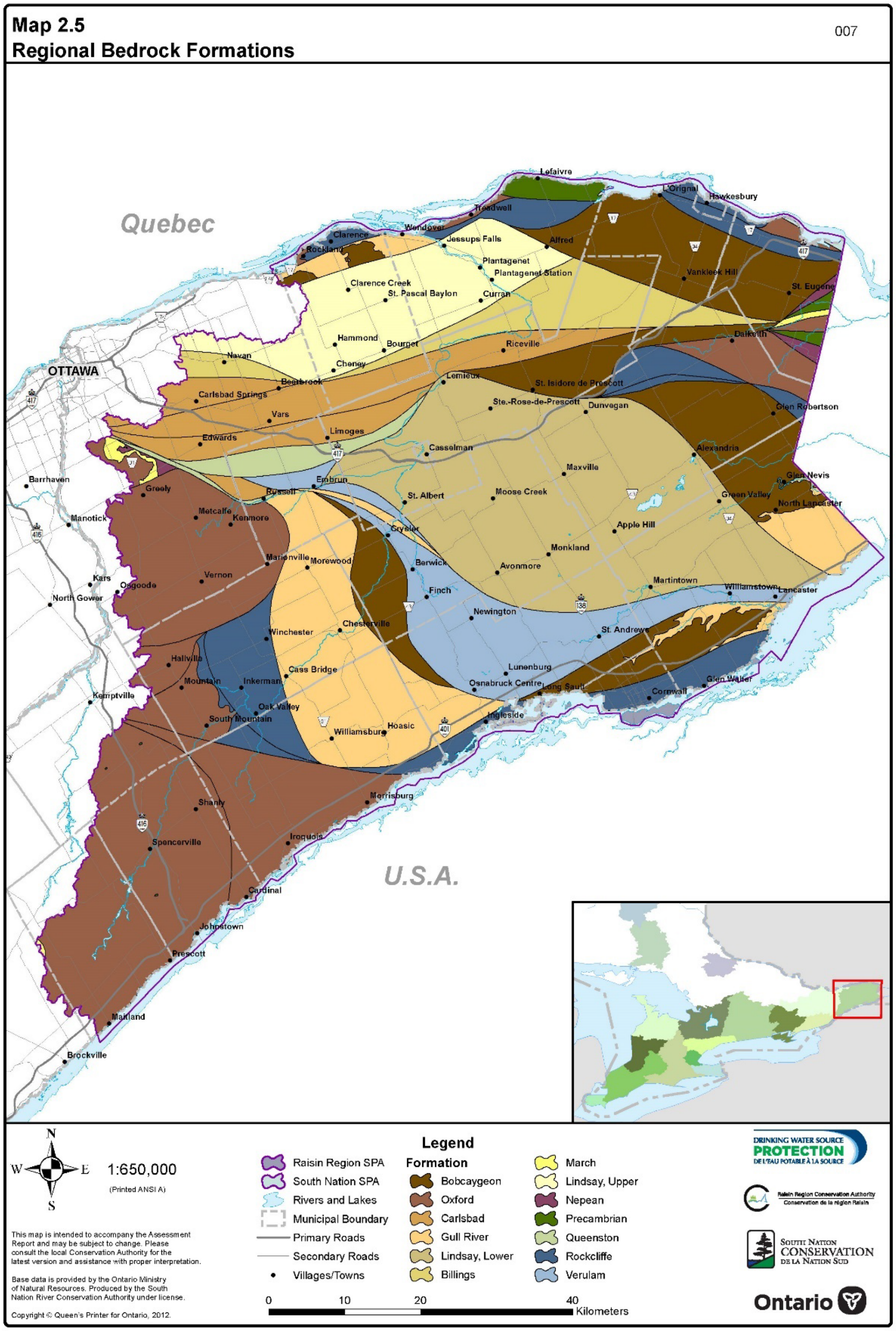
Map 2.3: Bedrock Topography of the Source Protection Region



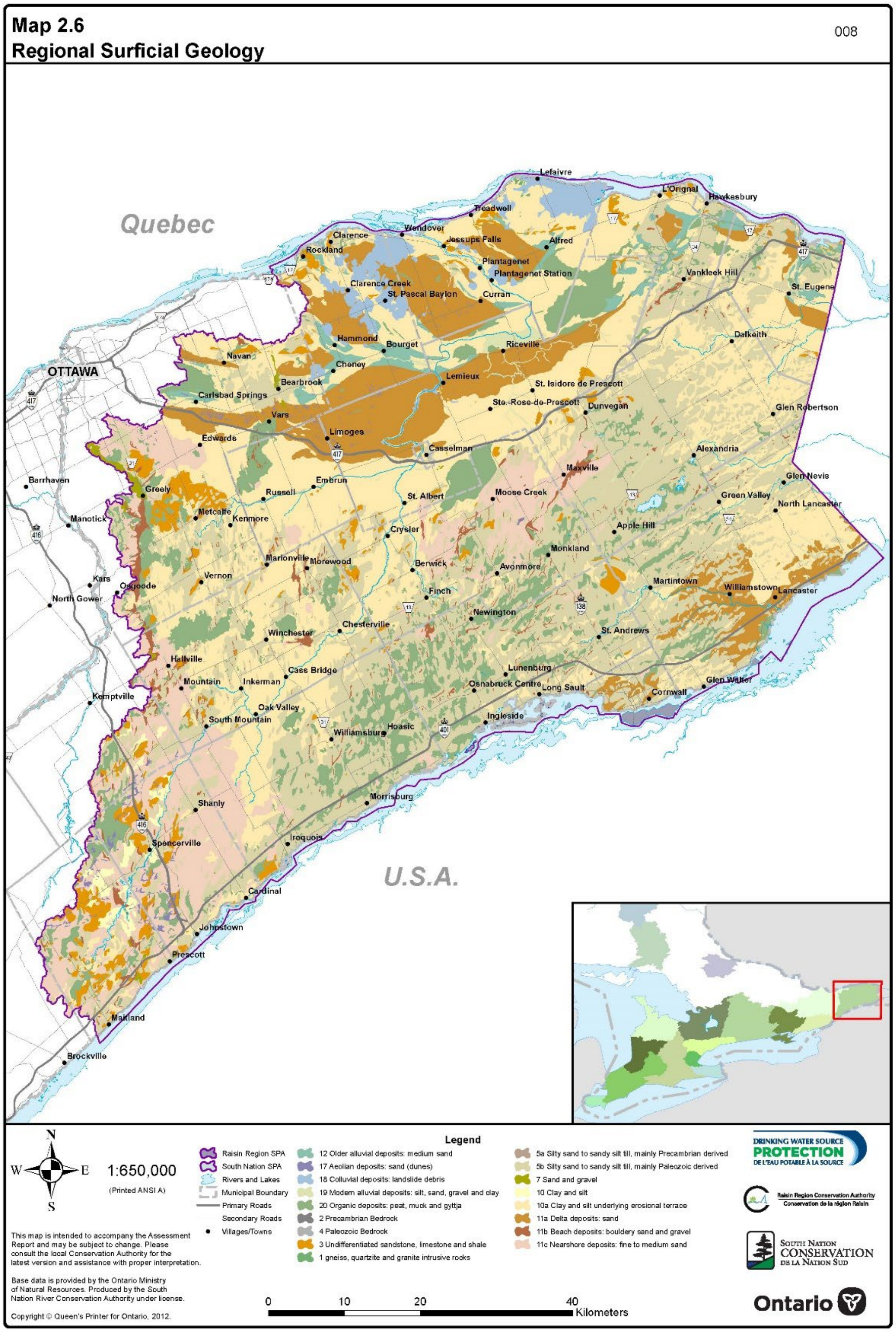
Map 2.4: Ground Surface Topography of the Source Protection Region



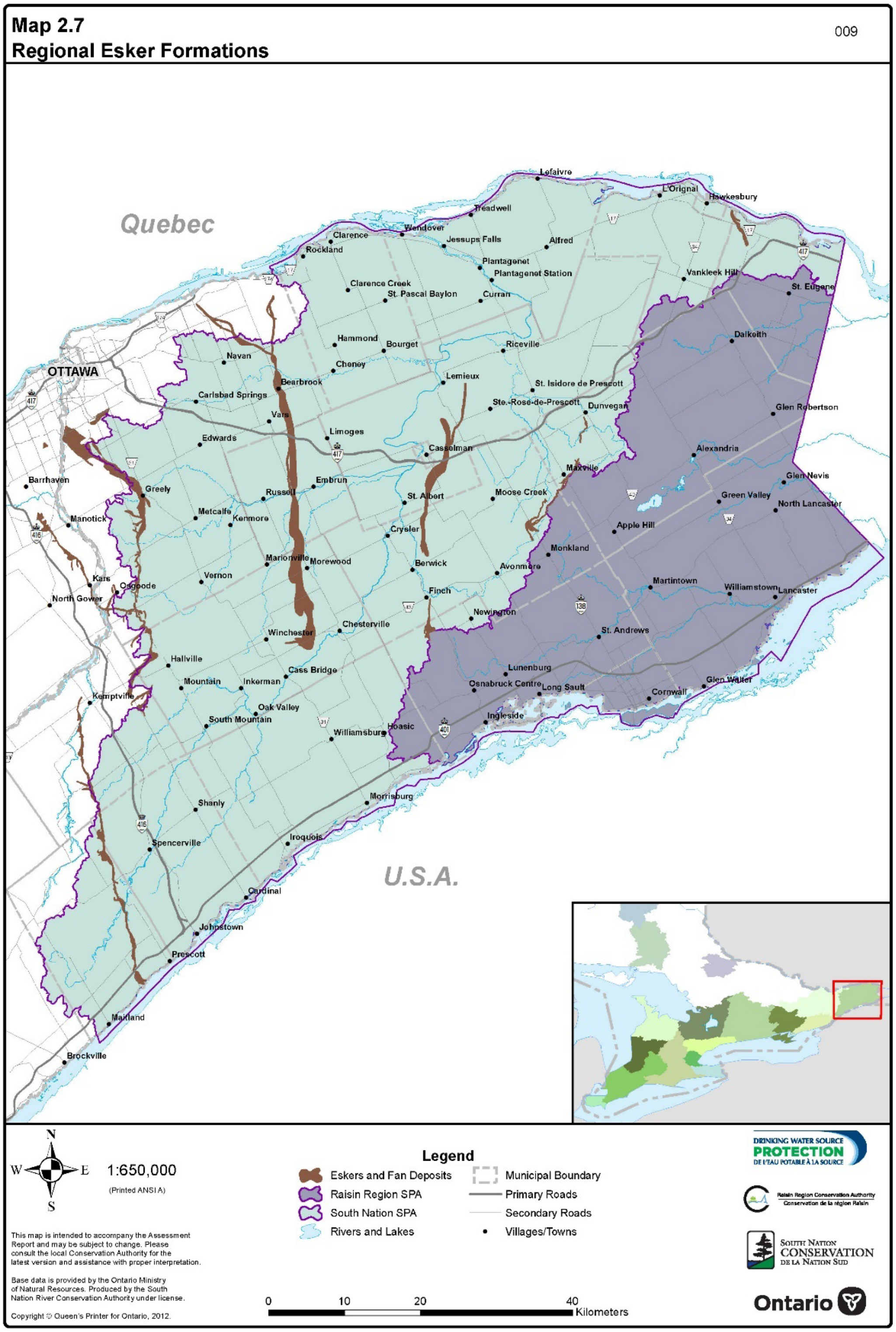
Map 2.5: Bedrock Formations of the Source Protection Region



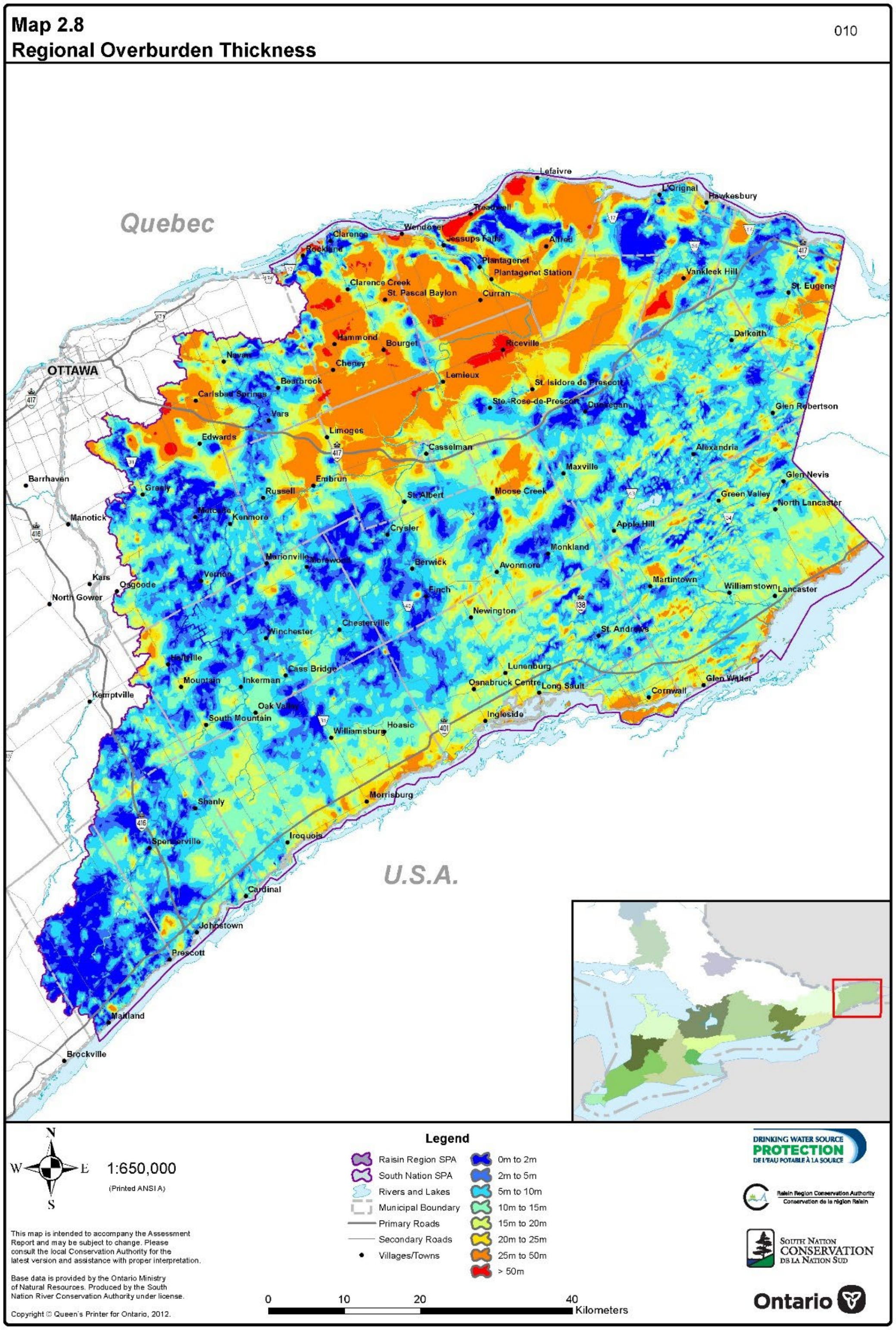
Map 2.6: Surficial Geology of the Source Protection Region



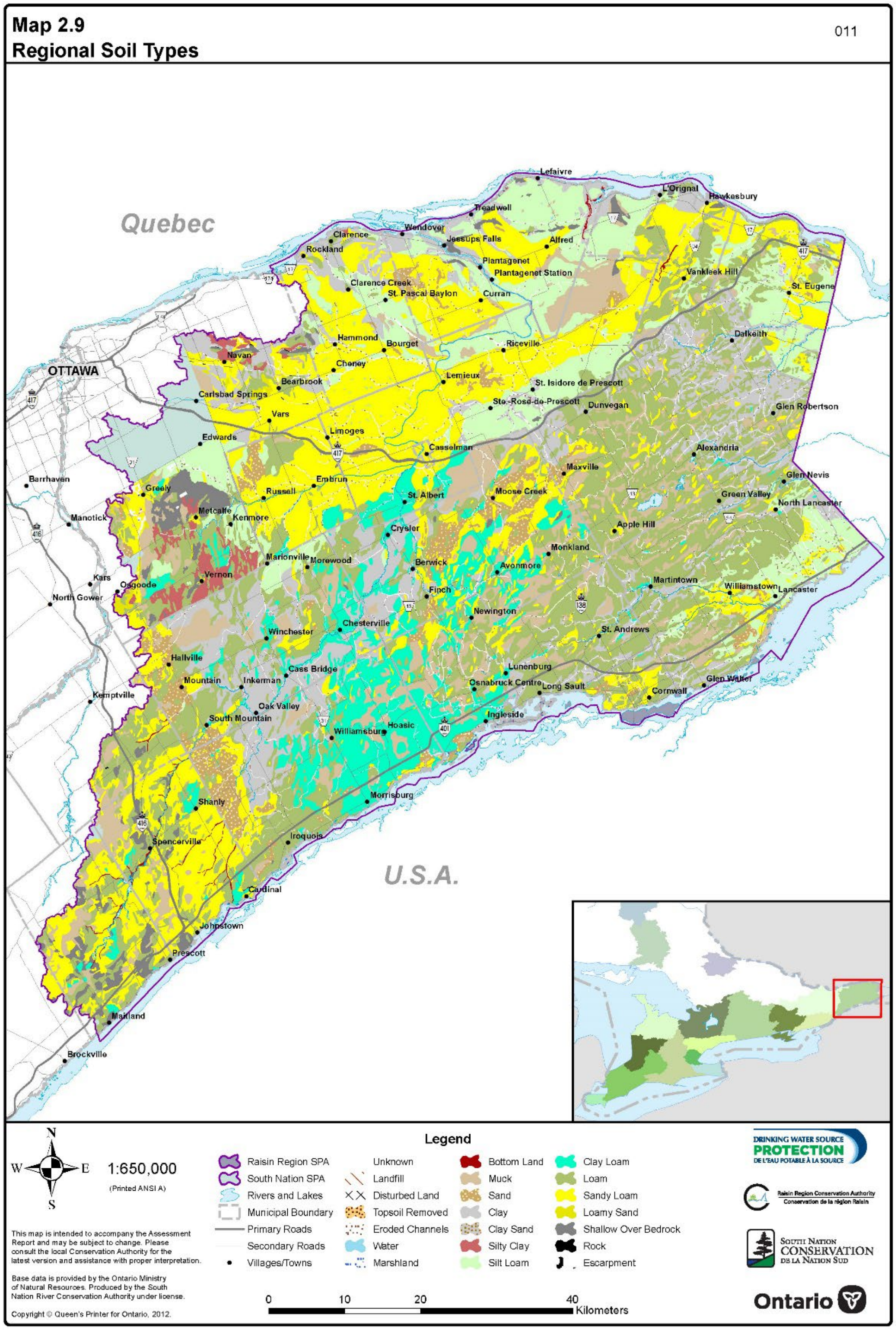
Map 2.7: Esker Formations in the Source Protection Region



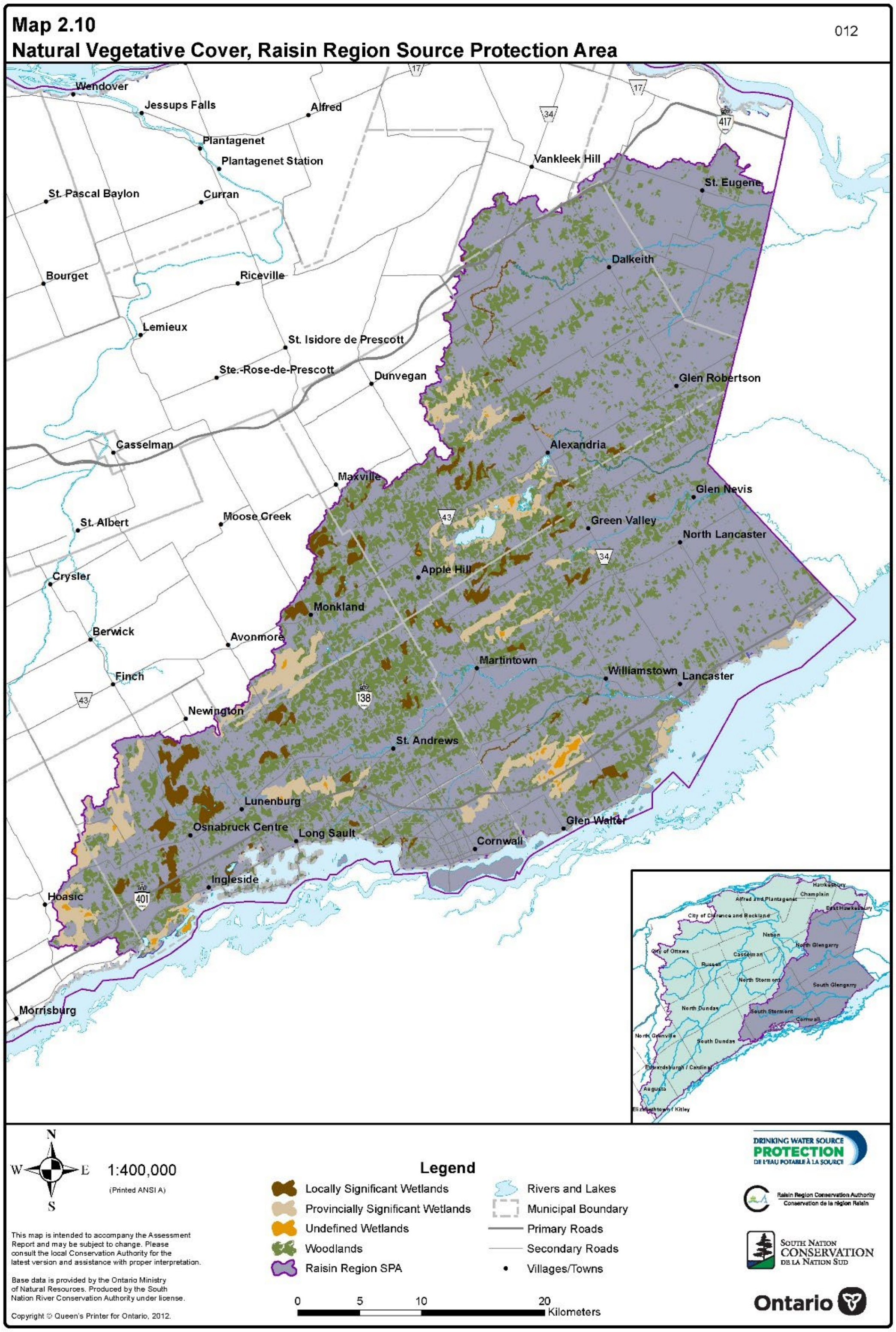
Map 2.8: Overburden Thickness of the Source Protection Region



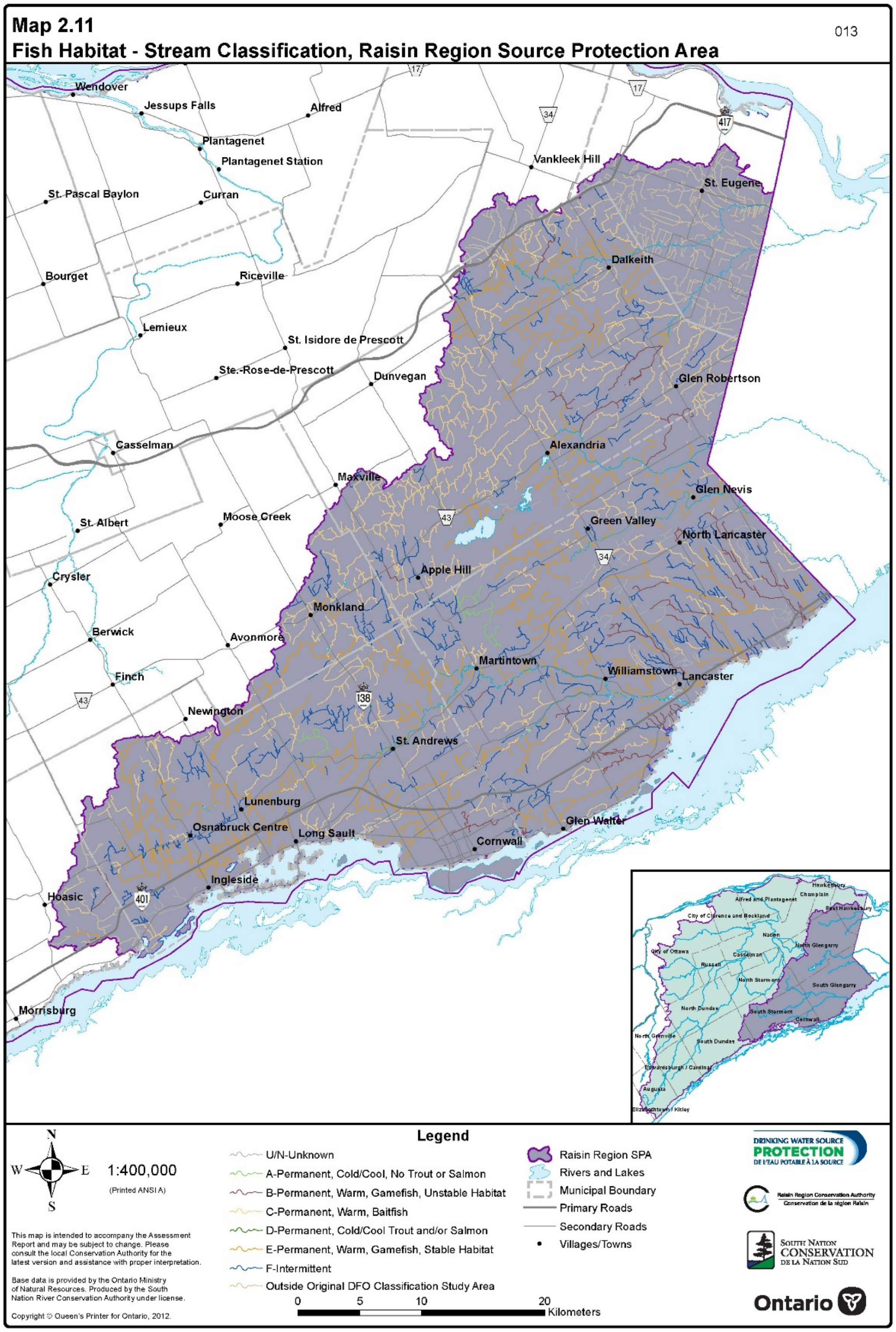
Map 2.9: Soil Types of the Source Protection Region



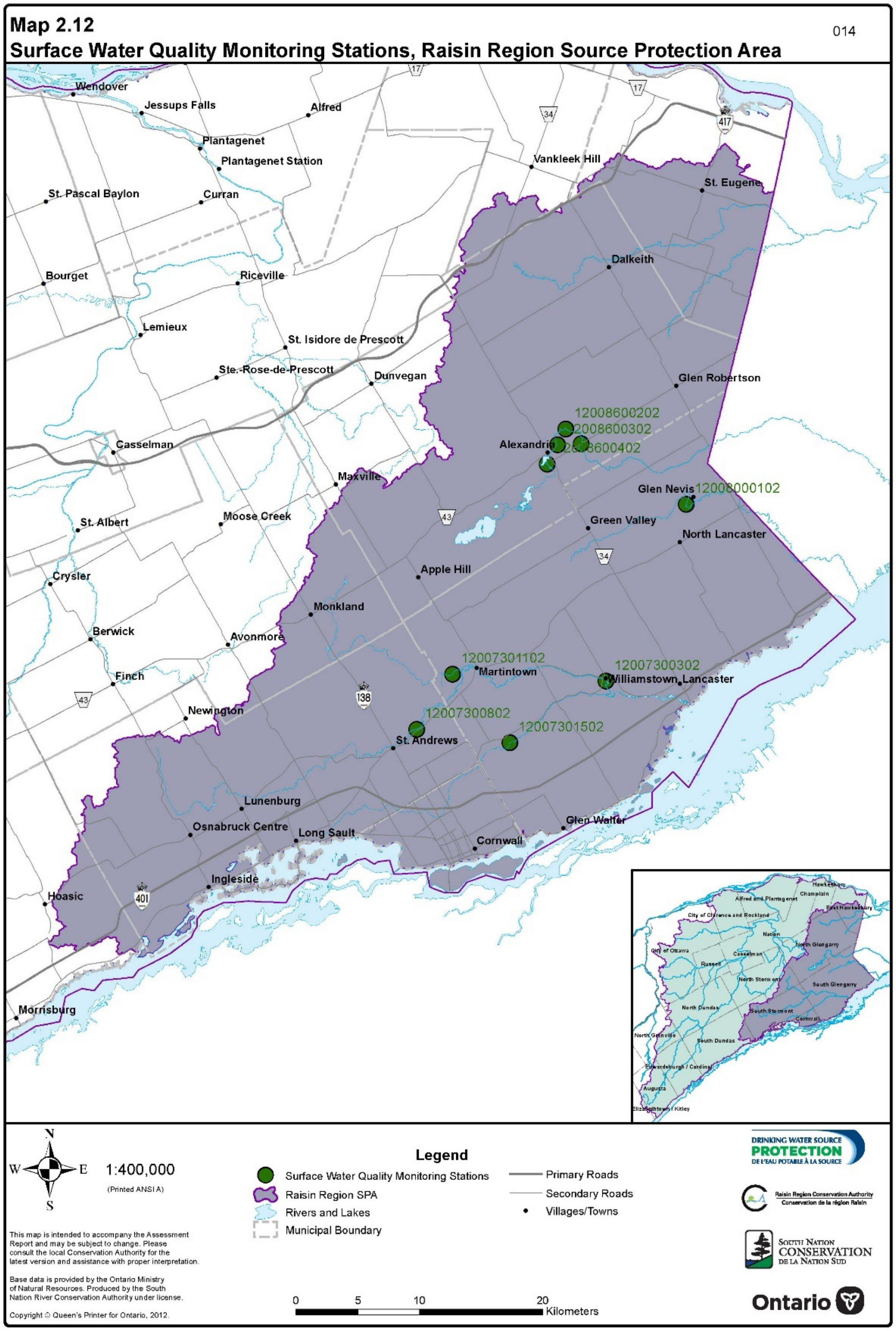
Map 2.10: Natural Vegetative Cover, Raisin Region Source Protection Area



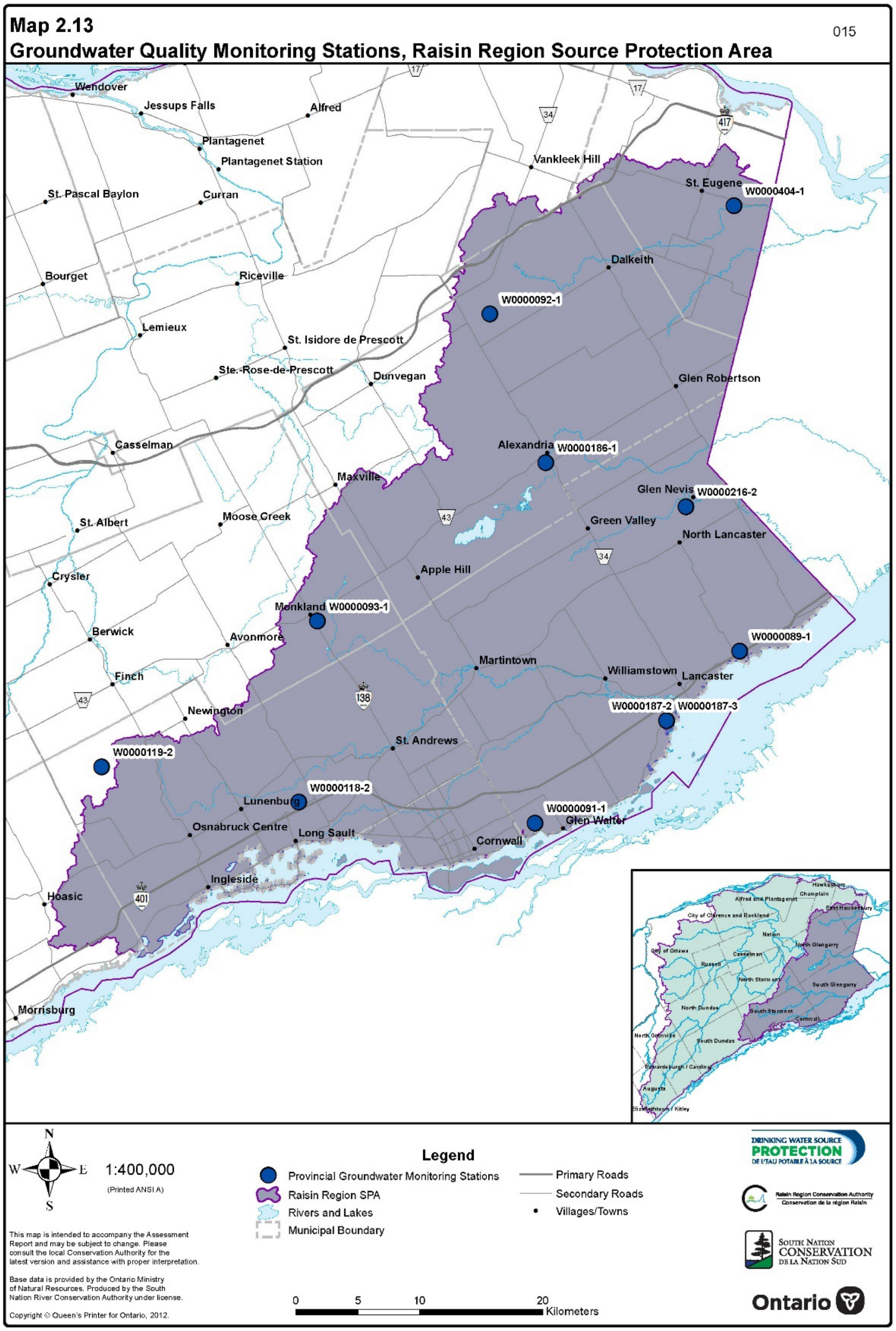
Map 2.11: Fish Habitat – Stream Classification, Raisin Region Source Protection Area



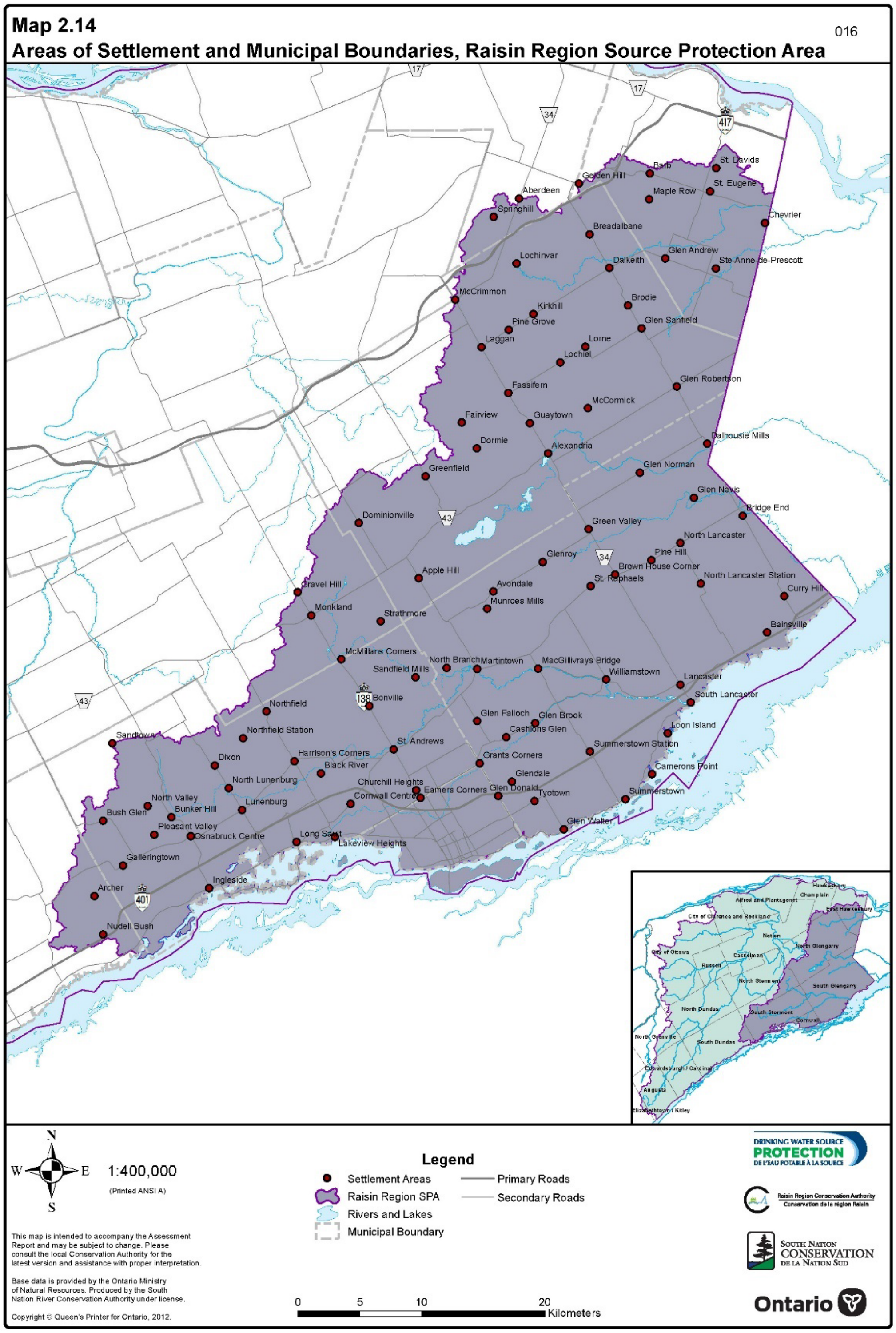
Map 2.12: Surface Water Quality Monitoring Stations, Raisin Region Source Protection Area



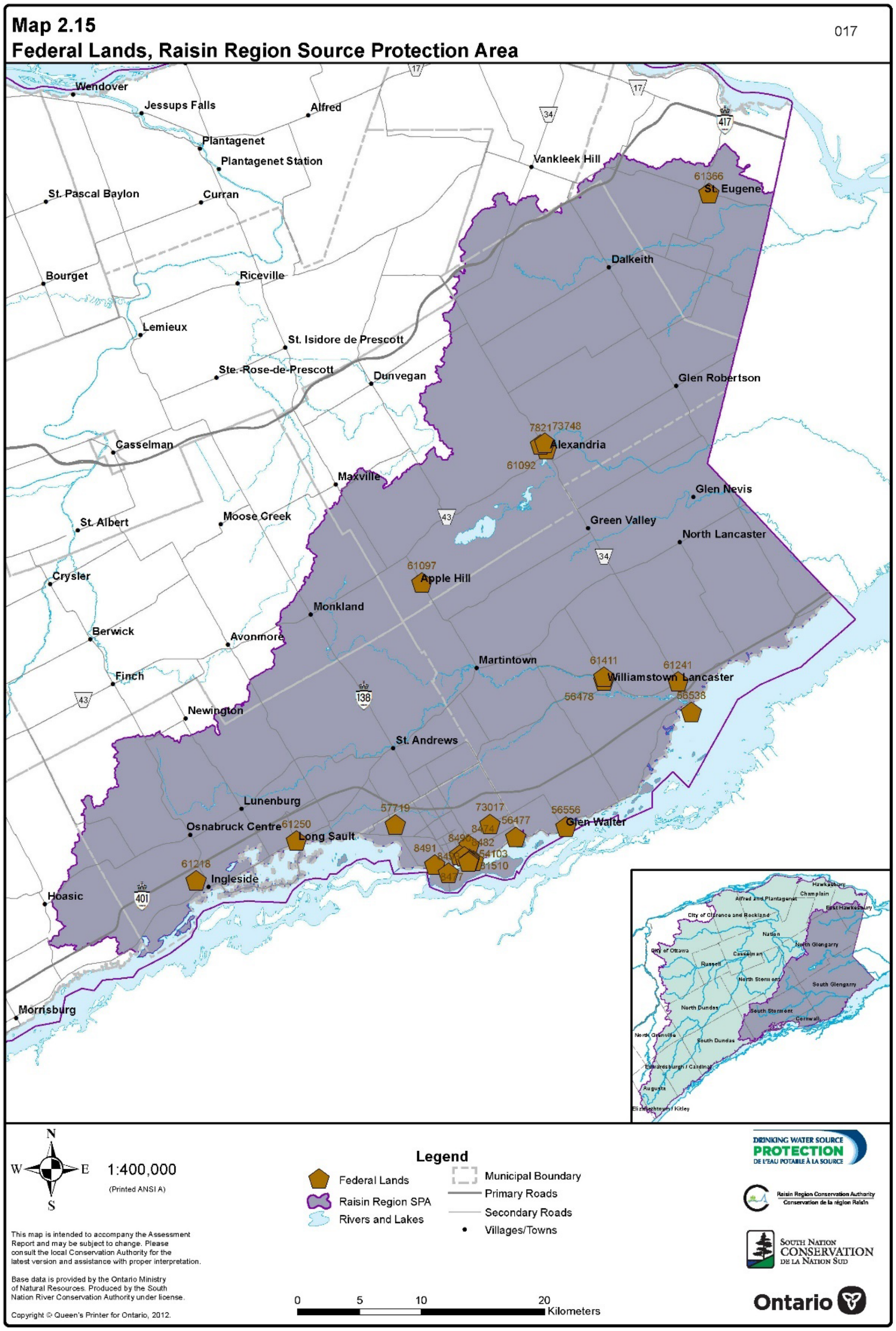
Map 2.13: Groundwater Quality Monitoring Stations, Raisin Region Source Protection Area



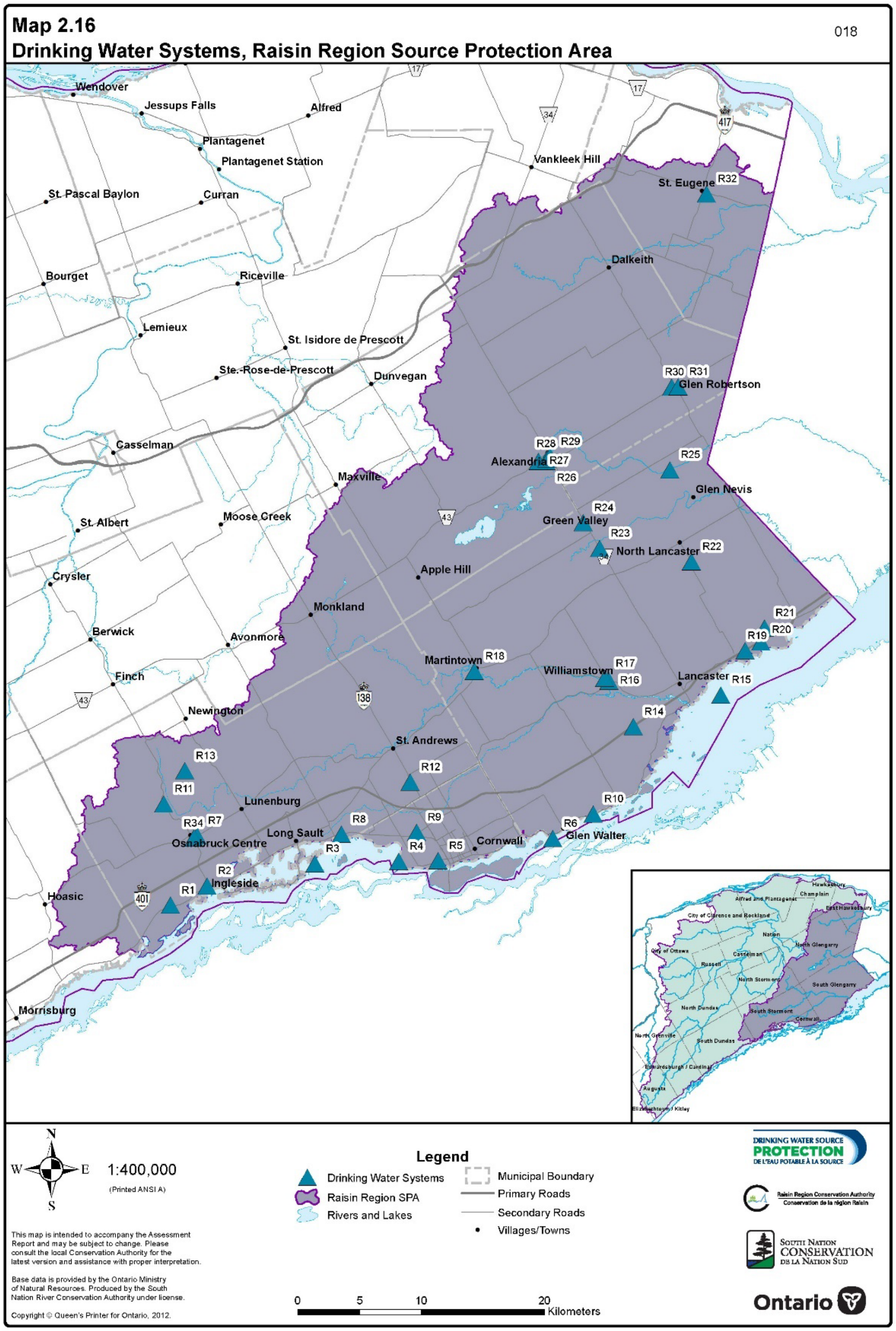
Map 2.14: Areas of Settlement and Municipal Boundaries, Raisin Region Source Protection Area



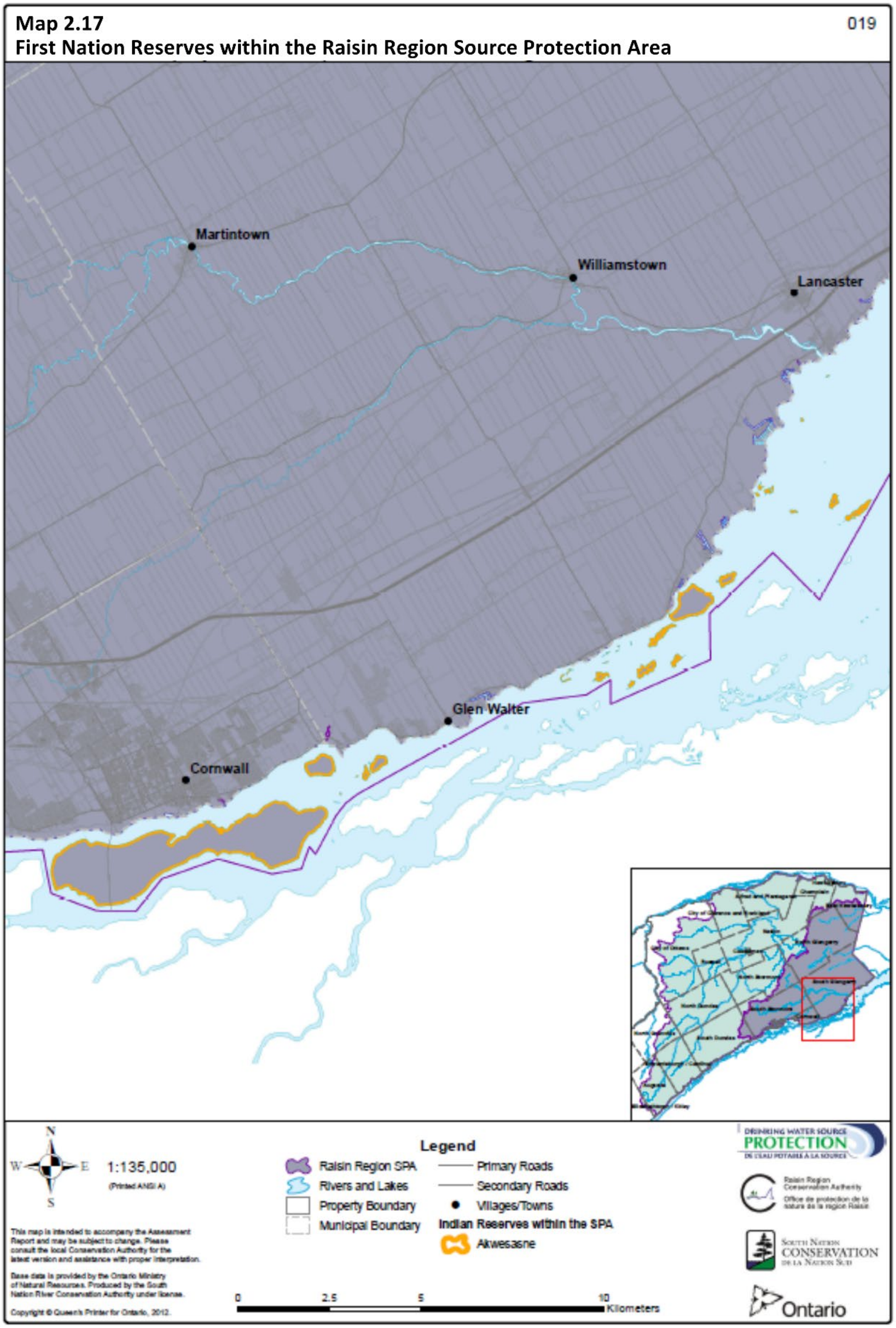
Map 2.15: Federal Lands, Raisin Region Source Protection Area



Map 2.16: Drinking Water Systems, Raisin Region Source Protection Area



Map 2.17: First Nation Reserves within the Raisin Region Source Protection Area



3 Water Quantity Threats Assessment

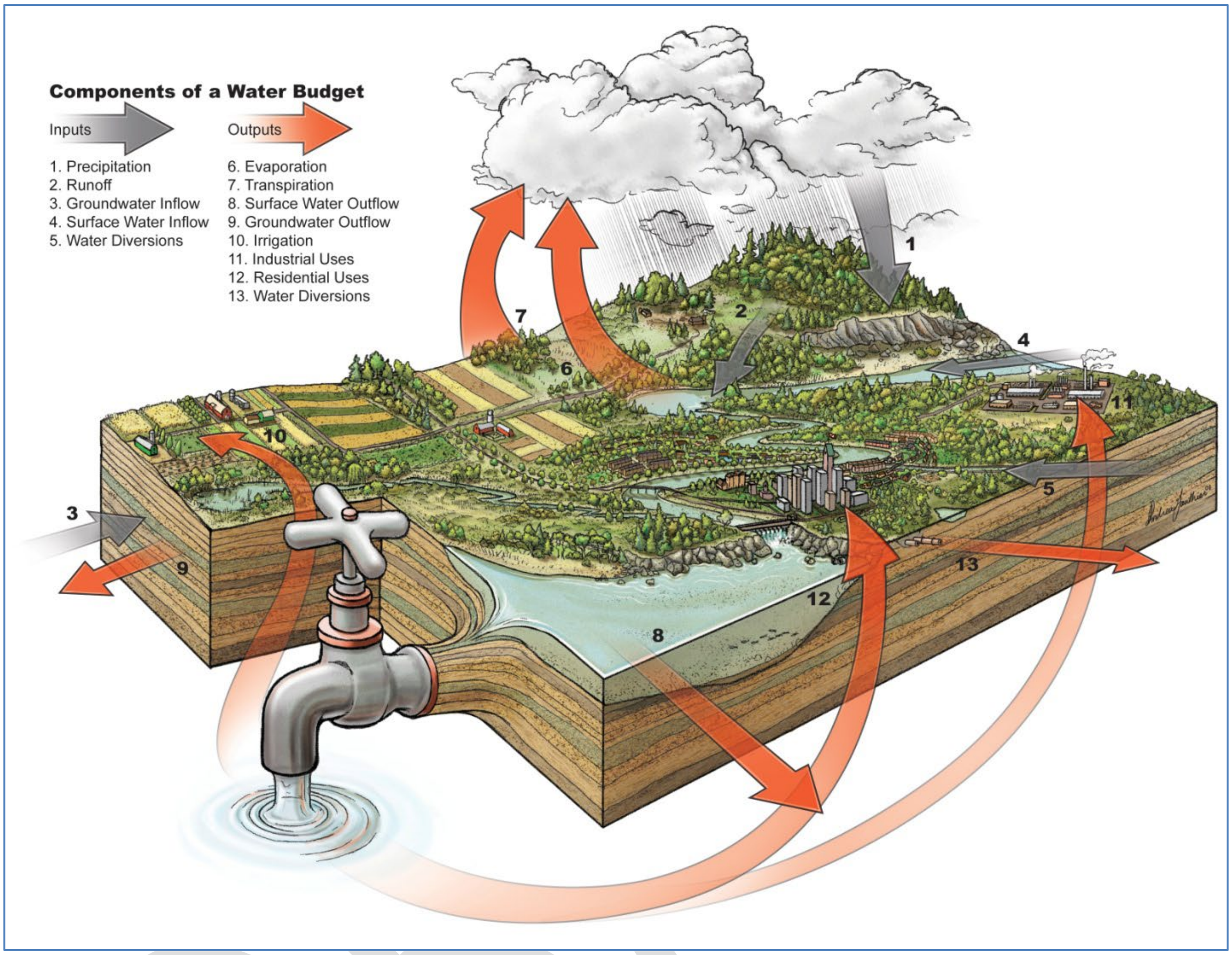
Ontario Regulation (O. Reg.) 287/07 (General) lists 2 activities that are prescribed as drinking water threats (PDWTs) with respect to water quantity:

1. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.
2. An activity that reduces the recharge of an aquifer.

The evaluation of Significant or Moderate water quantity threats requires an assessment of subwatershed stress. A water quantity stress assessment relates the water demand to the available water and the amount of water kept in reserve. Such an assessment requires an understanding of how water enters and leaves the subwatershed, and a comprehensive accounting of quantities: a water budget.

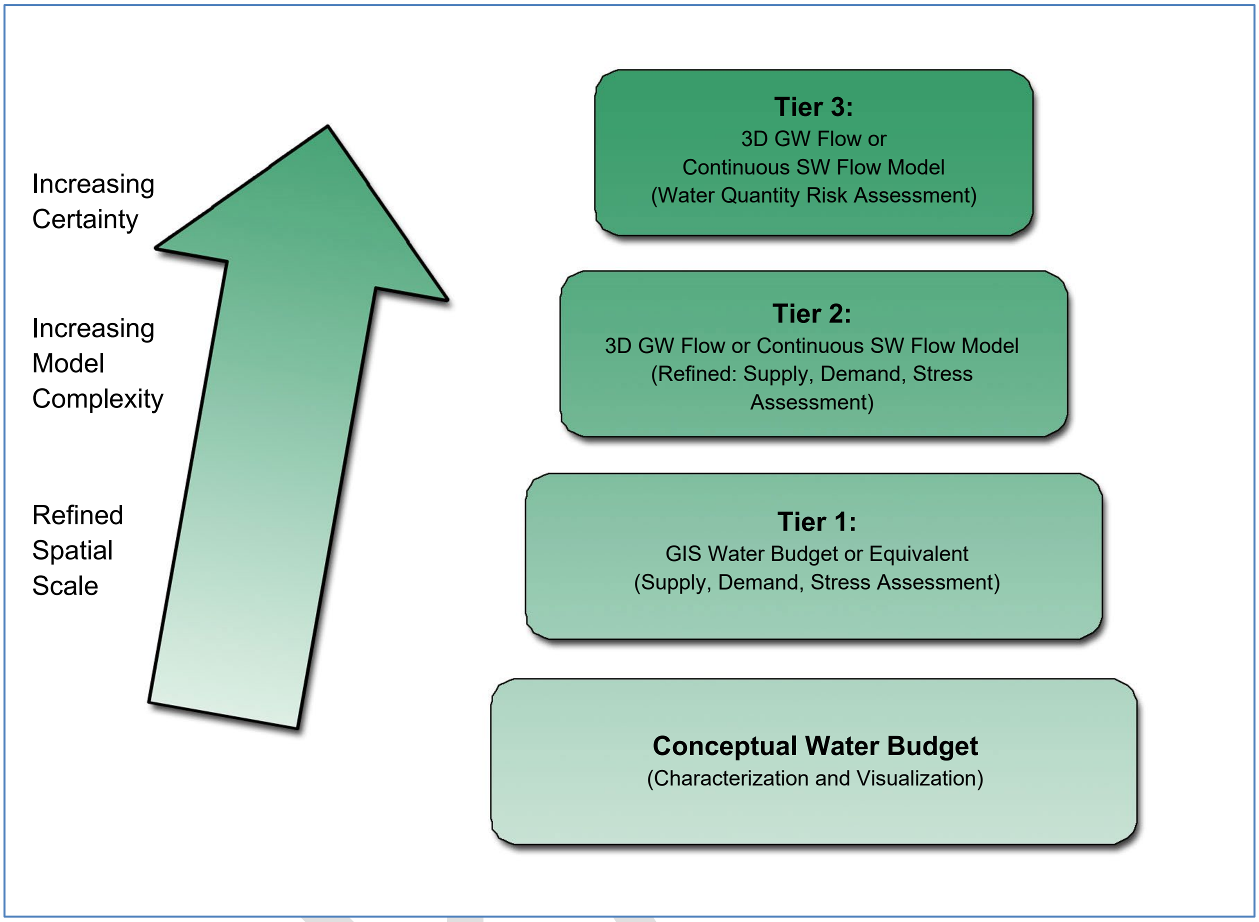
A water budget looks at how much water enters a watershed; how much water is stored and how much water leaves. This information helps determine how much water is available for human uses, while ensuring there is still enough left for natural processes (e.g., there has to be enough water in a watershed to maintain streams, rivers and lakes and to support aquatic life).

Figure 0.8: Components of a Water Budget



The water budget process can include up to four tiers. This process starts out uncomplicated but becomes more complex if there are problems with how much water is available in the area. The higher the level or tier, the more complex the science involved becomes and the area of study narrows. Moving from one tier of a water budget to another makes sure that those involved in Source Protection Planning can know more specifically the amount of stress a water supply is under. They then can strategically focus on the complex work required in the areas that really need it. The water budget framework is presented in *Figure 0.9*.

Figure 0.9: Water Budget Framework



3.1 Conceptual Water Budget

The Conceptual Water Budget is an initial overview of the function of the regional flow system (both groundwater and surface water). Four basic questions underpin the conceptual understanding:

1. Where is the water?
2. How does the water move between the various watershed elements (soils, aquifers, lakes, rivers)?
3. What and where are the stresses on surface water and groundwater?
4. What are the trends?

The answers to these questions can be revealed after an understanding of the climate, physiography, geology, climate, land cover, surface water flows, groundwater levels and flows, water takings, and interactions between the groundwater and surface water components.

A comprehensive document, "Water Budget: Conceptual Understanding, 2009", was produced by the Source Protection Region to support this portion of the Assessment Report. The results from this peer-reviewed report are presented herein. Source Protection Area specific results are discussed where appropriate or available.

3.1.1 Climate

Climate is the significant driver of the water budget: the major input being precipitation; the major output being evapotranspiration. The water surplus (precipitation minus evapotranspiration) is then partitioned into runoff and groundwater recharge.

Within an 80km radius of the Source Protection Region's centroid, 25 Environment Canada climate stations were active up to January 1, 2006. Sixteen stations had a sufficient record to compile representative climate normals. The climate stations are shown on *Map 3.1*.

3.1.1.1 Precipitation

Spatial GIS rasters have been produced by the Canadian Forestry Service of Natural Resources Canada using recorded weather station data and computer model interpolation techniques. Average normal regional precipitation and temperature values are listed in *Table 0.16* and shown in *Figure 0.10* and *Figure 0.11*.Average annual precipitation for the Raisin Region Source Protection Area was determined to be 978mm/year (with 8mm standard deviation).

Table 0.16: Average Normal Monthly Precipitation and Daily Temperature of the Source Protection Region

Month	Precipitation (mm)	Avg. Daily Temperature (°C)
January	73 (± 1.6)	-10 (± 1.3)
February	60 (± 1.9)	-8 (± 0.8)
March	70 (± 2.6)	-2 (± 0.6)
April	76 (± 2.3)	5 (± 0.5)
May	79 (± 2.6)	13 (± 0.5)
June	87 (± 5.9)	17 (± 0.4)
July	90 (± 2.4)	20 (± 0.8)
August	94 (± 6.3)	19 (± 0.5)
September	97 (± 2.3)	14 (± 0.5)
October	82 (± 4.6)	7 (± 0.5)
November	84 (± 3.9)	1 (± 0.8)
December	82 (± 2.5)	-6 (± 1.1)

Figure 0.10: Average Normal Monthly Precipitation of the Source Protection Region

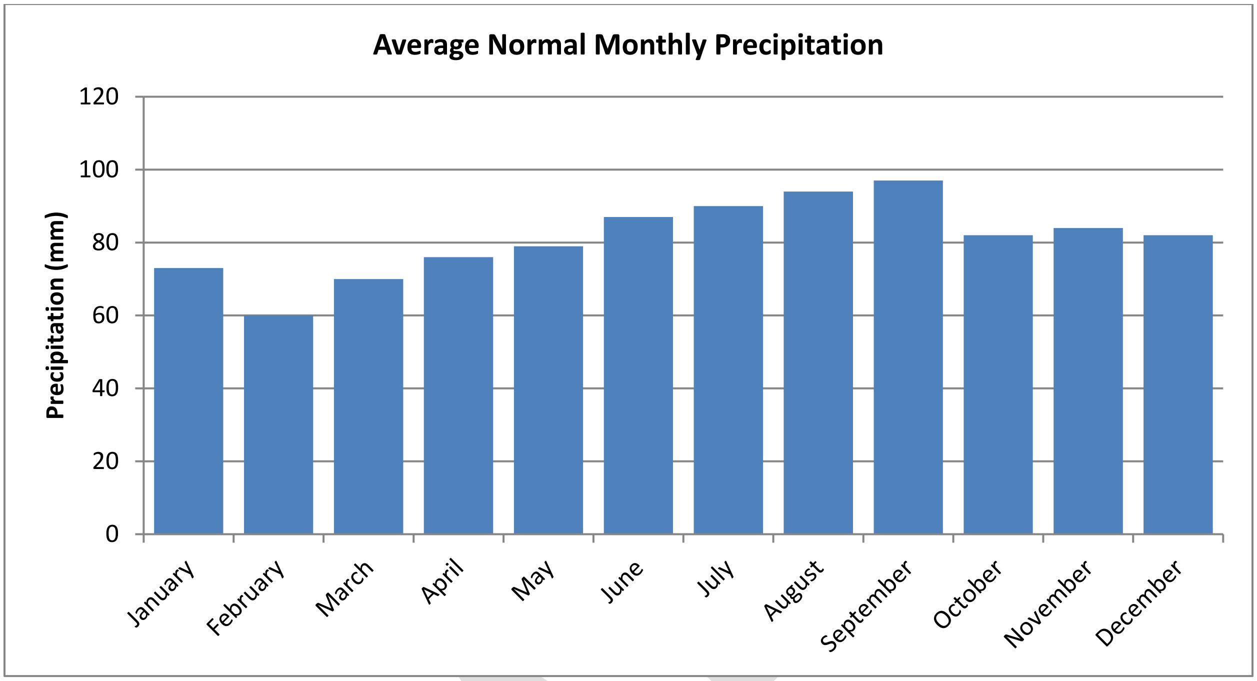
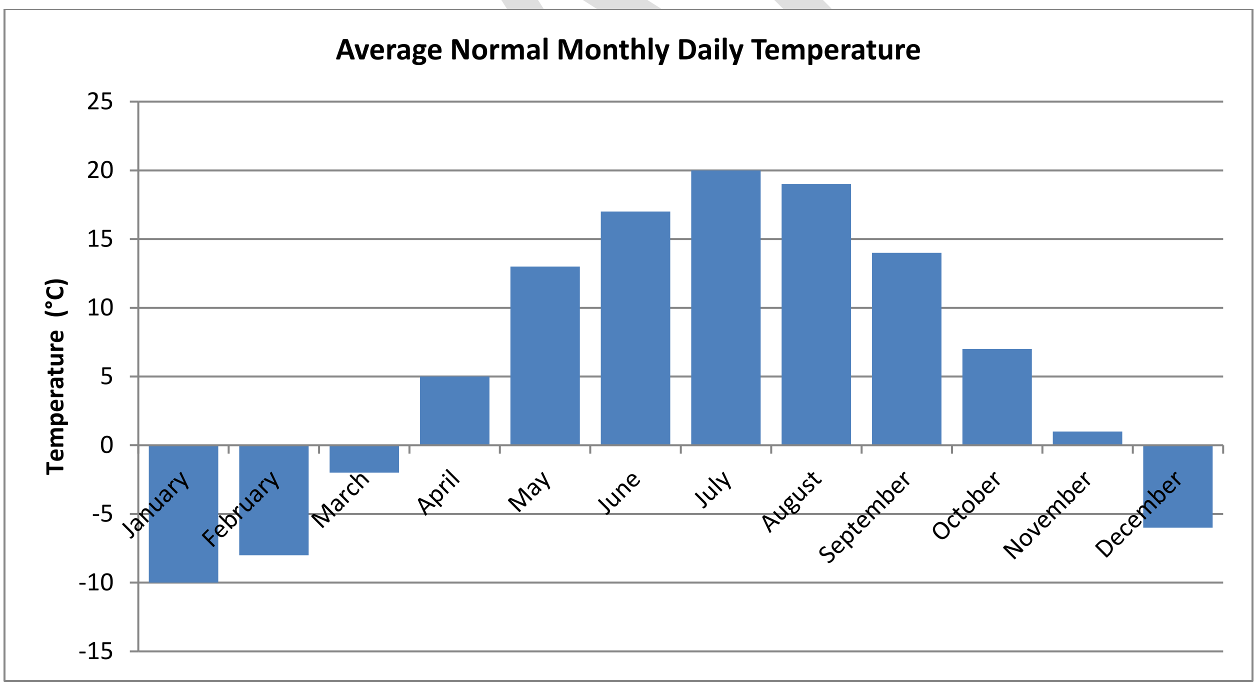


Figure 0.11: Average Normal Monthly Daily Temperature of the Source Protection Region



3.1.1.2 Evapotranspiration

Evapotranspiration is the term used to describe the sum of evaporation (driven by solar energy) and plant transpiration ("sweating" of plants and trees). It is the return of water to the atmosphere through vaporization. Evapotranspiration is the single largest output of the hydrologic cycle. It is inherently difficult to measure; however, for conceptual purposes, it can be empirically estimated through a surrogate such as land cover classes. A list of evapotranspiration rates is shown in *Table 0.17*.

Table 0.17: Land Cover Classes and Corresponding Evapotranspiration Values

Land Cover Classes	Evapotranspiration (mm/year)
Urban	150
Agricultural (coarse textured)	270
Agricultural (unclassed texture)	330
Open/Sparse forest	335
Agricultural (fine textured)	340
Agricultural (medium textured)	390
Forest - conifer	445
Forest - mixed	541
Forest - unclassed	577
Forest - deciduous	638
Water	640

Evapotranspiration is shown regionally in *Map 3.2*. Evapotranspiration for the Raisin Region Source Protection Area is estimated to be 473 mm/year.

3.1.2 Physiography and Geology

A comprehensive characterization of the Physiography and Geology is presented in *Section 2.2* of the *Watershed Characterization* component of this report. Understanding the composition, structure and distribution of rocks and sediments is essential to understanding the media over and through which water moves.

3.1.2.1 Cross Sections

Nineteen cross sections though the Source Protection Region were prepared as part of a technical study (WESA, 2006) to illustrate the various bedrock and overburden features. The locations of these sections are shown in *Figure 0.12* and *Figure 0.13*.

A regional cross section produced by the Geologic Survey of Canada (GSC, 2004) highlighting aquifers (highly permeable) and aquitards (does not easily yield water content) is shown in *Figure 0.14*.

Figure 0.12: Location of Regional and Stream Cross Sections, Source Protection Region

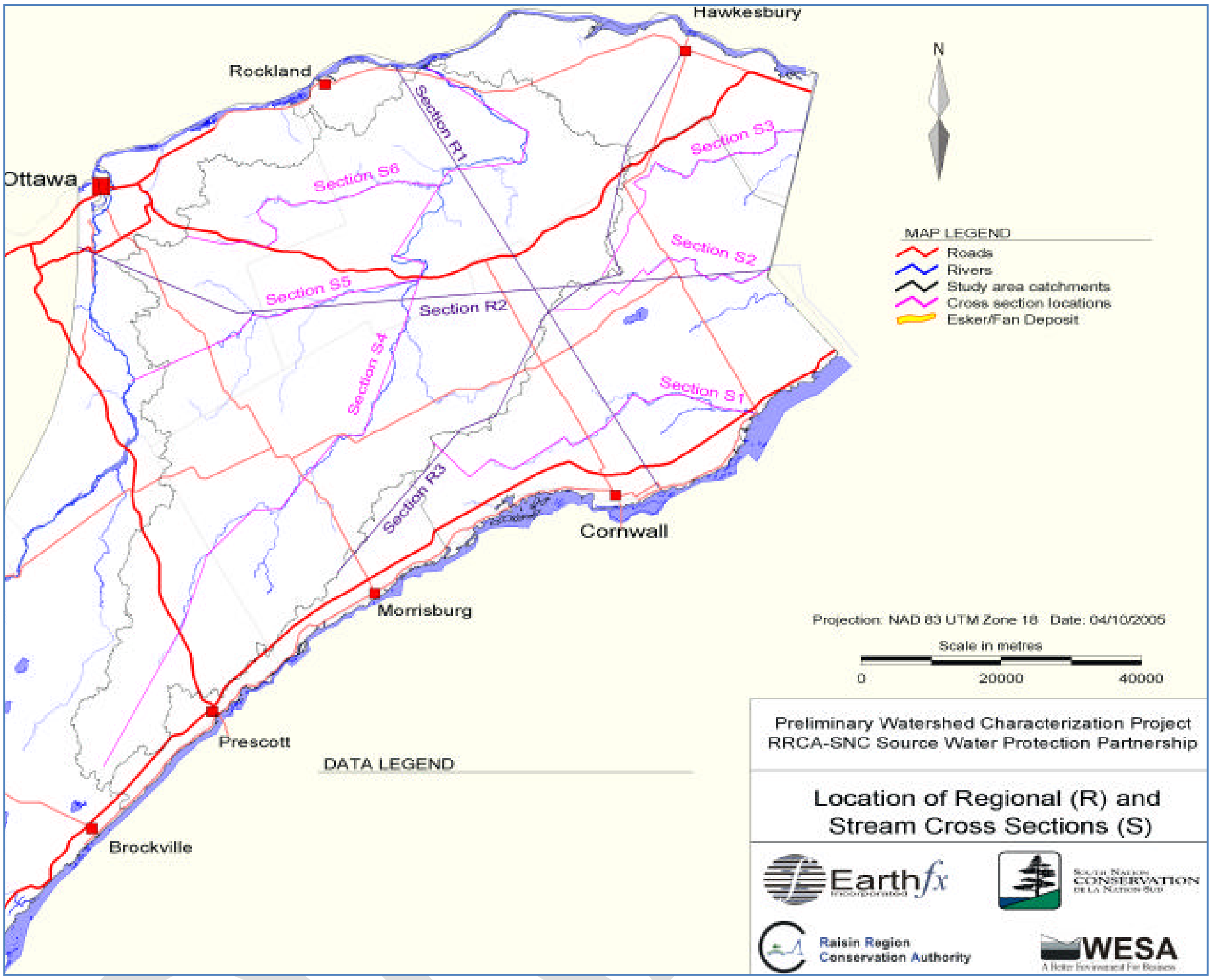


Figure 0.13: Location of Bedrock Valley, Esker and Fault Cross Sections, Source Protection Region

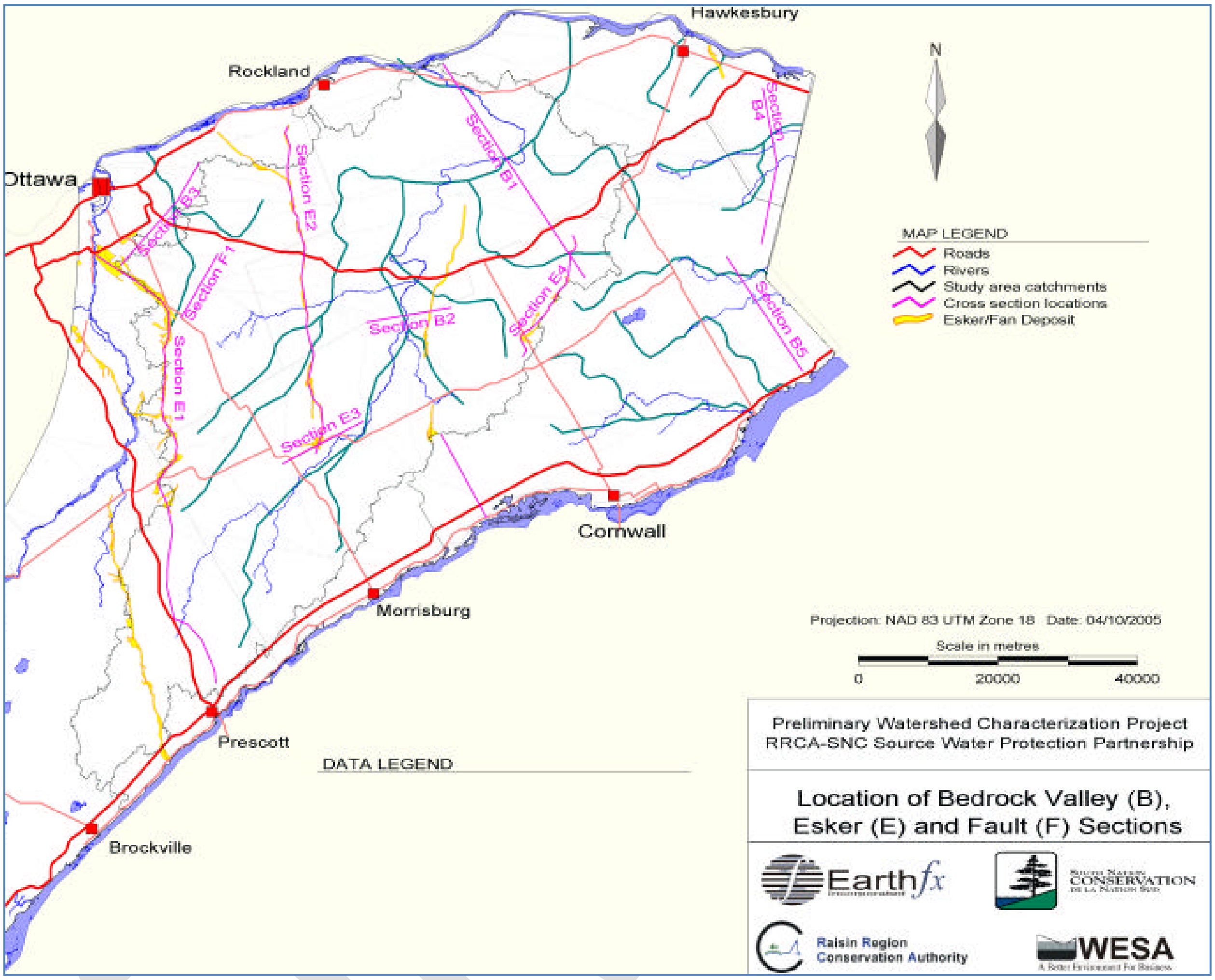
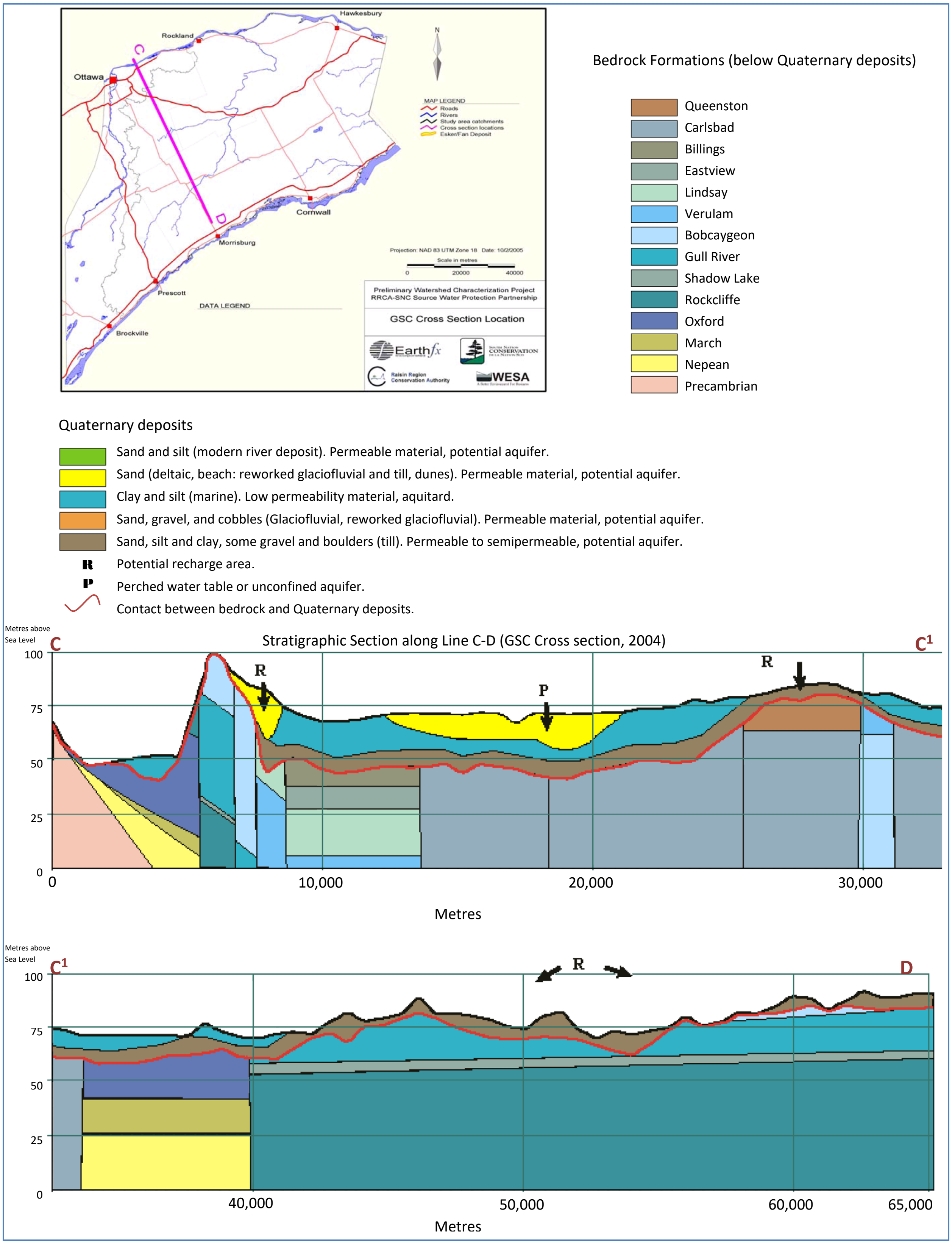


Figure 0.14: Regional Cross Section Showing Aquifers and Aquitards



3.1.3 Land Cover

Land cover within the Source Protection Region is divided into several broad categories: agricultural (54% of total region), forests (34%), urban (7%), wetlands (4%), water (0.5%) and exposed bedrock (0.4%). The distribution of these land classes can have a significant impact on the distribution and movement of water within the watershed. Additionally, the effects of modification of land use may be observed throughout the watershed as changes in quantity and/or quality of runoff, infiltration, evapotranspiration, discharge, and water use. Land cover is shown in *Map 3.3*.

3.1.4 Agricultural Land Use

The nature and intensity of agricultural activities will have an impact on the water budget in terms of water quantity, as water requirements differ between crop types and intensity or livestock type and intensity. Crop type will affect the water budget as different crops have different water demands; this is directly related to evapotranspiration, which is estimated to be a significant output of the water budget.

Due to the generally flat topography and the widespread fine sediments covering the region, tile drainage and municipal drains have been extensively developed to increase productivity of the land. Tile drains effectively prevent the water table from rising above the elevation of the drain. Tile drains have no impact on the natural draining characteristics of the soil; but when the water table is above the drain, they increase the speed at which runoff reaches surface water bodies. The net impact is a small time-shift and increased “peakedness” of the hydrograph of adjacent rivers. There is little change to the integrated hydrograph, and consequently little change to the amount of water actually recharged to the phreatic aquifer.

3.1.5 Forestry

Woodlands include treed areas, woodlots or forested areas and vary in their level of significance at the local, regional and provincial levels. Woodlands affect water quantity and quality in a number of ways: they reduce the intensity and volume of stormwater runoff, thereby decreasing soil erosion and flooding; they act as a semi-conductor or regulator for water movement between its percolation into the ground and its release into the atmosphere; they act as a soil stabilizer, filtering system and control water temperatures along stream courses.

The forested area of the region has remained relatively unchanged from 34% over the past twenty years.

3.1.6 Urban Areas

In terms of water budgets, urbanization has significant impacts on the quantity of water within a watershed. Urban areas are generally considered impervious land cover. As a result, precipitation is rapidly diverted as direct runoff to watercourses and recharge to the subsurface is limited. The shallow groundwater regime as well as surface water drainage patterns change drastically through urban development. The quality of runoff water from urban areas may be poor due to increased point and nonpoint source pollution. Water demands increase in urban centers. Water extraction for municipal supply, industrial, recreational and private usage is concentrated in and around urban and rural developments.

3.1.7 Wetlands

Wetlands have an important function in terms of water storage and transport. Wetlands serve as a temporary storage feature, they act as a sieve to filter and immobilize nutrients, sediments and toxins from surface water runoff, and they reduce the intensity and volume of storm water runoff thereby decreasing soil erosion.

3.1.8 Aquatic Habitat

Water budgeting exercise should maintain some amount of "reserve" to support other uses within the watershed such as ecosystem requirements. Localized aquatic habitats may be dependent upon water depth, flow and temperature. Habitat classification (Drain Classification) is discussed in the *Watershed Characterization* portion of this report (*above*).

3.1.9 Surface Water

In addition to the St. Lawrence River, the Raisin Region Source Protection Area comprises the following significant surface water bodies: Raisin River, Rigaud River, Delisle River, Garry River (including Loch Garry, Middle Lake and Mill Pond), Rivière Beaudette, Wood Creek, Gunn Creek, Sutherland Creek, Westley's Creek, Pattingale Creek, Finney Creek, Fraser Creek, Gray's Creek, Hoople Creek and Hoasic Creek.

3.1.9.1 Surface Water Flows

Long term stream gauge data is available for: Raisin River (near Williamstown), Delisle River (near Alexandria) and Rivière Beaudette (near Glen Nevis). The stream gauge locations are shown in *Map 3.4*. Flows can be represented as volume per unit of time (e.g., m^3/s) or as an annual depth equivalent (e.g., mm/year). Depth equivalents are the measured flow rates divided by the contributing area multiplied by the number of seconds per year. Depth equivalent measurements are useful when comparing watersheds of different sizes. Long term monthly and annual flows are summarized in *Table 0.18* and shown in *Figure 0.15* and *Figure 0.16*.

Map 3.4

Stream Gauge Locations, Raisin Region Source Protection Area

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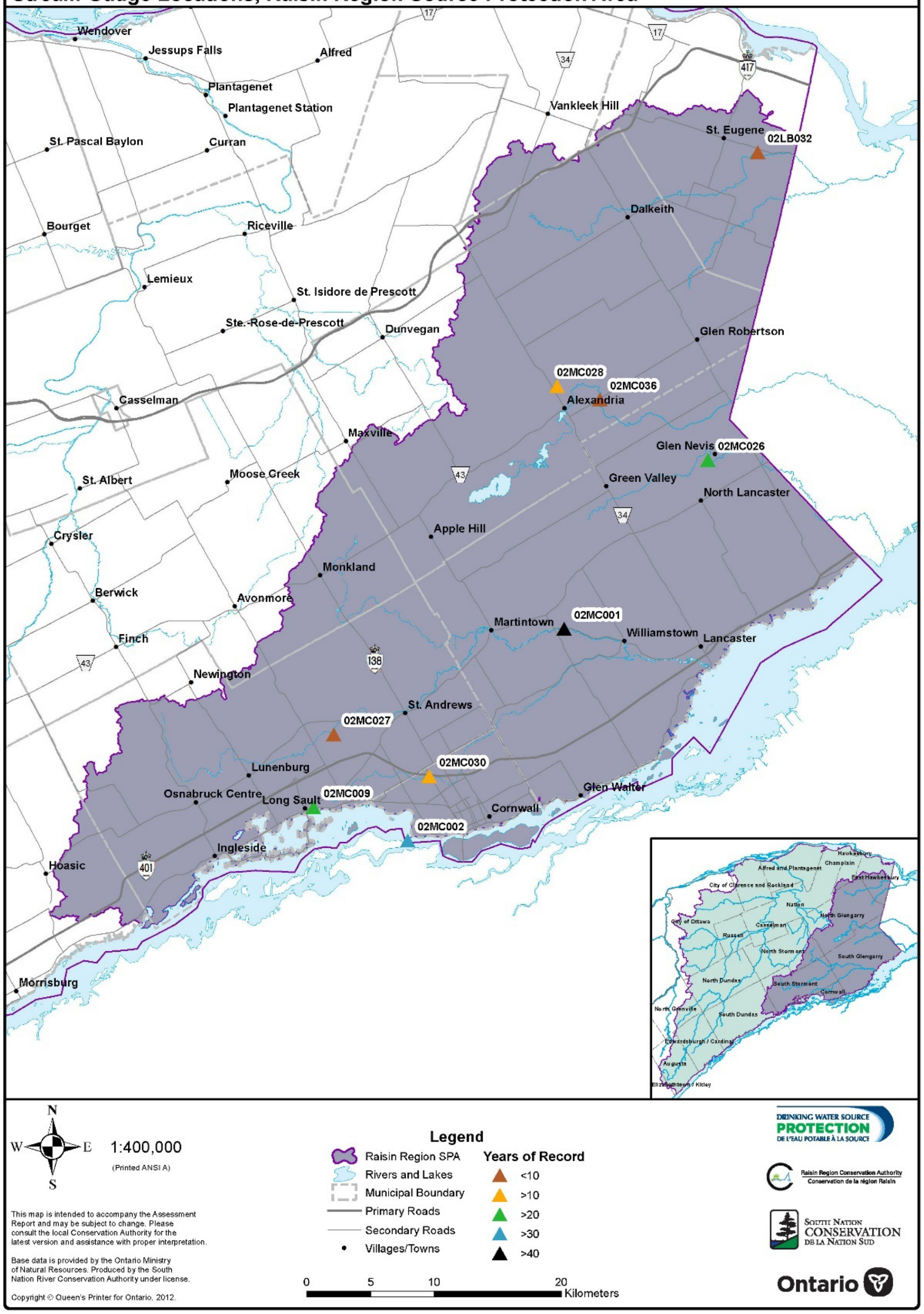


Table 0.18: Long Term Monthly Stream Flows, Raisin Region Source Protection Area

Month	Raisin River near Williamstown (02MC001)[1]		Delisle River near Alexandria (02MC028)[2]		Rivière Beaudette near Glen Nevis (02MC026)[3]	
	m^3/s	mm /year	m^3/s	mm /year	m^3/s	mm /year
January	2.8	18	1.2	25	0.8	24
February	3.3	20	1.3	25	0.7	20
March	12.4	82	4.0	87	2.4	77
April	21.0	135	7.2	150	4.2	127
May	5.2	35	1.9	41	1.1	34
June	2.3	15	1.0	20	0.5	14
July	0.9	6	0.4	8	0.3	8
August	0.7	5	0.2	5	0.1	4
September	0.7	5	0.2	4	0.1	3
October	2.5	17	0.8	16	0.5	17
November	4.8	31	1.7	35	1.1	33
December	4.7	31	1.8	40	0.9	29
Total for Year	**n.a.**	**398**	**n.a.**	**457**	**n.a.**	**390**

Notes:
1) Gauged watershed area is approximately 404 km^2; period of analysis is 1960 to 2003 (44 years)
2) Gauged watershed area is approximately 124 km^2; period of analysis is 1983 to 2003 (21 years)
3) Gauged watershed area is approximately 85km^2; period of analysis is 1985 to 1998 (14 years)

Figure 0.15: Long Term Monthly Stream Flows, Raisin Region Source Protection Area

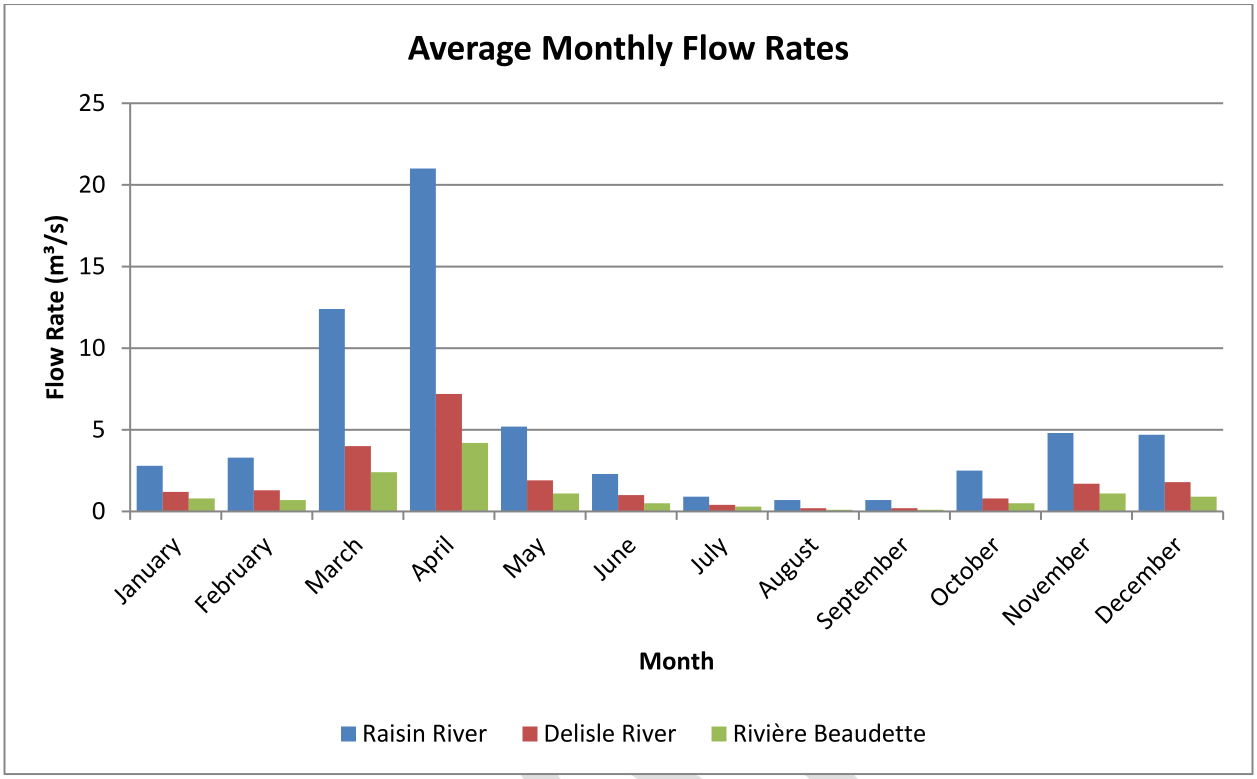
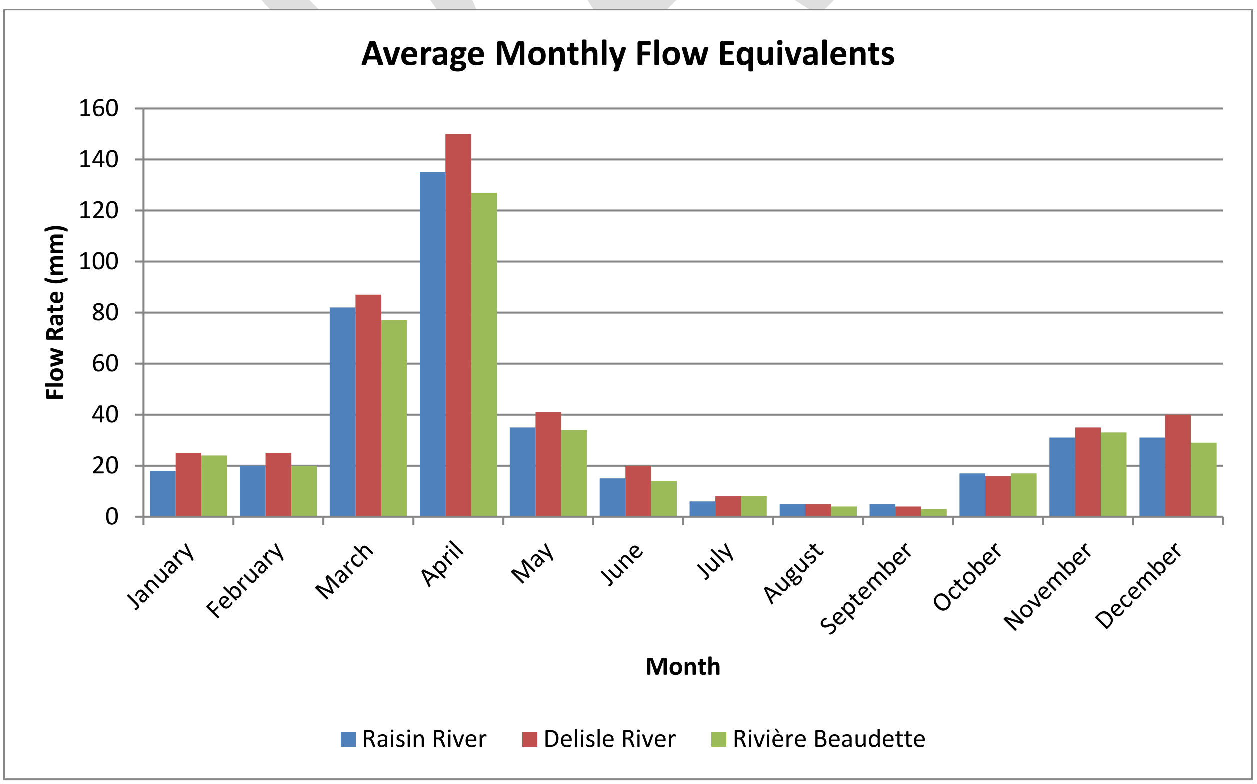


Figure 0.16: Long Term Monthly Stream Flow Equivalents, Raisin Region Source Protection Area



3.1.9.2 Surface Water Control Structures

The RRCA maintains and operates several control structures along the reaches of its watercourses. The structures provide flood control, stormwater management, erosion control, low flow augmentation, and recreation. They are also used to manage a municipal water supply in Alexandria.

The locations of the control structures are shown on *Map 3.5*.

Fly Creek Stormwater Pond

Fly Creek Stormwater Pond was originally built in 1980, and completed in 1996 to alleviate chronic stormwater flooding problems in Fly Creek, an urban watershed that constitutes 1100 hectares, approximately 20% of the City of Cornwall's total catchment area. Recently, the pond was retrofitted to include water quality control in addition to water quantity control.

Long Sault Diversion

The Long Sault Diversion is a low-flow augmentation structure that is manually opened each year to allow a measured amount of water from the St. Lawrence River into the headwaters of the South Branch of the Raisin River. Typical flow rates are on the order of 0.3 m^3/s. An agreement with the International Joint Commission allows the diversion to be open for a maximum of 100 days per year.

St. Andrews West Berm

St. Andrews West Berm is an earthen berm structure constructed in St. Andrews West to provide a measure of protection, for approximately 20 private residences, from high water-levels along the Raisin River.

Martintown Dam

The Martintown Dam is a structure located on the Raisin River at Martintown. It was originally built to control water into a Mill but is now primarily used to back up water for a recreational pond.

Garry River Watershed Control Structures

Three dams along the Garry River form three lakes in a 34 km^2 watershed to form the water supply for the Town of Alexandria. The three control dams (Loch Garry Dam, Kenyon Dam and Alexandria Dam) are operated primarily for water supply and flood control purposes. Stop logs and slot logs are manually added or removed to manage the water levels and outflow rates of the three lakes. The RRCA maintains an Operation Manual for the Garry River System.

Delisle River Weir

This weir, located slightly northeast of the intersection of Highway 34 and Power Dam Road, in Alexandria, was formerly part of a small power plant operation. It is no longer a managed weir and water is free to flow over it naturally.

Weir at Glen Nevis

This weir, located near Glen Nevis, is currently used to create a small amount of back-water to facilitate the operation of a Water Survey of Canada stream gauging station.

3.1.9.3 Surface Water Intakes

Drinking water systems within the Source Protection Area are listed in *Section 2.6*. In total, there are six systems with a surface water intake, five of which are municipal drinking water systems. The surface water intake locations are shown on *Map 3.6*. The total withdrawal from all surface water intakes for drinking water systems on an annual basis is approximately 16 million cubic metres. Most of the surface water (approximately 93%) is removed from the St. Lawrence River. Of all the St. Lawrence River withdrawals, 85% is attributed to the City of Cornwall's intake. The Town of Alexandria has the only "in-land" surface water intake. Additional surface water withdrawals under the Permit to Take Water Program are discussed in *Section 3.1.11*.

3.1.10 Groundwater

A hydrogeologic model for the Source Protection Region was developed from a comprehensive literature review and GIS analyses. Hydrogeological data including geophysical information, aquifer hydraulic test data, modelling results and water level information were extracted from a number of consulting and scientific reports. These data were used to determine aquifer properties and groundwater flow characteristics and conditions. Hydrogeological data from the MOE Water Well database (static water levels, elevation of water found, and lithology at well screen) were used to establish water bearing units, regional potentiometric surface and direction of vertical hydraulic gradients.

3.1.10.1 Watershed Scale Aquifer Units

On a regional scale, southeastern Ontario has an abundance of water bearing formations both in the bedrock and overburden: some formations are highly permeable (aquifers), and others do not easily yield their water content (aquitards).

Bedrock aquifer units have been identified (Singer et al., 2003) and are rated on their water-yielding capabilities and qualities in *Table 0.19*.The Nepean-March-Oxford unit, the Rockcliffe unit and the Ottawa Group are widely exploited across the study area for private, commercial, institutional and municipal use.

Table 0.19: Bedrock Aquifer Units of the Source Protection Region

Unit	Water-Yield	Water Quality
Precambrian (close to surface)	Poor Producer	Poor Quality
Nepean-March-Oxford	Excellent to Good Producer	Good Quality
Rockcliffe	Poor Producer	Good Quality
Ottawa Group (Gull River, Bobcaygeon, Verulam and Lindsay)	Good Producer	Fair Quality
Billings-Carlsbad-Queenston	Poor Producer	Inferior Quality

The importance of the overburden as a water supply material is most noticeable in the overburden and shallow bedrock contact zone. The basal granular material plays a key role in availability of adequate amounts of water at the bedrock interface.

Approximately 12% of the wells in the Source Protection Area are overburden wells. Known surficial aquifer complexes are listed in *Table 0.20*.

Table 0.20: Identified Surficial Aquifer Complexes of the Source Protection Region

Source Protection Area	Aquifer	Notes
Raisin Region	Lancaster-Cornwall	Basal gravel deposit along the north shore of the St. Lawrence River.
South Nation	Champlain Aquifer	Deltaic coarse-grained glaciomarine deposit, located within the Prescott-Russell Sand Plain geological terrain.
South Nation	Rideau Front Aquifer	Large glaciofluvial aquifer system that is located along the western boundary.
South Nation	Rockland Aquifer, Plantagenet Aquifer, Clarence Creek Aquifer, Sarsfield Aquifer, Notre Dame Aquifer, Bourget Aquifer	A series of small buried glacial sand, and sand and gravel deposits, buried beneath confining layers of glaciomarine fine grained sediments (clays deposits).
South Nation	Central South Nation Aquifer Complex	Covers a large area just south of the Champlain Aquifer, within the Winchester Clay plain between St. Isidore de Prescott and the western boundary. Complex consists of coarse-textured sediments resting on bedrock and confined by fine textured glaciomarine and till deposits.

3.1.10.2 Water Table, Potentiometric Surfaces and Groundwater Flow Direction

The water table elevation is estimated from water levels in well records, the elevations of surface water bodies and by empirical relationships based on ground surface elevation and proximity to surface water bodies. A resulting potentiometric surface is developed, which is representative of the elevation to which water in an aquifer would rise by hydrostatic pressure.

Regionally, shallow groundwater flows toward the surface water network. The watershed boundaries also delimit the boundaries of shallow groundwater flow in most areas. The direction of groundwater flow within the Raisin Region Source Protection Area is generally from the northwest towards the St. Lawrence River. A northeast portion of the Source Protection Area appears to flow toward the Quebec border. The hydraulic gradient in the southern part of the area between Cornwall and Lancaster is relatively low corresponding to a slow groundwater flow.

The potentiometric surface and direction of groundwater flow for the overburden is shown in *Map 3.7*.

Groundwater flow in bedrock is conceptualized in three geologic zones: Shallow, Intermediate and Deep. The horizons represent the first 15m of depth into the bedrock, 15 to 30meters and depths greater than 30 metres. Within the bedrock zones, horizontal flow is dominant. Groundwater flows out of the Source Protection Area across the Ontario-Quebec border to the east.

Potentiometric surfaces and groundwater flow directions for the Shallow Bedrock, Intermediate Bedrock and Deep Bedrock are shown in *Map 3.8*, *Map 3.9* and *Map 3.10* respectively.

3.1.10.3 Assessment of Wells

There are 29 groundwater drinking water systems identified in *Section 2.6*, and shown on *Map 3.11*. Of those groundwater systems identified there are two municipal drinking water systems: Glen Robertson and Redwood Estates. These two systems combine to withdraw less than 15,000 cubic metres per year. The total withdrawals from groundwater drinking water systems would be significantly less than that of surface water. The withdrawals from private wells and groundwater withdrawals requiring a permit are discussed in *Section 3.1.11* and *Section 3.1.12*.

3.1.11 Water Takings Requiring a Permit

The Ontario Water Resources Act (Section 34) requires the acquisition of a permit if any water taking on any day by any means exceeds 50,000 litres per day. A Permit to Take Water (PTTW) database is maintained by the Province. The latest available database is dated October 2009. Permit limits are expressed as “Maximum litres per day” and “Maximum days per year”. A resulting maximum volume per year can be computed as the product. Values for actual and projected takings are not currently recorded in the database. The permit holder may take all, nothing, or anywhere in between the allowed specified taking values. A summary of maximum water takings by permit purpose for the Source Protection Area is included in *Table 0.21* and represented on *Map 3.12*.

Table 0.21: Summary of Water Taking Permits (October 2009), Raisin Region Source Protection Area

General Purpose	Specific Purpose	Source	Total Permits	Maximum Volume (m^3/year)
Agricultural	Tender Fruit	Both	4	148,781
Commercial	Golf Course Irrigation	Surface	2	702,321
Commercial	Golf Course Irrigation	Both	3	106,116
Commercial	Mall / Business	Ground	2	265,489
Commercial	Other - Commercial	Ground	1	116,150
Commercial	Other - Commercial	Surface	2	1,637
Dewatering	Other - Dewatering	Ground	3	51,397
Dewatering	Pits and Quarries	Ground	6	9,295,062
Dewatering Construction	Construction	Ground	2	4,466
Dewatering Construction	Construction	Both	4	4,600,600
Industrial	Cooling Water	Ground	3	3,635,950
Industrial	Food Processing	Ground	3	101,824
Institutional	Hospitals	Ground	2	15,120
Miscellaneous	Dams and Reservoirs[1]	Surface	1	5,135,550,000
Miscellaneous	Heat Pumps	Ground	3	171,871
Miscellaneous	Pumping Test	Ground	1	389
Miscellaneous	Wildlife Conservation[2]	Surface	21	249,442,447
Water Supply	Communal	Ground	3	894,855
Water Supply	Municipal	Ground	1	81,760
Water Supply	Municipal	Surface	7	45,234,085
Water Supply	Other - Water Supply	Ground	1	55,188
Water Supply	Other - Water Supply	Both	2	86,378

Notes: 1) Permit is for the Martintown Dam.
2) Wildlife Conservation permits are typically for water impoundment structures and are not necessarily indicative of water use.

It should be cautioned that the PTTW database is only a reflection of maximum permitted takings and does not account for smaller users (less than 50,000 L/day). In addition, some permits do not represent sustained water takings (e.g., dewatering or construction).

3.1.12 Water Takings Not Requiring a Permit

Water takings that do not exceed 50,000 litres per day do not require a permit to take water. Private groundwater well takings do not require a permit.

Private residential water use can be estimated using commonly accepted values for residential water usage. Within the Source Protection Area, there are approximately 27,500 residents who are not serviced by municipal drinking water systems, and therefore are presumably using a private well for drinking water. Based on the number of private well water users in the Source Protection Area, and an estimate of 385 litres/capita/day, the annual water consumption would be approximately 3.9 million cubic metres per year.

A more detailed water use analysis is presented in the Tier-1 Water Budget Section.

3.1.13 Groundwater and Surface Water Interactions

Groundwater recharge refers to the downward flux of water into an aquifer through its top boundary; whereas discharge refers to the upward flux of water leaving the aquifer. Recharge and discharge are essential components of the water budget calculation.

In general, areas of high water levels (high water potential, or hydraulic head) in an aquifer correspond to recharge areas where groundwater flow is generally downwards into the aquifer; in unconfined aquifers these often are associated to topographic high areas. Areas of low potential are generally discharge zones where groundwater flow is upwards towards surface water features such as streams.

3.1.13.1 Groundwater Recharge

The conceptual understanding of groundwater recharge within the Source Protection Region can be summarized as follows:

1. Within the shallow flow regime, groundwater recharge and discharge occur at a very local scale; recharge occurring within topographically higher regions, and discharge occurring tens of metres to a few kilometres farther down gradient in ditches or small streams. In the region this process is often short-circuited by the interception of tile drains and directed immediately to the nearby surface watercourse.
2. Of the water that recharges into the unconfined, overburden aquifer, most of the water stays within the upper aquifer and discharges locally into surface water bodies. A lesser volume of water moves through the confining layers (till and fine-textured marine sediments) and enters the confined/semi-confined deeper overburden deposits and the shallow bedrock interface (the contact zone aquifer).

3. The greatest recharge to the contact zone aquifer would likely occur within the more permeable materials found within the Edwardsburgh Sand Plains and the Prescott-Russell Sand Plains.
4. It is expected that topographically higher areas would act as groundwater recharge areas, on a regional scale.

A preliminary estimate of recharge on a regional scale based on land slope, soil type and land cover (MOE 1995 methodology) is presented in *Map 3.13*. Partitioning analyses of recharge for Overburden Aquifers (shallow) and Contact Zone Aquifers (deep) show that most of the recharge 99+% is to the overburden. Over the Raisin Region Source Protection Area, groundwater recharge is estimated conceptually to be 251 mm; with 0.2 mm penetrating to the contact zone.

3.1.13.2 Groundwater Discharge

Over the long term, it can be assumed that groundwater discharge is equivalent to surface water baseflow. Baseflow estimates from automated hydrograph separation tools (i.e., BFLOW) for gauged watercourses in the Source Protection Area are presented in *Table 0.22*.

Table 0.22: Average Annual Baseflow Estimates, Raisin Region Source Protection Area

Gauge Location	Annual Discharge (mm/year)	Baseflow Fraction	Annual Baseflow (mm/year)
Raisin River near Williamstown (02MC001)	398	0.58	230
Delisle River near Alexandria (02MC028)	390	0.59	230
Rivière Beaudette near Glen Nevis (02MC026)	457	0.61	280

3.1.14 Natural Water Budget

To determine the natural water budget, four main components of the water cycle are considered: precipitation, evapotranspiration, surface water flow and groundwater flow.

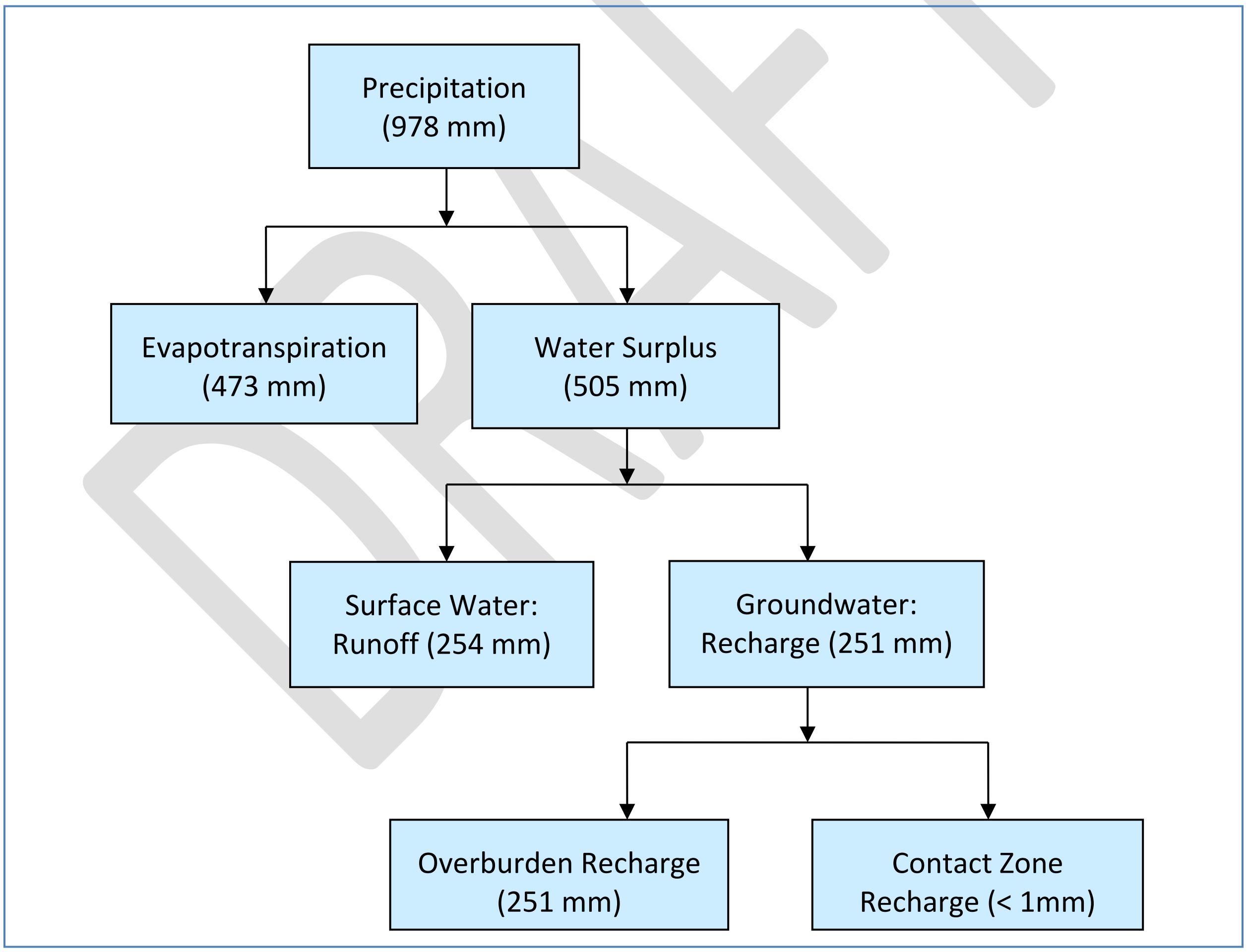
At a conceptual level, the components of the water budget are analyzed on an average annual basis. This analysis is conducted with an assumption of steady state (no change in storage). For this analysis, the water budget does not consider anthropogenic water inputs and outputs.

The natural water budget for the Raisin Region Source Protection Area is summarized in *Table 0.23* and shown in *Figure 0.17*.

Table 0.23: Components of the Natural Water Budget, Raisin Region Source Protection Area

Component	Mean (mm/yr.)	Standard Deviation (mm/yr.)	Minimum (mm/yr.)	Maximum (mm/yr.)	Range (mm/yr.)
Precipitation	978	8	960	998	38
Actual Evapotranspiration	473	136	150	640	490
Water Surplus	505	136	321	825	504
Surface Water (Fast Runoff)	254	92	32	571	539
Groundwater Recharge (Overburden and Contact Zone)	251	71	46	635	681
Groundwater Contact Zone Recharge	0.2	9	-86	136	222

Figure 0.17: Components of the Natural Water Budget, Raisin Region Source Protection Area



3.1.15 Climate Change

The effects of climate change on the Source Protection Region have been assessed and published by academics (Crabbé and Robin, 2003). Climate change projections report increased average temperature, decreased river water levels and a shift in precipitation to the winter months resulting in more frequent and intense summer droughts. Reduced flow for tributaries could impact water quality throughout the region. Over the course of a year, the effects of climate change do not appear to affect groundwater quantity. On a monthly basis, extreme scenarios of temperature, precipitation and a combination of the two have been projected at a localized level. Analyses described in Crabbé and Robin (2003) have demonstrated certain areas, such as aquifer recharge areas, to be vulnerable to drought in the dry summer months, even during “wet” years. Tier-2 Water Budget stress assessments test groundwater response to extended drought. The results are discussed in subsequent sections.

3.2 Tier 1 Water Budget

Water budget and stress assessments follow a three-tiered approach, with each tier being more detailed and containing greater certainty in the results than the previous. A Tier 1 study is the first level in this approach. Each tier of the Water Budget and Stress Assessment studies estimates the quantity of water flowing through each subwatershed, determines the primary hydrological pathways moving water through each subwatershed and assesses the reliability of water quantity in each subwatershed. The purpose of a Tier 1 analysis is to estimate the hydrologic stress of subwatersheds in order to screen out areas that are unstressed from a water quantity perspective. Tier 2 and Tier 3 assessments will focus on areas that are stressed.

A comprehensive document, “Raisin-South Nation Source Protection Region, Tier 1 Water Budget and Water Quantity Stress Assessment (Revision 2)”, was produced by Intera Engineering in 2010 to support this section of the Assessment Report. The results from this peer-reviewed report are presented herein.

3.2.1 Tier 1 Subwatershed Delineation

The spatial scale for Tier 1 analysis was mostly based on quaternary watershed scale mapping (MNR 2006). Some watersheds were amalgamated to prevent the creation of very small subwatersheds, which would not fit in with the water quantity stress assessment process. Sixty-seven (67) subwatersheds were delineated within the Source Protection Region, 14 of which were identified to be within the Raisin Region Source Protection Area. These subwatersheds are shown on *Map 3.14* and detailed in *Table 0.24*.

Table 0.24: Subwatersheds for Tier 1 Water Budget Analysis, Raisin Region Source Protection Area

SWS Reference # (as per Map 3.14)	Area (km²)	Common Subwatershed Name
1	132.0	Rigaud River (Lower)
2	72.7	Westley’s Creek
3	79.2	Sutherland Creek

SWS Reference # (as per Map 3.14)	Area (km²)	Common Subwatershed Name
4	46.2	Fraser Creek
5	44.6	Gray's Creek
6	91.6	Hoople Creek
7	34.3	Garry River
8	154.3	Beaudette River
9	41.2	Wood Creek
10	342.3	Raisin River (Main Branch)
11	113.6	Raisin River (South Branch)
12	88.3	Froatburn Swamp, Upper Canada, Riverside Heights
13	121.9	Raisin River (North Branch)
65	319.5	Rigaud River (Upper)
66	193.5	Delisle River

3.2.2 Tier 1 Analysis Time Scale

The time scale used for the Tier 1 analysis was refined from annual average values used in the Conceptual Understanding. Water budgets were carried out on monthly and on annual time scales. Groundwater stress assessments were carried out on monthly and annual scales. Surface water stress assessments were undertaken on a monthly time scale.

3.2.3 Tier 1 Water Takings

Surface water and groundwater takings were computed for each subwatershed. Total anthropogenic consumptive water demand was taken as the sum of municipal usage, takings under the Permit to Take Water program (PTTW), agricultural takings (based on Agricultural Census data) and private takings (e.g., non-municipally serviced residential takings). The final water takings are calculated using the data described above, multiplied by a consumptive factor.

Consumptive factors account for how much water is consumed versus returned to the system. Consumptive factors have a range between 0 and 1. A consumptive factor of 0 means all of the water is returned to where it was taken from (i.e., water pumped from a well is returned to the groundwater system). A factor of 1 means none of the water is returned (e.g., water bottling). Consumptive factors were taken from the Provincial Guidance. Drinking water takings (municipal and private) had a consumptive factor of 0.2, meaning 80% of the water is returned. Industrial takings had a consumptive factor of 0.25, heat pumps had a factor of 0.1, construction had a factor of 0.75, pit and quarry operations had a factor of 0.25, water bottling used all of the water, irrigation used 0.7, gardens and markets used 0.9, and agriculture used 0.8. The takings are summarized in *Table 0.25*.

Table 0.25: Tier 1 Consumptive Water Takings

SWS	Surface Water Takings (m^3/s)		Groundwater Takings (m^3/s)				Total Combined Taking (mm)
	Municipal	PTTW	Municipal	PTTW	Agricultural	Private	
1			0.000		0.004	0.001	1
2		0.006	0.000		0.003	0.001	4
3		0.000		0.000	0.003	0.001	2
4					0.002	0.000	1
5		0.001		0.032	0.001	0.000	24
6					0.002	0.001	1
7	0.006				0.001	0.000	7
8				0.000	0.005	0.001	1
9					0.002	0.000	1
10					0.010	0.003	1
11		0.006		0.050	0.002	0.001	16
12				0.000	0.003	0.001	1
13					0.003	0.001	1
65		0.004		0.006	0.009	0.002	2
66					0.006	0.001	1

3.2.4 Tier 1 Water Budget Equation

Water Budgets are based on a simple mass balance principle – the water that moves into a system is balanced by the water leaving the system and a change in the amount of water in the system. The water budget for a subwatershed can be expressed by the following equation:

Equation 3.1: Water Budget Mass Balance

$$P + SW_{in} + GW_{in} + ANTH_{in} = ET + SW_{out} + GW_{out} + ANTH_{out} + \Delta S + Diversions$$

Where P is precipitation (rainfall + snowmelt); SW_{in} is the surface water flow into the subwatershed; GW_{in} is the groundwater inflow; $ANTH_{in}$ is the anthropogenic flow into the subwatershed (e.g. wastewater return); ET is evapotranspiration (evaporation + transpiration) that removes water from the subwatershed; SW_{out} is the surface water outflow; GW_{out} is the groundwater outflow; $ANTH_{out}$ is the anthropogenic flow out (e.g. drinking water takings); ΔS is the change in water storage (e.g. changes in lake levels and aquifer levels); and Diversions represent water removed from one subwatershed and added to another.

At the Tier 1 stage, the change in storage is assumed to be zero. Shallow groundwater is also assumed to recharge and discharge to surface water features within the same subwatershed.

Deep, regional-scale groundwater flow is assumed not to discharge in the region. As change in storage is assumed to be zero, the changes in groundwater levels are assumed to be zero, therefore, groundwater inflow and outflow terms balance, and can be removed from the water budget mass balance. Consumptive water takings were computed to be minimal (*Table 0.25*); thus, the anthropogenic fluxes can also be removed from the mass balance. There are no inter-subwatershed diversions either. The resulting Tier 1 water budget equation is as follows:

Equation 3.2: Tier 1 Water Budget Equation

$$P + SW_{in} = ET + SW_{ou}$$

3.2.5 Tier 1 Water Budgets by Subwatershed

The primary water flow paths through the Source Protection Region were examined using a numerical model called, Hydrological Simulation Program-Fortran (HSPF). HSPF uses meteorological data (precipitation, dew point, temperature, wind speed, and cloud cover) along with physiographic data (slope, soil type, land cover, land use) to reproduce river flow data. The HSPF model output solved the following equation:

Equation 3.3: HSPF Modelling Equation

$$P = ET + OF + IF + BF + R$$

Where P is precipitation, ET is evapotranspiration, OF is overland flow; IF is interflow, BF is base flow and R is deep groundwater recharge.

Overland flow (OF) represents the runoff water that travels on the ground surface to the rivers and is the first water to arrive in a river after a significant precipitation event. Interflow (IF) can be conceptualized as precipitation that arrives in a river after overland flow. Interflow infiltrates into the shallow groundwater flow system and travels directly to the river. Base flow (BF) represents the slow, steady addition of groundwater to rivers. Base flow is shallow groundwater and is assumed to recharge and discharge in the same subwatershed. The remaining water not used in overland flow, interflow or base flow is considered deep groundwater recharge (R).

The HSPF model was calibrated to reproduce observed surface water flows from monitored stream gauge stations using 2003 data, and the model was run using measured 2004 climate data.

Monthly and annual water budgets for each subwatershed are presented inTable 0.26.

Table 0.26: Tier 1 Monthly and Annual Water Budgets by Subwatershed

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	Precipitation	6.5	9.8	191.3	98.6	77.7	62	116.1	119.6	78.5	40.4	96.5	88.1	985
	Overland Flow	0.6	0.9	24.2	7.9	5.2	3.7	7.4	8.4	6.7	2.6	8.4	9.9	85.8

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Interflow	3.4	0.2	90.1	35.7	2.6	0.6	0.1	0.3	2	0.1	1.1	6.5	142.7
	Base Flow	9	1.5	15.3	38.4	10.1	6.2	3.5	8.1	15.9	4.7	21	17	150.6
	Evapotranspiration	0	1.4	2	18	72	91.8	104.3	84.1	54.6	24.1	2.7	1.1	456.2
	Deep Recharge	2.5	0.9	15.4	19.1	8.5	6	10.6	10.6	9.9	4.8	17.3	4.9	110.7
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	13	2.6	129.7	81.9	17.8	10.5	10.9	16.8	24.5	7.3	30.5	33.4	379.1
2	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2	2.6	145.3	36.5	4.3	2.9	5.6	6.6	13.2	2	9.8	52.1	282.9
	Interflow	3.9	0.4	28.4	30	4.7	2.8	0.5	2.9	9.4	0.3	14.1	8.6	106
	Base Flow	9.6	4.5	4.7	11.7	8.1	3.8	0.8	1.1	4	2.9	5.3	11.4	67.9
	Evapotranspiration	0	1.4	2	18	72	96.4	114.1	89	57.5	24	2.7	1.1	478.3
	Deep Recharge	2.5	1.2	8.1	20	5.8	3.3	6.8	8.4	9.7	3.6	15.8	10.1	95.4
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	15.5	7.6	178.5	78.2	17	9.5	6.9	10.6	26.6	5.2	29.2	72.1	456.9
3	Precipitation	3.6	1.1	161.3	103.9	77.7	62	116.1	119.6	78.5	40.4	96.3	98.3	958.7
	Overland Flow	0.3	0.1	13.8	7	4.2	3	6	6.8	5.4	2.1	6.9	7.9	63.5
	Interflow	6.9	0	61.8	43.3	2.2	0.4	0	0.1	0.7	0	0.7	8	124.1
	Base Flow	14.8	3.1	15	39.6	15	9.5	2.8	7.6	17.7	5.6	17	30.6	178.3
	Evapotranspiration	0	0.3	7.3	27.3	73.6	95.7	111.5	87.5	56.5	14.5	6.7	0.6	491.6
	Deep Recharge	1.1	0	50.8	22.9	1.4	0.2	0.1	0.2	0.7	0	1.2	22.7	101.2
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	21.9	3.2	90.5	89.9	21.4	12.8	8.8	14.6	23.8	7.8	24.6	46.5	365.9
4	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2.3	3.1	150	40.4	7.2	5	9.7	11.4	16.7	3.5	14.6	55.3	319.2
	Interflow	3.7	0.4	26.3	28.3	4.4	2.7	0.5	2.8	8.9	0.3	13.5	8.1	100
	Base Flow	8.9	4.2	4.4	10.8	7.5	3.5	0.7	1	3.7	2.7	5	10.7	63.2
	Evapotranspiration	0	1.4	2	18	72	92.2	109.3	85.7	54.6	23.2	2.7	1.1	462.2
	Deep Recharge	2.5	1.1	7.4	18.7	5.3	3.1	6.5	7.9	9.1	3.4	14.8	9.4	89.2
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	14.9	7.8	180.7	79.5	19.1	11.2	11	15.2	29.4	6.5	33.1	74.1	482.4
5	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2.3	3.1	150	40.4	7.2	5	9.7	11.4	16.7	3.5	14.6	55.3	319.2
	Interflow	3.7	0.4	26.3	28.3	4.4	2.7	0.5	2.8	8.9	0.3	13.5	8.1	100
	Base Flow	8.9	4.2	4.4	10.8	7.5	3.5	0.7	1	3.7	2.7	5	10.7	63.2
	Evapotranspiration	0	1.4	2	18	72	92.2	109.3	85.7	54.6	23.2	2.7	1.1	462.2
	Deep Recharge	2.5	1.1	7.4	18.7	5.3	3.1	6.5	7.9	9.1	3.4	14.8	9.4	89.2
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	SW_{out}	14.9	7.8	180.7	79.5	19.1	11.2	11	15.2	29.4	6.5	33.1	74.1	482.4
6	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2	2.6	145.3	36.5	4.3	2.9	5.6	6.6	13.2	2	9.8	52.1	282.9
	Interflow	3.9	0.4	28.4	30	4.7	2.8	0.5	2.9	9.4	0.3	14.1	8.6	106
	Base Flow	9.6	4.5	4.7	11.7	8.1	3.8	0.8	1.1	4	2.9	5.3	11.4	67.9
	Evapotranspiration	0	1.4	2	18	72	96.4	114.1	89	57.5	24	2.7	1.1	478.3
	Deep Recharge	2.5	1.2	8.1	20	5.8	3.3	6.8	8.4	9.7	3.6	15.8	10.1	95.4
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	15.5	7.6	178.5	78.2	17	9.5	6.9	10.6	26.6	5.2	29.2	72.1	456.9
7	Precipitation	8.1	21.4	145.5	86.6	77.7	62	116.1	119.6	78.5	40.4	96.3	117.1	969.4
	Overland Flow	0.7	1.9	14.5	6.3	4.7	3.4	6.7	7.6	6	2.3	7.6	10.9	72.5
	Interflow	9.6	1.2	69.5	25.2	2.8	0.9	0.1	0.5	2.6	0.2	2.4	18.1	133.3
	Base Flow	20.9	4.3	26.6	52.1	14.2	11.6	5.3	16.6	28.5	9.2	24.9	42.8	257
	Evapotranspiration	0	1.4	8.2	27.1	73.1	95.4	112.6	89.2	56.7	24.4	9.5	1.1	498.6
	Deep Recharge	0.2	0.1	1.1	1.1	0.6	0.4	0.8	0.7	0.7	0.3	1	1	8
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	31.3	7.4	110.6	83.6	21.7	15.9	12.1	24.6	37.1	11.7	34.9	71.7	462.8
8	Precipitation	3.6	1.1	161.3	103.9	77.7	62	116.1	119.6	78.5	40.4	96.3	98.3	958.7
	Overland Flow	0.3	0.1	13.8	7	4.2	3	6	6.8	5.4	2.1	6.9	7.9	63.5
	Interflow	6.9	0	61.8	43.3	2.2	0.4	0	0.1	0.7	0	0.7	8	124.1
	Base Flow	14.8	3.1	15	39.6	15	9.5	2.8	7.6	17.7	5.6	17	30.6	178.3
	Evapotranspiration	0	0.3	7.3	27.3	73.6	95.7	111.5	87.5	56.5	14.5	6.7	0.6	491.6
	Deep Recharge	1.1	0	50.8	22.9	1.4	0.2	0.1	0.2	0.7	0	1.2	22.7	101.2
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	21.9	3.2	90.5	89.9	21.4	12.8	8.8	14.6	23.8	7.8	24.6	46.5	365.9
9	Precipitation	3.6	1.1	161.3	103.9	77.7	62	116.1	119.6	78.5	40.4	96.3	98.3	958.7
	Overland Flow	0.3	0.1	13.8	7	4.2	3	6	6.8	5.4	2.1	6.9	7.9	63.5
	Interflow	6.9	0	61.8	43.3	2.2	0.4	0	0.1	0.7	0	0.7	8	124.1
	Base Flow	14.8	3.1	15	39.6	15	9.5	2.8	7.6	17.7	5.6	17	30.6	178.3
	Evapotranspiration	0	0.3	7.3	27.3	73.6	95.7	111.5	87.5	56.5	14.5	6.7	0.6	491.6
	Deep Recharge	1.1	0	50.8	22.9	1.4	0.2	0.1	0.2	0.7	0	1.2	22.7	101.2
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	21.9	3.2	90.5	89.9	21.4	12.8	8.8	14.6	23.8	7.8	24.6	46.5	365.9
10	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2	2.6	145.3	36.5	4.3	2.9	5.6	6.6	13.2	2	9.8	52.1	282.9
	Interflow	3.9	0.4	28.4	30	4.7	2.8	0.5	2.9	9.4	0.3	14.1	8.6	106
	Base Flow	9.6	4.5	4.7	11.7	8.1	3.8	0.8	1.1	4	2.9	5.3	11.4	67.9

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Evapotranspiration	0	1.4	2	18	72	96.4	114.1	89	57.5	24	2.7	1.1	478.3
	Deep Recharge	2.5	1.2	8.1	20	5.8	3.3	6.8	8.4	9.7	3.6	15.8	10.1	95.4
	SW_{in}	10.5	5.3	123.5	54.2	12.4	7.1	6.1	8.8	19.2	4	21.4	50.3	322.8
	SW_{out}	25.9	12.8	302.1	132.4	29.4	16.6	13	19.5	45.8	9.2	50.6	122.3	779.7
11	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2.3	3.1	150	40.4	7.2	5	9.7	11.4	16.7	3.5	14.6	55.3	319.2
	Interflow	3.7	0.4	26.3	28.3	4.4	2.7	0.5	2.8	8.9	0.3	13.5	8.1	100
	Base Flow	8.9	4.2	4.4	10.8	7.5	3.5	0.7	1	3.7	2.7	5	10.7	63.2
	Evapotranspiration	0	1.4	2	18	72	92.2	109.3	85.7	54.6	23.2	2.7	1.1	462.2
	Deep Recharge	2.5	1.1	7.4	18.7	5.3	3.1	6.5	7.9	9.1	3.4	14.8	9.4	89.2
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	14.9	7.8	180.7	79.5	19.1	11.2	11	15.2	29.4	6.5	33.1	74.1	482.4
12	Precipitation	4.3	43.4	78.7	71.1	73.4	76.2	65	111	143.8	60.5	87.9	95.8	911.1
	OF	0.5	7.7	9	6	6	5.2	4.3	9.8	16.3	5.3	10	19.5	99.6
	IF	12.7	6.5	22.9	15.7	11.2	5.3	0.2	1	19.4	1.7	7.3	19.7	123.6
	BF	18.6	10.1	13.9	12.1	7.2	4.1	3.3	3.6	6.2	7.3	9.9	14.8	111.1
	ET	0	1.4	2	18	72	93.4	106.5	81.3	53.4	23.3	4.4	1.1	456.8
	Deep	0.7	14.3	19.4	12.7	10.5	4.7	0.1	1.1	19.9	1.6	13.4	22	120.4
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	31.8	24.3	45.8	33.8	24.4	14.6	7.8	14.4	41.9	14.3	27.2	54	334.3
13	Precipitation	6.3	9.7	210.6	113.3	77.7	62	116.1	119.6	78.5	40.4	96.3	99.6	1029.9
	Overland Flow	2	2.6	145.3	36.5	4.3	2.9	5.6	6.6	13.2	2	9.8	52.1	282.9
	Interflow	3.9	0.4	28.4	30	4.7	2.8	0.5	2.9	9.4	0.3	14.1	8.6	106
	Base Flow	9.6	4.5	4.7	11.7	8.1	3.8	0.8	1.1	4	2.9	5.3	11.4	67.9
	Evapotranspiration	0	1.4	2	18	72	96.4	114.1	89	57.5	24	2.7	1.1	478.3
	Deep Recharge	2.5	1.2	8.1	20	5.8	3.3	6.8	8.4	9.7	3.6	15.8	10.1	95.4
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	15.5	7.6	178.5	78.2	17	9.5	6.9	10.6	26.6	5.2	29.2	72.1	456.9
65	Precipitation	6.5	9.8	191.3	98.6	77.7	62	116.1	119.6	78.5	40.4	96.5	88.1	985
	Overland Flow	0.6	0.9	24.2	7.9	5.2	3.7	7.4	8.4	6.7	2.6	8.4	9.9	85.8
	Interflow	3.4	0.2	90.1	35.7	2.6	0.6	0.1	0.3	2	0.1	1.1	6.5	142.7
	Base Flow	9	1.5	15.3	38.4	10.1	6.2	3.5	8.1	15.9	4.7	21	17	150.6
	Evapotranspiration	0	1.4	2	18	72	91.8	104.3	84.1	54.6	24.1	2.7	1.1	456.2
	Deep Recharge	2.5	0.9	15.4	19.1	8.5	6	10.6	10.6	9.9	4.8	17.3	4.9	110.7
	SW_{in}	0	0	0	0	0	0	0	0	0	0	0	0	0
	SW_{out}	13	2.6	129.7	81.9	17.8	10.5	10.9	16.8	24.5	7.3	30.5	33.4	379.1
66	Precipitation	8.1	21.4	145.5	86.6	77.7	62	116.1	119.6	78.5	40.4	96.3	117.1	969.4

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Overland Flow	0.7	1.9	14.8	6.3	4.7	3.4	6.7	7.6	6.1	2.4	7.7	11	73.3
	Interflow	9.6	1.2	69.5	25.1	2.9	0.9	0.1	0.5	2.6	0.2	2.3	17.7	132.3
	Base Flow	21	4.3	26.7	52.3	14.6	12.1	5.6	16.4	28.1	9.1	24.8	42.4	257.5
	Evapotranspiration	0	1.4	8.2	27.1	73.1	95.4	112.6	89.2	56.7	24.4	9.5	1.1	498.6
	Deep Recharge	0.2	0.1	1.1	1.1	0.6	0.4	0.8	0.7	0.7	0.3	1	1	8
	SW_{in}	5.6	1.3	19.6	14.8	3.9	2.8	2.2	4.4	6.6	2.1	6.2	12.7	82.1
	SW_{out}	36.9	8.8	130.6	98.5	26	19.2	14.6	28.9	43.4	13.8	41	83.8	545.2

3.2.6 Tier 1 Stress Assessment

Tier 1 studies use a simple ratio of water demand to water supply to determine if water supply in a subwatershed is stressed with respect to water quantity. The percent water demand is calculated using the following equation:

Equation 3.1: Water Budget Mass Balance

$$\%\ \textit{Water Demand} = \frac{Q_{Demand}}{Q_{Supply} - Q_{Reserve}} \times 100$$

Where Q_{Demand} is the anthropogenic water use from streams, ponds, lakes or groundwater in the subwatershed; Q_{Supply} is the surface water supply or groundwater supply; and $Q_{Reserve}$ is a measure of safety designed to account for the ecological demand and water used that is not accounted for in subwatersheds.

The percent water demand ratio is used as a relative indicator of hydrologic stress and is designed to highlight subwatersheds where the degree of stress warrants further analysis for quantity risk characterization. Water demand is evaluated considering current demand and future demand conditions.

Surface water and groundwater quantity stress assessments were carried out for all 14 (Raisin) and 53 (South Nation) subwatersheds. The thresholds for qualifying water quantity stress levels are shown in *Table 0.27*.Subwatersheds that supply a municipal drinking source that show Moderate or Significant stress based on these thresholds are to be considered for Tier 2 stress assessment.

Table 0.27: Tier 1 Water Quantity Stress Level Thresholds

Water Quantity Stress Level	Maximum Monthly Percent Demand (Surface Water)	Maximum Monthly Percent Demand (Groundwater)	Maximum Annual Percent Demand (Groundwater)
Significant	> 50 %	> 50 %	> 25 %
Moderate	20% to 50%	20% to 50%	10% to 25%
Low	< 20%	< 25%	< 10%

Low, sensitivity analysis of data required	18% to 20%	23% to 25%	8% to 10%

3.2.7 Tier 1 Surface Water Stress Calculations

Current percent water demand calculations for surface water were carried out on a monthly scale. The Supply, Reserve, Current Demand and Current Percent Demand values for each subwatershed are presented in *Table 0.28*.Future demand stress assessments were carried out for the subwatershed containing the Alexandria Municipal Drinking Water System. This is the only subwatershed in the Source Protection Area that contains a Municipal Drinking Water System that draws its water from an inland lake source and not from the St. Lawrence River. The results of the future demand stress assessment are shown in *Table 0.29*.

The Percent Demand was calculated in accordance with *Equation 3.1*; Water Supply was calculated through the HSPF numerical model; Water Reserve was estimated as the tenth percentile of monthly flow. Demand is represented as anthropogenic consumptive demand.

Table 0.28: Tier 1 Surface Water Stress Assessment, Current Demand (flows in m^3/s)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	QSUPPLY	0.426	0.086	5.110	3.783	0.735	0.328	0.133	0.676	0.706	0.247	1.209	1.273
	QRESERVE	0.210	0.059	0.803	1.755	0.258	0.133	0.021	0.243	0.276	0.086	0.464	0.528
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	QSUPPLY	0.324	0.133	2.390	2.088	0.443	0.203	0.069	0.281	0.318	0.113	0.440	0.880
	QRESERVE	0.194	0.109	0.357	0.814	0.242	0.096	0.033	0.077	0.146	0.070	0.164	0.374
	QDEMAND	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
	%DEMAND	4%	**26%	0%	1%	3%	6%	16%	3%	3%	13%	2%	1%
3	QSUPPLY	0.431	0.082	1.807	2.423	0.560	0.315	0.071	0.304	0.435	0.172	0.534	1.118
	QRESERVE	0.203	0.053	0.655	1.176	0.252	0.112	0.027	0.117	0.228	0.075	0.270	0.752
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
4	QSUPPLY	0.167	0.081	0.703	0.855	0.243	0.117	0.030	0.116	0.144	0.062	0.313	0.310
	QRESERVE	0.115	0.068	0.118	0.397	0.127	0.047	0.013	0.026	0.062	0.041	0.087	0.195
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	QSUPPLY	0.161	0.079	0.678	0.824	0.234	0.113	0.029	0.112	0.139	0.060	0.302	0.299
	QRESERVE	0.111	0.066	0.114	0.382	0.123	0.046	0.013	0.025	0.060	0.039	0.083	0.188
	QDEMAND	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	%DEMAND	2%	10%	0%	0%	1%	2%	7%	1%	2%	6%	1%	1%
6	QSUPPLY	0.408	0.168	3.013	2.632	0.559	0.256	0.087	0.355	0.401	0.143	0.554	1.110

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	QRESERVE	0.245	0.138	0.450	1.026	0.305	0.121	0.042	0.097	0.185	0.088	0.207	0.472
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	QSUPPLY	0.290	0.072	1.365	1.123	0.267	0.153	0.074	0.277	0.335	0.136	0.384	0.836
	QRESERVE	0.123	0.045	0.467	0.517	0.086	0.060	0.007	0.131	0.165	0.059	0.175	0.382
	QDEMAND	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
	%DEMAND	4%	**22%	1%	1%	3%	6%	9%	4%	3%	8%	3%	1%
8	QSUPPLY	0.840	0.159	3.518	4.719	1.091	0.614	0.138	0.592	0.847	0.335	1.040	2.177
	QRESERVE	0.395	0.104	1.275	2.289	0.491	0.219	0.052	0.229	0.444	0.147	0.527	1.465
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	QSUPPLY	0.225	0.043	0.941	1.262	0.292	0.164	0.037	0.158	0.227	0.089	0.278	0.582
	QRESERVE	0.106	0.028	0.341	0.612	0.131	0.059	0.014	0.061	0.119	0.039	0.141	0.392
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	QSUPPLY	2.574	1.059	19.011	16.607	3.524	1.614	0.552	2.237	2.527	0.900	3.497	7.000
	QRESERVE	1.543	0.868	2.840	6.474	1.923	0.765	0.264	0.610	1.165	0.553	1.304	2.977
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	QSUPPLY	0.411	0.200	1.729	2.103	0.597	0.288	0.073	0.286	0.355	0.152	0.770	0.763
	QRESERVE	0.282	0.168	0.290	0.976	0.313	0.117	0.032	0.063	0.152	0.101	0.213	0.480
	QDEMAND	0.005	0.005	0.005	0.005	0.005	0.010	0.009	0.009	0.010	0.005	0.005	0.005
	%DEMAND	4%	16%	0%	0%	2%	6%	**23%	4%	5%	9%	1%	2%
12	QSUPPLY	0.225	0.036	2.076	1.711	0.692	0.253	0.073	0.451	0.466	0.494	0.954	2.528
	QRESERVE	0.058	0.018	0.224	1.154	0.149	0.098	0.017	0.068	0.099	0.121	0.210	0.328
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
13	QSUPPLY	0.645	0.248	5.274	4.670	0.773	0.390	0.125	0.433	0.710	0.205	0.645	1.778
	QRESERVE	0.367	0.203	0.804	1.637	0.432	0.189	0.069	0.169	0.300	0.131	0.301	0.744
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
65	QSUPPLY	0.709	0.144	8.508	6.299	1.224	0.546	0.221	1.125	1.175	0.411	2.013	2.120
	QRESERVE	0.350	0.098	1.337	2.922	0.429	0.221	0.034	0.405	0.459	0.144	0.773	0.878
	QDEMAND	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	%DEMAND	1%	10%	0%	0%	1%	1%	2%	1%	1%	2%	0%	0%
66	QSUPPLY	1.978	0.489	9.182	7.648	1.864	1.051	0.431	1.906	2.264	0.891	2.470	5.646
	QRESERVE	0.830	0.307	3.154	3.506	0.598	0.414	0.061	0.910	1.126	0.400	1.176	2.588

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	QDEMAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	%DEMAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

**20 – 50%	Indicates Moderate Stress
***> 50 %	Indicates Significant Stress

Table 0.29: Tier 1 Surface Water Stress Assessment, Future Demand (flows in m³/s)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	Q_{SUPPLY}	0.290	0.072	1.365	1.123	0.267	0.153	0.074	0.277	0.335	0.136	0.384	0.836
	$Q_{RESERVE}$	0.123	0.045	0.467	0.517	0.086	0.060	0.007	0.131	0.165	0.059	0.175	0.382
	Q_{DEMAND}	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
	$\%_{DEMAND}$	5%	**30%	1%	1%	4%	8%	12%	5%	5%	10%	4%	2%

**20 – 50%	Indicates Moderate Stress
***> 50 %	Indicates Significant Stress

3.2.8 Tier 1 Surface Water Stress Assessment

The maximum monthly percent water demand for subwatersheds #2, 7 and 11 showed moderate stress in one or more months under the current demand scenario. No subwatersheds showed significant stress. The remaining subwatersheds were considered low stress. Subwatershed #7 contains a municipal drinking water source (Town of Alexandria), and was therefore assessed under a future scenario (based on increased demand from anticipated population growth as per Official Plan estimates). Under the future scenario, anthropogenic consumption increased by 34%. Subwatershed #7 is still considered moderately stressed in the future scenario.

The municipal drinking water supply for the Town of Alexandria has also had documented periodic water shortages, thereby supporting the stress assessment calculations.

3.2.9 Tier 1 Groundwater Stress Calculations

Current percent water demand calculations for groundwater were carried out on a monthly and annual scale. The Supply, Reserve, Current Demand and Current Percent Demand values for each subwatershed are presented in *Table 0.30*. Future demand stress assessments were carried out for the two subwatersheds in the Source Protection Area that have a municipal drinking water system (Glen Robertson and Redwood Estates). The results of the future demand stress assessment are shown in *Table 0.31*.

The Percent Demand was calculated in accordance with *Equation 3.1*; monthly Water Supply was calculated as one-twelfth the annual groundwater recharge (as computed through the HSPF numerical model); Water Reserve is assumed as 10% of the supply. Demand is represented as anthropogenic consumptive demand.

Table 0.30: Tier 1 Groundwater Stress Assessment, Current Demand (flows in m³/s)

SWS	Param.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	Q_{SUPPLY}	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630
1	$Q_{RESERVE}$	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
1	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.007	0.007	0.004	0.004	0.004	0.004	0.004
1	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
2	Q_{SUPPLY}	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157
2	$Q_{RESERVE}$	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
2	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.007	0.007	0.003	0.003	0.003	0.003	0.003
2	$\%_{DEMAND}$	2%	2%	2%	2%	2%	5%	5%	2%	2%	2%	2%	2%
3	Q_{SUPPLY}	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448
3	$Q_{RESERVE}$	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
3	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.007	0.007	0.003	0.003	0.003	0.003	0.004
3	$\%_{DEMAND}$	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
4	Q_{SUPPLY}	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093
4	$Q_{RESERVE}$	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
4	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.002	0.002	0.002	0.002	0.002
4	$\%_{DEMAND}$	2%	2%	2%	2%	2%	5%	5%	2%	2%	2%	2%	3%
5	Q_{SUPPLY}	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
5	$Q_{RESERVE}$	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
5	Q_{DEMAND}	0.033	0.033	0.033	0.033	0.033	0.034	0.034	0.033	0.033	0.033	0.033	0.033
5	$\%_{DEMAND}$	**41%	**41%	**41%	**41%	**41%	**42%	**42%	**41%	**41%	**41%	**41%	***41%
6	Q_{SUPPLY}	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197
6	$Q_{RESERVE}$	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
6	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.007	0.007	0.002	0.002	0.002	0.002	0.003
6	$\%_{DEMAND}$	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	2%
7	Q_{SUPPLY}	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
7	$Q_{RESERVE}$	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
7	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001
7	$\%_{DEMAND}$	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%
8	Q_{SUPPLY}	0.872	0.872	0.872	0.872	0.872	0.872	0.872	0.872	0.872	0.872	0.872	0.872
8	$Q_{RESERVE}$	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087
8	Q_{DEMAND}	0.006	0.006	0.006	0.006	0.006	0.013	0.013	0.006	0.006	0.006	0.006	0.007
8	$\%_{DEMAND}$	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
9	Q_{SUPPLY}	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
9	$Q_{RESERVE}$	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
9	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.002	0.002	0.002	0.002	0.002
9	$\%_{DEMAND}$	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%

SWS	Param.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10	Q_{SUPPLY}	0.738	0.738	0.738	0.738	0.738	0.738	0.738	0.738	0.738	0.738	0.738	0.738
10	$Q_{RESERVE}$	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
10	Q_{DEMAND}	0.009	0.009	0.009	0.009	0.009	0.027	0.027	0.009	0.009	0.009	0.009	0.012
10	$\%_{DEMAND}$	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	2%
11	Q_{SUPPLY}	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228
11	$Q_{RESERVE}$	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
11	Q_{DEMAND}	0.052	0.052	0.052	0.052	0.052	0.057	0.057	0.052	0.052	0.052	0.052	0.053
11	$\%_{DEMAND}$	**26%	**26%	**26%	**26%	**26%	**28%	**28%	**26%	**26%	**26%	**26%	***26%
12	Q_{SUPPLY}	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
12	$Q_{RESERVE}$	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
12	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.009	0.009	0.003	0.003	0.003	0.003	0.004
12	$\%_{DEMAND}$	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
13	Q_{SUPPLY}	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263
13	$Q_{RESERVE}$	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
13	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.009	0.009	0.003	0.003	0.003	0.003	0.004
13	$\%_{DEMAND}$	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	2%
65	Q_{SUPPLY}	1.526	1.526	1.526	1.526	1.526	1.526	1.526	1.526	1.526	1.526	1.526	1.526
65	$Q_{RESERVE}$	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153
65	Q_{DEMAND}	0.015	0.015	0.015	0.015	0.015	0.023	0.023	0.015	0.015	0.015	0.015	0.017
65	$\%_{DEMAND}$	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
66	Q_{SUPPLY}	1.580	1.580	1.580	1.580	1.580	1.580	1.580	1.580	1.580	1.580	1.580	1.580
66	$Q_{RESERVE}$	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
66	Q_{DEMAND}	0.006	0.006	0.006	0.006	0.006	0.012	0.012	0.006	0.006	0.006	0.006	0.007
66	$\%_{DEMAND}$	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	1%

Monthly Basis	Annual Basis	
*23 - 25%	*8 - 10%	Indicates Low Stress, but sensitivity analysis is required
**25 - 50%	**10 - 25%	Indicates Moderate Stress
***> 50%	***> 25%	Indicates Significant Stress

Table 0.31: Tier 1 Groundwater Stress Assessment, Future Demand (flows in m³/s)

SWS	Param.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	Q_{SUPPLY}	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630	0.630
1	$Q_{RESERVE}$	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
1	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.007	0.007	0.004	0.004	0.004	0.004	0.004
1	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
2	Q_{SUPPLY}	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157
2	$Q_{RESERVE}$	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016

SWS	Param.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.007	0.007	0.003	0.003	0.003	0.003	0.004
2	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	5%	5%	2%	2%	2%	2%	2%

3.2.10 Tier 1 Groundwater Stress Assessment

The maximum monthly percent water demand for subwatersheds #5 and 11 showed moderate stress in one or more months under the current demand scenario, and significant stress in the annual assessment for current demand. The remaining subwatersheds were considered low stress. Subwatersheds #1 and #2 contain a municipal drinking water source (Glen Robertson and Redwood Estates), and were therefore assessed under a future scenario (based on increased demand from anticipated population growth as per Official Plan estimates). Under the future scenario, anthropogenic consumption increased by 27% for Glen Robertson and 19% for Redwood Estates and resulted in little change on the stress calculations. Neither of the subwatersheds with a municipal drinking water system is considered stressed in terms of groundwater demand for the future scenario.

There have been no documented shortages for municipal groundwater drinking water supplies in the Source Protection Area; thereby supporting the stress assessment calculations.

There are no subwatersheds to be considered for a Tier 2 groundwater stress assessment in the Source Protection Area.

3.2.11 Subwatersheds to be studied further in a Tier 2 Stress Assessment

Subwatersheds are to be studied further in a Tier 2 stress assessment if there is historical record of water supply problems and/or a subwatershed containing a municipal drinking water system can be shown to be *Moderately* or *Significantly* stressed in the current demand or future demand scenario. A summary of stress assessments is presented in **Table 0.32** and shown on *Map 3.15* and *Map 3.16*.Subwatersheds to be considered for a Tier 2 surface water stress assessment are shown in *Table 0.33*.

Table 0.32: Tier 1 Summary of Stress Assessments

SWS	Surface Water Subwatersheds				Groundwater Subwatersheds					
	Current Demand	Future Demand	Has Municipal system?	Elevate to Tier 2?	Current Demand		Future Demand		Has Municipal system?	Elevate to Tier 2?
					Monthly	Annual	Monthly	Annual		
1	Low	n/a	No		Low	Low	Low	Low	Yes	No
2	Moderate	n/a [1]	Yes [2]		Low	Low	Low	Low	Yes	No
3	Low	n/a	No		Low	Low	n/a	n/a	No	
4	Low	n/a	Yes [2]		Low	Low	n/a	n/a	No	
5	Low	n/a	No		Moderate	Significant	n/a [1]	n/a [1]	No	

6	Low	n/a	No		Low	Low	n/a	n/a	No	
7	Moderate	Moderate	Yes	Yes	Low	Low	n/a	n/a	No	
8	Low	n/a	No		Low	Low	n/a	n/a	No	
9	Low	n/a	No		Low	Low	n/a	n/a	No	
10	Low	n/a	No		Low	Low	n/a	n/a	No	
11	Moderate	n/a [1]	Yes [2]		Moderate	Significant	n/a [1]	n/a [1]	No	
12	Low	n/a	No		Low	Low	n/a	n/a	No	
13	Low	n/a	No		Low	Low	n/a	n/a	No	
65	Low	n/a	No		Low	Low	n/a	n/a	No	
66	Low	n/a	No		Low	Low	n/a	n/a	No	

Note: 1) Although the Stress Assessment is greater than "Low", future demand is not considered as there is no municipal system in the subwatershed (drawing from a source other than the St. Lawrence River)
2) These surface water subwatersheds have municipal drinking water systems; however, the source water is the St. Lawrence River and future demand stress assessments are not required.

Table 0.33: Subwatersheds to be considered for Tier 2 Stress Assessment

SWS	Surface Water or Groundwater	Water Quantity Stress Level	Rationale for Tier 2 Assessment
7	Surface Water	Moderate	Percent Demand is 22% under current situation for the month of February; Percent Demand is 30% under future demand scenario for the month of February. Subwatershed has a municipal surface water intake. Historic water supply problems have been previously documented.

3.2.12 Tier 1 Stress Assessment Uncertainty

There are various sources of uncertainty in the Tier 1 stress assessment, which are primarily related to the regional scale calculations: specifically, extrapolation of regional climate data (precipitation and evapotranspiration). Additional uncertainty is attributed to consumptive demand: maximum permitted water withdrawal values were used where actual measured values were not available.

Overall, a conservative approach was used to carry out the percent water demand resulting in higher stress assessments than are actually the case. The aim of the Tier 1 assessment is to screen out subwatersheds that are not stressed. The over-estimation of stress reduces the uncertainty for the subwatersheds that were not elevated to Tier 2 studies. The uncertainty therefore is considered to be low.

3.3 Tier 2 Water Budget

Water budget and stress assessments follow a three-tiered approach, with each tier being more detailed and containing greater certainty in the results than the previous. Section 3.2 described the approach and results for the Tier 1 study, the first level in the three-tiered approach. The Tier 1 analyses for the Raisin Region subwatersheds identified one subwatershed, SWS7 or the Garry River subwatershed, which required a Tier 2 analysis. The Tier 2 analysis of this subwatershed is described in this section.

The Tier 2 analysis is carried out at the same spatial scale and the same time scale as the Tier 1 analysis. The subwatershed area for the Garry River subwatershed is shown in *Map 3.14*.

A comprehensive document, "Tier 2 Water Budget. Subwatershed #7 - Garry River for Raisin-South Nation Source Protection Region", was produced by Dillon Consulting in 2010 to support this section of the Assessment Report. The results from this report are presented herein.

3.3.1 Tier 2 Stress Analysis Scenarios

The stress assessment is based on three conditions that are combined to define the various scenarios evaluated in this study. These include:

1. Current conditions - to identify subwatersheds under stress with existing water takings and average climate conditions;
2. Future demand - to identify additional subwatersheds that may become stressed with increased water takings or planned land use changes. The future demand projections are to be consistent with local municipal Official Plans;
3. Drought conditions - to evaluate stress levels under a prolonged drought (2 and 10 years).

Based on the above conditions, nine scenarios are defined for existing and planned systems. The nine scenarios are described in *Table 0.34*. The Garry River subwatershed does not have planned systems; therefore, assessment of scenarios related to planned systems (Scenarios C, F and I) are not required. Scenarios A and B are evaluated using the percent water demand equation and compared to the stress thresholds shown in *Table 0.35* below in order to assign a stress level.

Table 0.34 Tier 2 Scenarios for existing systems

Scenario	Description
Scenario A	• This scenario calculates the water quantity stress based on current conditions • Historical land use and climate data were used as the model input • Level of stress determined using the stress thresholds in Table 3.12
Scenario B	• This scenario calculates the water quantity stress based on future conditions • Historical climate data were used as the model input • Future land use was estimated based on current land use • Future water demand was estimated based on projected population. • Level of stress determined using the stress thresholds in Table 3.12

Scenario	Description
Scenario C	• This scenario applies to planned systems and is therefore not considered for existing systems.
Scenario D	• This scenario examines the performance of the system during a two year drought based on current conditions • Historical land use and climate data were used as the model input • Level of stress determined based on the relative depth of the calculated groundwater level compared to depth of the well screen
Scenario E	• This scenario examines the performance of the system during a two year drought based on future conditions • Historical climate data were used as the model input • Future land use was estimated based on current land use • Future water demand was estimated based on projected population. • Level of stress determined based on the relative depth of the calculated groundwater level compared to depth of the well screen
Scenario F	• This scenario applies to planned systems and is therefore not considered for existing systems.
Scenario G	• This scenario examines the performance of the system during a ten year drought based on current conditions • Historical land use and climate data were used as the model input • Level of stress determined based on the relative depth of the calculated groundwater level compared to depth of the well screen
Scenario H	• This scenario examines the performance of the system during a ten year drought based on future conditions • Historical climate data were used as the model input • Future land use was estimated based on current land use • Future water demand was estimated based on projected population. • Level of stress determined based on the relative depth of the calculated groundwater level compared to depth of the well screen
Scenario I	• This scenario applies to planned systems and is therefore not considered for existing systems.

The scenarios are undertaken sequentially. When a subwatershed is found to be moderately or significantly stressed by a specific scenario, no further evaluation at the Tier 2 scale is required. If a subwatershed is found to have low stress under all scenarios, then no further evaluation at the Tier 3 scale is required.

Figure 0.18: Tier 2 Stress Assessment Process

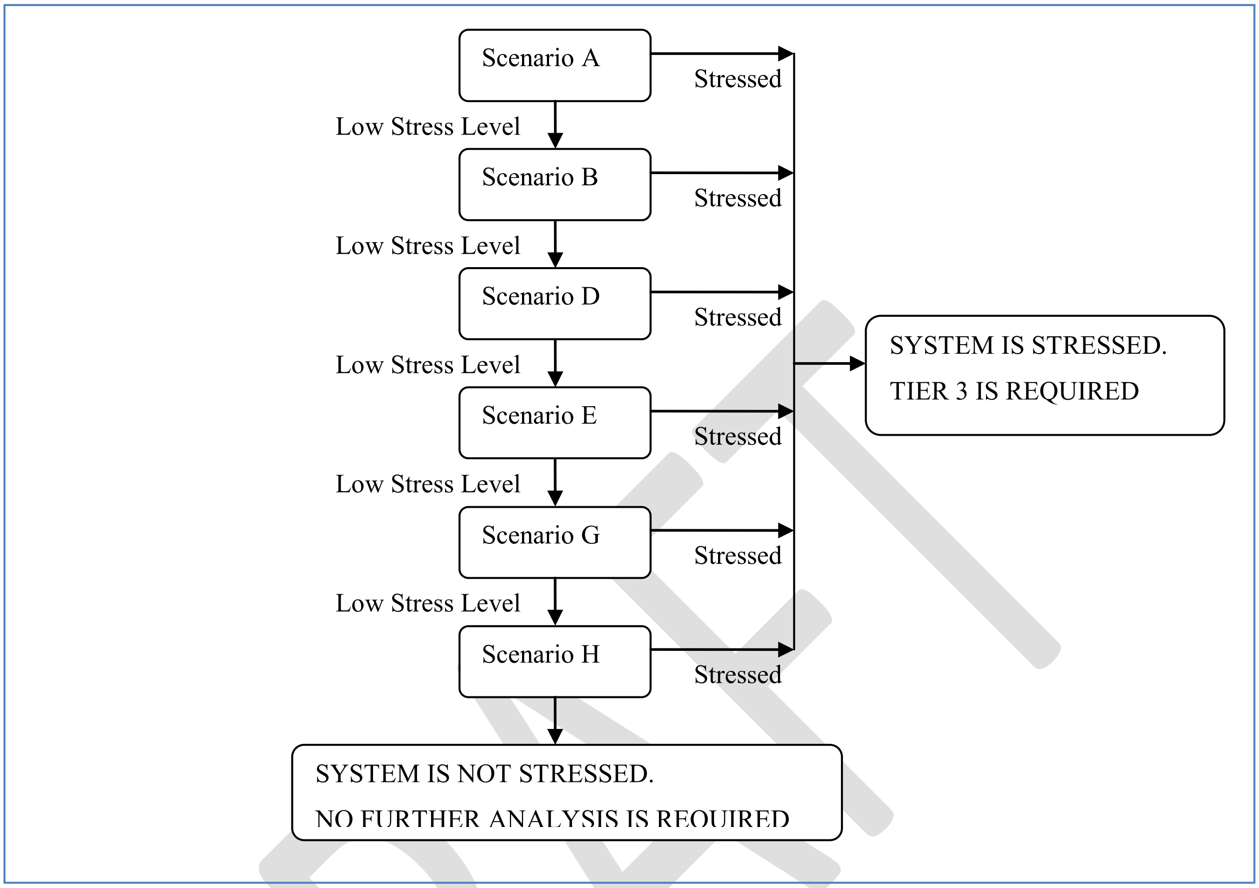


Table 0.35 Surface Water Stress Thresholds

Surface Water Quantity Stress Assignment (% Water Demand)	Current Conditions Monthly Maximum	Future Demand Monthly Maximum
Significant	50% or higher	50% or higher
Moderate	More than 20% but less than 50%	More than 20% but less than 50%
Low	20% or less	20% or less

3.3.2 Tier 2 Water Takings

The only permitted water taking from the Garry River subwatershed was the Alexandria water treatment plant. The Tier 2 water taking was revised compared to the taking reported in the Tier 1 analysis. The revised taking was based on data that showed the closure of a significant business. Consumptive factors, the measure of how much water is consumed versus returned to the system, were taken from Provincial Guidance.

The Tier 2 study also revised the consumptive factor for the Alexandria water treatment plant water taking to 1, which indicates all of the water taken by the treatment plant is removed from the subwatershed. The consumptive factor was revised because all of the water taken from the treatment plant is returned to the Delisle River, and not returned to the Garry River subwatershed. Future demand was based on a projected population increase of approximately 1% per year over a 20 year time frame. The takings are summarized in *Table 0.36*.

Table 0.36: Tier 1 Consumptive Water Takings

SWS	Surface Water Takings (m^3/s)	
	Current	Future
7	0.025	0.032

3.3.3 Tier 2 Water Demand (Scenarios A and B)

Tier 2 studies use a simple ratio of water demand to water supply to determine if water supply in a subwatershed is stressed with respect to water quantity. The percent water demand is calculated using *Equation 3.1*.

The demand in the Garry River subwatershed was the anthropogenic water use from the Alexandria water treatment plant, and the supply and reserve water is from the Garry River. Surface water supply and demand are obtained from surface water flow data. However, surface water flow data was not available for the Garry River. The closest surface water flow gauge was located downstream of the Garry River subwatershed, in the Delisle River near Glen Norman. In order to obtain surface water flow data for the Garry River, a numerical model was created for the Delisle River watershed, which includes the Garry River subwatershed.

The physical system for the Delisle River watershed model was simulated by inputting data for topography, land use, soil type, and climate (e.g., precipitation and temperature) into a hydrological model called Hydrologic Simulation Program Fortran or HSPF. HSPF is a numerical model created by the U.S. Environmental Protection Agency. Surface water flows in the Delisle River and the Garry River were simulated by changing the hydrological responses of different land uses and soil types until the calculated surface water flows in the Delisle River were as close as possible to the observed flows in the Delisle River for the period of 1990 to 2004.

The simulated surface water flows for the Garry River were used to calculate the surface water supply and surface water reserve values for the percent water demand calculation. Water Supply was calculated as the median (50^{th} percentile) monthly water flow in the Garry River simulated by the HSPF numerical model. Water Reserve was estimated as the 10^{th} percentile of the simulated Garry River monthly flow. The percent water demand was calculated monthly for the Garry River subwatershed for the current (*Table 0.37*) and future (*Table 0.38*) scenarios.

Table 0.37: Tier 2 Surface Water Stress Assessment, Scenario A - Current Demand (flows in m³/s)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	Q_{SUPPLY}	0.419	0.323	0.694	1.441	0.756	0.532	0.527	0.496	0.476	0.535	0.510	0.473
	$Q_{RESERVE}$	0.187	0.249	0.590	0.858	0.474	0.405	0.358	0.318	0.358	0.327	0.348	0.330
	Q_{DEMAND}	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	$\%_{DEMAND}$	11%	**35%	**25%	4%	9%	20%	15%	14%	**22%	12%	16%	18%

Table 0.38: Tier 2 Surface Water Stress Assessment, Scenario B - Future Demand (flows in m³/s)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	Q_{SUPPLY}	0.419	0.323	0.694	1.441	0.756	0.532	0.527	0.496	0.476	0.535	0.510	0.473
	$Q_{RESERVE}$	0.187	0.249	0.590	0.858	0.474	0.405	0.358	0.318	0.358	0.327	0.348	0.330
	Q_{DEMAND}	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	$\%_{DEMAND}$	14%	**44%	**31%	6%	12%	**25%	19%	18%	**28%	16%	20%	23%

** Indicates Moderate Stress

3.3.4 Tier 2 Surface Water Stress Assessment

The maximum monthly percent water demand for the Garry River subwatershed showed *Moderate* stress in four months in the current demand scenario (Scenario A) and *Moderate* stress in six months in the future demand scenario (Scenario B). Due to the calculated *Moderate* stresses subsequent drought scenarios (Scenarios D, E, G and H) were not calculated.

Subwatersheds are to be studied further in a Tier 3 stress assessment if there is historical record of water supply problems and/or a subwatershed containing a municipal drinking water system can be shown to be *Moderately* or *Significantly* stressed in the current demand or future demand scenario. There are documented records of the Alexandria water supply system having low water quantity, and the Garry River subwatershed had calculated *Moderate* stresses (*Table 0.39*). Therefore, the Garry River subwatershed (SWS7) should be considered for a Tier 3 surface water stress assessment. The Tier 2 Surface Water Stress Assessment is shown on *Map 3.17*.

Table 0.39: Subwatersheds to be considered for Tier 2 Stress Assessment

SWS	Surface Water or Groundwater	Water Quantity Stress Level	Rationale for Tier 2 Assessment
7	Surface Water	Moderate	Percent Demand is 35% under current situation for the month of February; Percent Demand is 44% under future demand scenario for the month of February. Subwatershed has a municipal surface water intake. Historic water supply problems have been previously documented.

3.3.5 Tier 2 Stress Assessment Uncertainty

The uncertainty in the Tier 2 stress assessment is primarily related to the watershed scale calculations. Specifically, there is uncertainty in simulating the hydrologic response of a watershed based on user defined land use and climate data. However, the HSPF model was satisfactory calibrated to historical surface water flows, and permitted water demands were certain. In addition, the maximum percentage water demand is sufficiently high that potential uncertainties in the input parameters would not affect the determined stress level. The uncertainty is considered to be low.

3.4 Tier 3 Water Budget

A Tier 3 Water Budget Assessment is carried out on all municipal water supplies located within the subwatersheds that are classified in the Tier 2 assessment as moderately stressed or significantly stressed. The Alexandria municipal surface water intake is the only surface water intake located in the Garry River watershed. The Tier 3 assessment is a more detailed study than the Tier 2 assessment and considers storage changes and water level fluctuations on a daily scale.

The subwatershed area for the Garry River subwatershed is shown in *Map 3.14*. As per the *Technical Rules*, this area is considered the *Local Area* for the purpose of the Tier-3 evaluation.

Water for the Alexandria drinking water supply is directly drawn from Mill Pond. Mill Pond is a small, shallow lake. The surface area is approximately 0.26 km^2 and the average depth is less than 1.5m. The intake is located at a deeper area of the lake, where the Garry River enters. Water travels along the Garry River into Mill Pond through Loch Garry and Middle Lake. Dams at Loch Garry and Middle Lake regulate their outflows. A dam at the downstream end of Mill Pond regulates the water level available to the drinking water system. The Ministry of the Environment requires a minimum 30 L/s outflow from Mill Pond be maintained at all times. This outflow is to ensure a minimum amount of assimilative capacity in the Delisle River for downstream wastewater lagoon effluent.

A comprehensive document, “Tier 3 Water Budget and Water Quantity Risk Assessment, Alexandria Water Supply”, was produced by Dillon Consulting in 2011 to support this section of the Assessment Report. The results from this report are presented herein.

3.4.1 Tier 3 Risk Scenarios

The Technical Rules require a risk level be assigned to every local area based on an evaluation of various scenarios. The various risk scenarios to be considered are presented in *Table 3.25*.

Table 0.40: Surface Water Quantity Risk Scenarios

Scenario	Time Period	Land Cover of the Local Area	Allocated Quantity of Water	Other Permitted Water Takings	Model Simulation
A	Climate data period	Existing	Existing demand	Existing	Long term daily flow using hourly climate and monthly pumping
B	Two year or greater drought period	Existing	Existing demand	Existing	Long term daily flow using hourly climate and monthly pumping
E (1)	Climate data period	Projected demand and reduction in recharge	Existing plus committed plus planned demand	Anticipated	Long term daily flow using hourly climate and monthly pumping
E (2)	Climate data period	Existing	Existing plus committed plus planned demand	Existing	Long term daily flow using hourly climate and monthly pumping
E (3)	Climate data period	Reduction in recharge	Existing	Anticipated	Long term daily flow using hourly climate and monthly pumping
F (1)	Two year or greater drought period	Projected demand and reduction in recharge	Existing plus committed plus planned demand	Anticipated	Long term daily flow using hourly climate and monthly pumping
F (2)	Two year or greater drought period	Existing	Existing plus committed plus planned demand	Existing	Long term daily flow using hourly climate and monthly pumping
F (3)	Two year or greater drought period	Reduction in recharge	Existing	Anticipated	Long term daily flow using hourly climate and monthly pumping

Scenarios E (1), E (2), F (1) and F (2) reference "committed plus planned demand". As there is no significant committed or planned demand (i.e., approved plans of subdivision) in the local area, these scenarios are not considered. Additionally, as there are no new significant developments expected to occur in the local area there will be no significant increase in impervious areas or a significant conversion of existing land cover upstream of the intake. There is therefore no requirement to review Scenarios E (1), E (3), F (1) and F (3).

The scenarios that are required to be evaluated are Scenario A and Scenario B.

3.4.2 Risk Assessment, Scenario A

From *the Rules*, the local area shall be assigned a risk level of significant if:

a) During the assessment period, the quantity of water that can be taken from the surface water body in the local area would be insufficient to meet the allocated quantity of water of the intake; or
b) During the assessment period, the existing system is not capable of meeting peak demand.

In selecting the assessment period for this analysis, historic water use was considered. In 2005, a significant water user ceased operation. This facility, a textile plant, consumed approximately 30% of the municipal water supply. Since 2005 the overall municipal water demand has dropped significantly. The recent period 2005 to 2010 was therefore selected as an appropriate assessment period for Tier 3 risk assessment analysis.

To evaluate whether the surface water body can meet the allocated quantity of water at the intake, the “shut-off” water elevation in Mill Pond is referenced. The shut-off elevation prior to May 2007 was reported as 81.1 masl. The benchmark for which this water level was referenced was resurveyed, and found to be 0.15 m too high. The benchmark has since been corrected. The actual shut-off elevation was not altered but it is now reported at 80.95 masl. The RRCA monitors water levels in Mill Pond. The minimum recorded water levels are shown in *Table 0.41*.

Table 0.41: Minimum Recorded Water Levels (masl), Mill Pond

Year	2005	2006	2007	2008	2009	2010
Minimum Level (masl)	81.38	81.48	81.45	81.32	81.40	81.38

The water level during the assessment period did not drop below the shut-off water elevation. The water treatment plant operator also confirmed that the intake was never shut off in the past due to low water levels.

To determine peak demand, the maximum daily flows recorded at the water treatment plant were reviewed for the assessment period. Maximum flows are presented in *Table 0.42*.

Table 0.42: Maximum Daily Flow Rate (m^3/day), Alexandria Water Treatment Plant

Year	2005	2006	2007	2008	2009	2010
Maximum Daily Flow (m^3/day)	2,807	3,082	3,940	3,957	3,391	2,420

The water treatment plant has a maximum rated capacity of 8,200 m^3/day. The maximum permitted flow rate into the treatment system established by the Permit to take Water (PTTW) is 5,616 m^3/day. The maximum flow rate did not exceed the PTTW limit during the assessment period. In the context of *the Rules*, the tolerance level of the drinking water system is therefore considered high. The system was capable of meeting peak demand.

3.4.3 Risk Assessment, Scenario B

From *the Rules*, the local area shall be assigned a risk level of significant if:

a) During a two-year or greater drought period, the quantity of water that can be taken from the surface water body in the local area would be insufficient to meet the allocated quantity of water of the intake; or
b) During a two-year or greater drought period, the existing system is not capable of meeting peak demand.

As this scenario is not necessarily based on previously observed results for the existing demand and land cover, a computerized model was used to simulate hydrologic response of the watershed. HSPF (Hydrologic Simulation Program-Fortran) was selected as the computer model. HSPF simulates for extended periods of time the hydrologic and associated water quality, processes on pervious and impervious land surfaces and in streams and well-mixed impoundments. HSPF uses continuous rainfall and other meteorological records to compute stream flow hydrographs. Amongst other things, HSPF simulates interception soil moisture, surface runoff, interflow, base flow, snowpack depth and water content, snowmelt, evapotranspiration and ground-water recharge.

Stage-discharge-storage relationships and operational “rule” curves for the three lakes: Loch Garry, Middle Lake and Mill Pond were incorporated into the model. The model was calibrated using known hydrologic inputs to match the daily flows observed at a gauging station downstream on the Delisle River at Glen Norman. The model was further validated using the daily water levels at Loch Garry and Mill Pond. The calibration and validation is shown graphically in *Figure 0.19*, *Figure 0.20* and *Figure 0.21*.

Figure 0.19: Observed and Simulated Daily Flows, Delisle River at Glen Norman

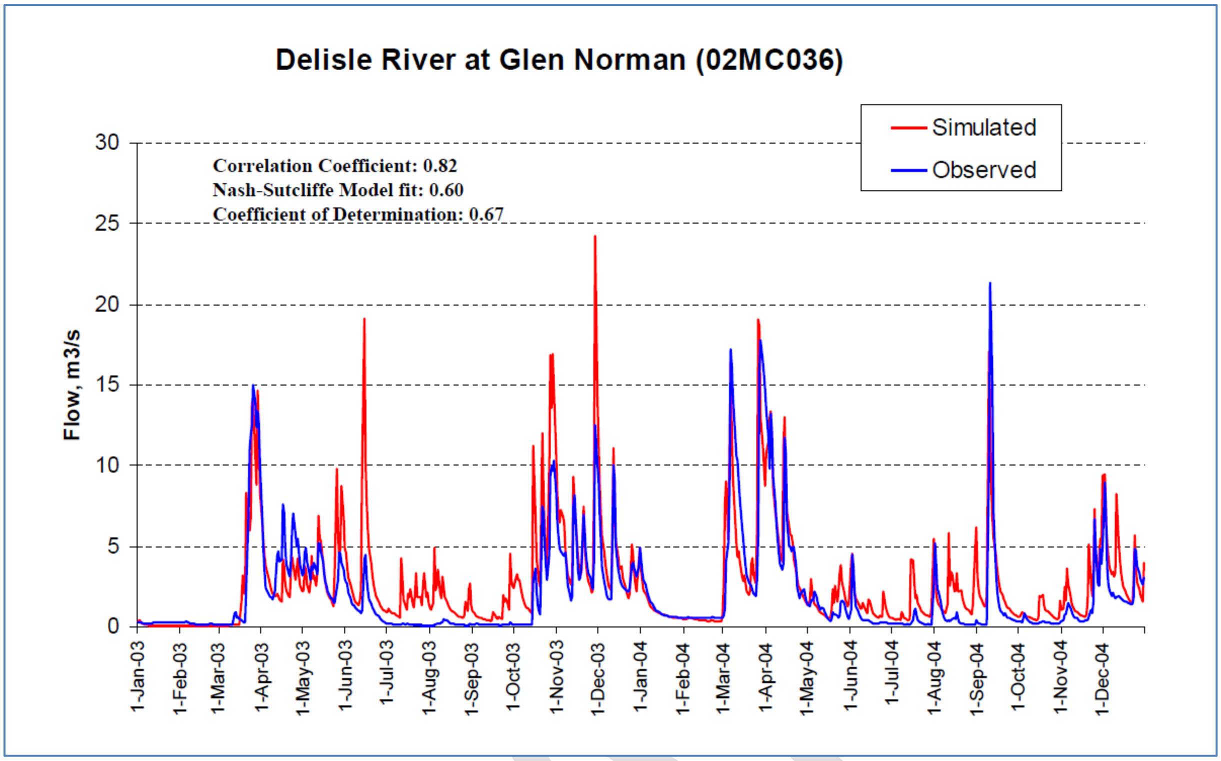


Figure 0.20: Observed and Simulated Water Levels in Loch Garry

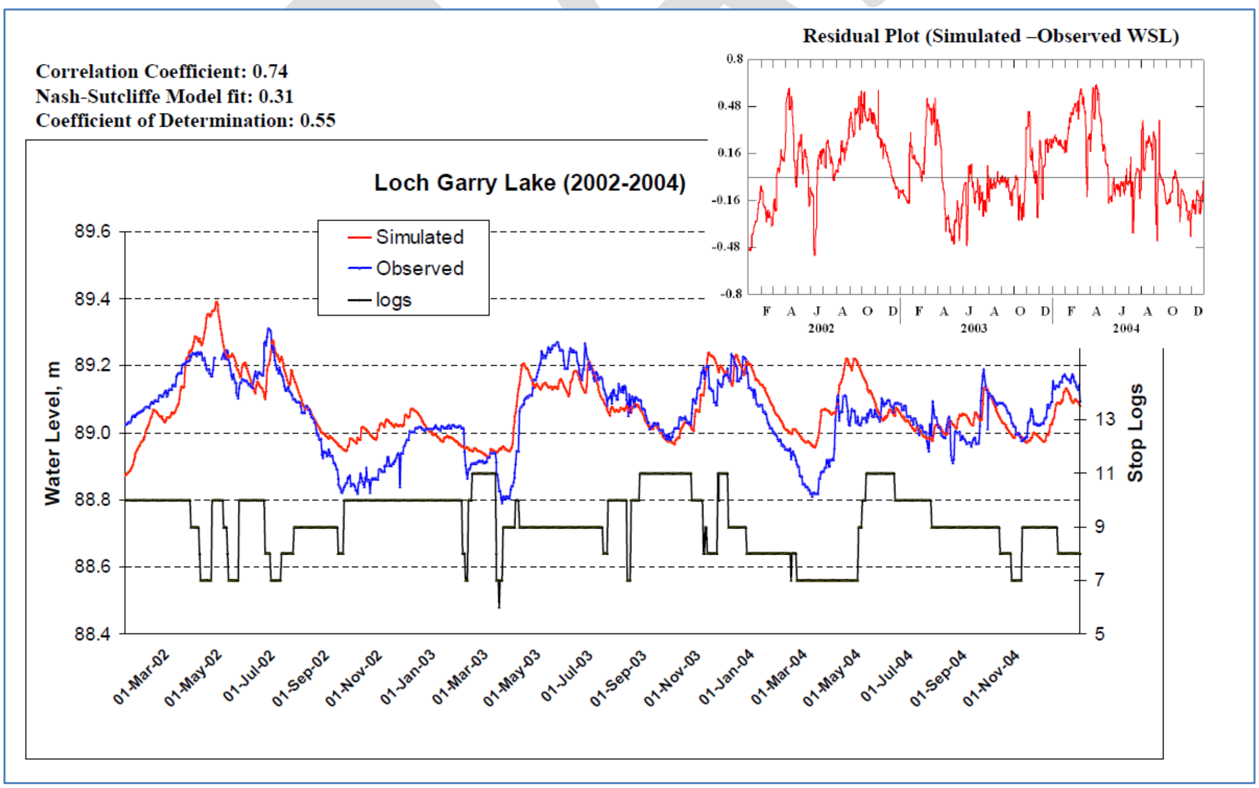
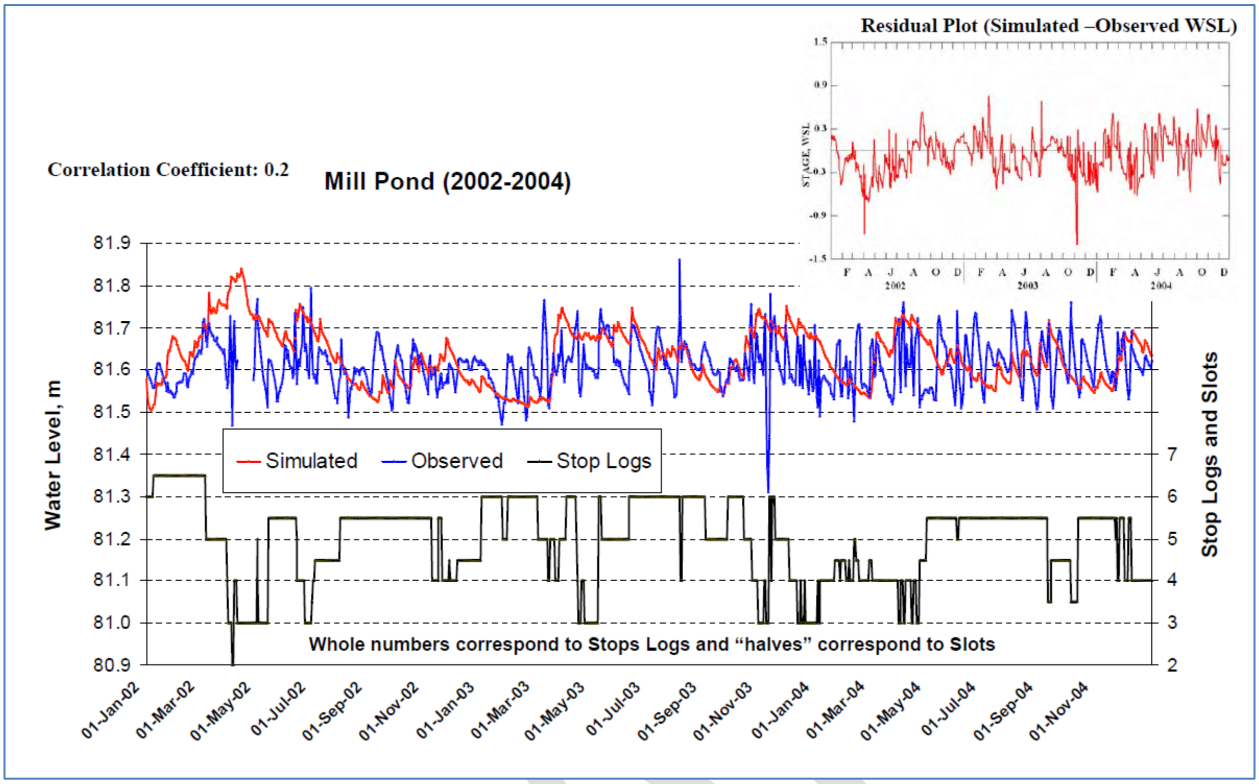


Figure 0.21: Observed and Simulated Water Levels in Mill Pond

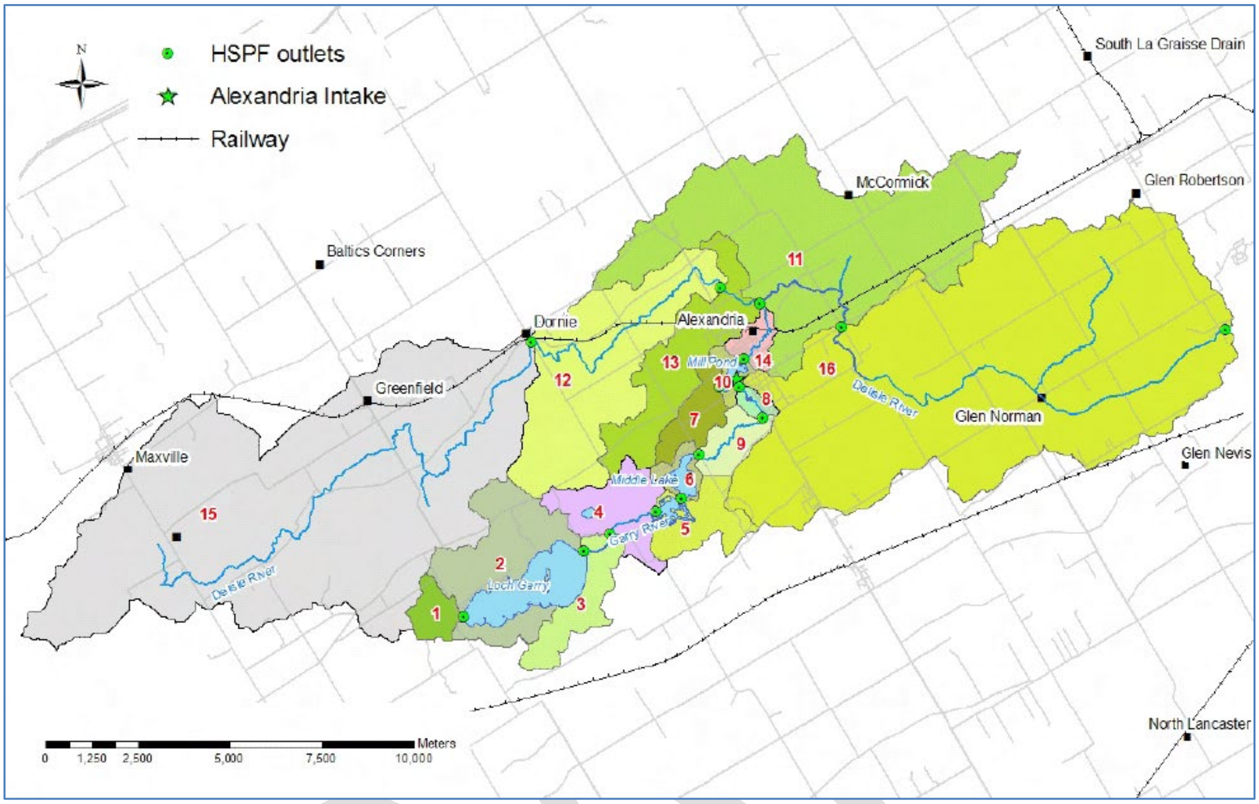


The HSPF model was expanded beyond the local subwatershed to adequately account for additional contributing area to the calibration point. The extents are shown in *Figure 0.22*. The model is a compilation of 15 subwatersheds. The water budget for the 10 subwatersheds of the local area is shown in *Table 0.43*.

Table 0.43: Tier 3 Water Budget for the Local Area

Sub-watershed ID	Precipitation (mm)	Overland Flow (mm)	Interflow (mm)	Baseflow (mm)	ET Total (mm)	Deep Percolation (mm)	Losses, Storage (mm)
1	968	102	187	152	509	18	0
2	968	91	135	160	560	21	1
3	968	95	165	151	536	19	2
4	968	131	178	143	497	17	2
5	968	136	161	146	504	18	3
6	968	95	127	162	550	22	12
7	968	151	182	142	473	16	4
8	968	286	148	100	415	12	7
9	968	145	179	150	473	17	4
10	968	258	103	117	460	16	14

Figure 0.22: HSPF Model Extents



The various water demands of the watershed are shown in *Table 0.44*.

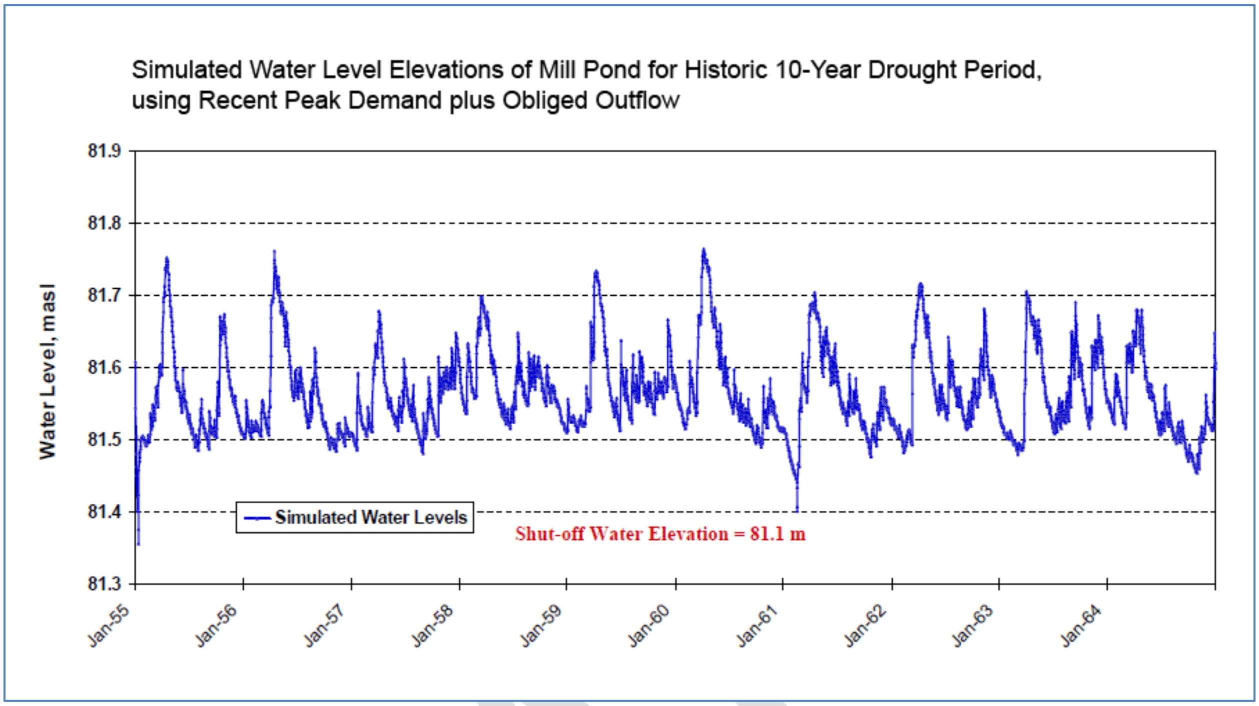
Table 0.44: Summary of Water Demands on the Local Area

Water Demand	Rate (m^3/day)	Rate (L/s)
Average Daily Demand for Study Period (2005-2010)	2,109	24.4
Maximum Daily Peak Demand observed during study period	3,957	45.8
Water Treatment Plant, Maximum Permitted Demand (C of A / PTTW)	5,616	65.0
Maximum Rated Capacity of WTP	8,200	95.0

Drought conditions were simulated using a “two year drought period” and a “ten year drought period”. These periods are defined as the continuous two and ten year period for which precipitation records exist with the lowest mean annual precipitation. A statistical analysis of the annual precipitation records found that the ten year drought period was 1995 to 1964 and the two year drought was 1960-1961.

The calibrated model was run with the drought scenarios and the maximum recorded daily peak demand (3,940 m^3/day) identified in Scenario A, plus the obligated 30L/s outflow. The results are shown in *Figure 0.23*. No instances of water levels dropping below the shut-off elevation of 81.1 masl were observed.

Figure 0.23: Model Simulation Results for Scenario B



3.4.4 Risk Assessment Results

The Scenario A (existing conditions) analysis has shown that the water treatment plant has been able to meet peak demands. In addition, the water level in Mill Pond has not dropped to the shut-off level. As per *the Rules*, there is no significant risk to the drinking water system for this scenario.

The Scenario B (drought conditions) analysis has shown that the water levels during the 10-year and 2-year drought do not drop to the shut-off level when peak demands are applied. As per *the Rules*, there is no significant risk to the drinking water system for this scenario.

The analyses did show that water levels drop below 81.4 m. Although this is higher than the shut-off elevation, it is a water level which becomes a concern for the water treatment operator. When water levels drop below this optimal minimum elevation, the treatment plant operation is not running as efficiently as possible due to low hydraulic head of the intake pump. Stop logs are adjusted where possible when water levels reach this elevation, to raise the water in Mill Pond.

3.4.5 Uncertainty Assessment

Input data for HSPF include extensive, long-term, hourly meteorological data and observed daily water levels and flows in the Delisle River, Mill Pond, Middle Lake and Loch Garry Lake. The HSPF model was satisfactorily calibrated to 3 gauges, the rule curves for each lake were incorporated into HSPF, and actual known pumping rates were used.

It should be noted that the model does its prediction assuming that the rule curve is followed in all three lakes. However, a manual stop-log operation depends on many subjective and objective factors and circumstances may exist when actual operation of stop-logs does not necessary correspond to the operational rule curves.

Quality assurance and quality control maintained in the study were those typically applied in hydrological modelling studies.

The uncertainty for the Tier 3 analysis is therefore considered low.

3.5 Enumeration of Water Quantity Threats

The Tier 3 Water Budget for the Garry River subwatershed has shown that the tolerance level for the drinking water system is high, and that there is no significant risk to the intake. There are therefore no significant drinking water quantity threats to the Garry River subwatershed.

It was shown that many instances were recorded where the water level in Mill Pond dropped below an optimal minimum operating water level. These drops highlight the sensitivity of the system. Under normal operating conditions, these drops potentially put the intake at some risk. Revised risk assessments should be undertaken should additional demands be added to or planned for the local area.

3.6 Significant Groundwater Recharge Areas

An aquifer is an area of soil or rock under the ground that has many cracks and spaces and has the ability to store water. Water that seeps into an aquifer is called recharge. Much of the natural recharge of an aquifer comes from rain and melting snow. The land area where the rain or snow seeps down into an aquifer is called a recharge area. Recharge areas often have loose or permeable soil, such as sand or gravel, which allows the water to seep easily into the ground. Areas with shallow fractured bedrock are also often recharge areas. A “significant groundwater recharge area” (SGRA) means an area within which it is desirable to regulate or monitor drinking water threats that may affect the recharge of an aquifer. SGRAs have a hydrological connection to an aquifer that is a source of drinking water for a drinking water system or a surface water body (excluding Great Lakes or Connecting Channels). All geographic areas within the Source Protection Area were reviewed as all areas have a connection to drinking water systems due to the high number of private drinking water systems distributed throughout the region.

A peer-reviewed technical study was completed in 2010 assessing SGRAs in the region: “Significant Groundwater Recharge Area Delineation in Raisin-South Nation Source Protection Region” (Intera Engineering, 2010). The results of that study are summarized below.

3.6.1 Significant Groundwater Recharge Area Delineation

The Rules outline two methods for delineating SGRAs. Method 1 identifies an SGRA if the area annually recharges water at a rate that is greater than 1.15 times the average recharge rate across the source protection region. Method 2 identifies an SGRA if an area recharges more than 55% of the difference of precipitation and evapotranspiration for the source protection region. The difference between precipitation (P) and actual evapotranspiration (AET) is called the water surplus.

Groundwater recharge had previously been computed as part of the Conceptual Understanding Water Budget (*Section 3.1.13.1*). Precipitation and Evapotranspiration datasets were also available from the Conceptual Understanding. A GIS program at a 100m × 100m grid scale (cell) was used to spatially analyze the groundwater recharge and water surplus.

The average recharge rate across the region was determined to be 181.3 mm/year. The threshold for significant recharge area (Method 1) was then computed to be 208.5 mm/year (1.15 times the average).

The average water surplus across the region was determined to be 390.4 mm/year. The threshold for significant recharge area (Method 2) was then computed to be 214.7 mm/year (55% of the average).

Mapping the distribution of SGRAs from Method 1 and Method 2 resulted in similar results, as expected due to topography and land cover. Method 1 delineated slightly more area than Method 2 and was therefore selected as the final SGRA approach.

The SGRA area is shown on *Map 3.17* and tabulated in *Table 0.45*.

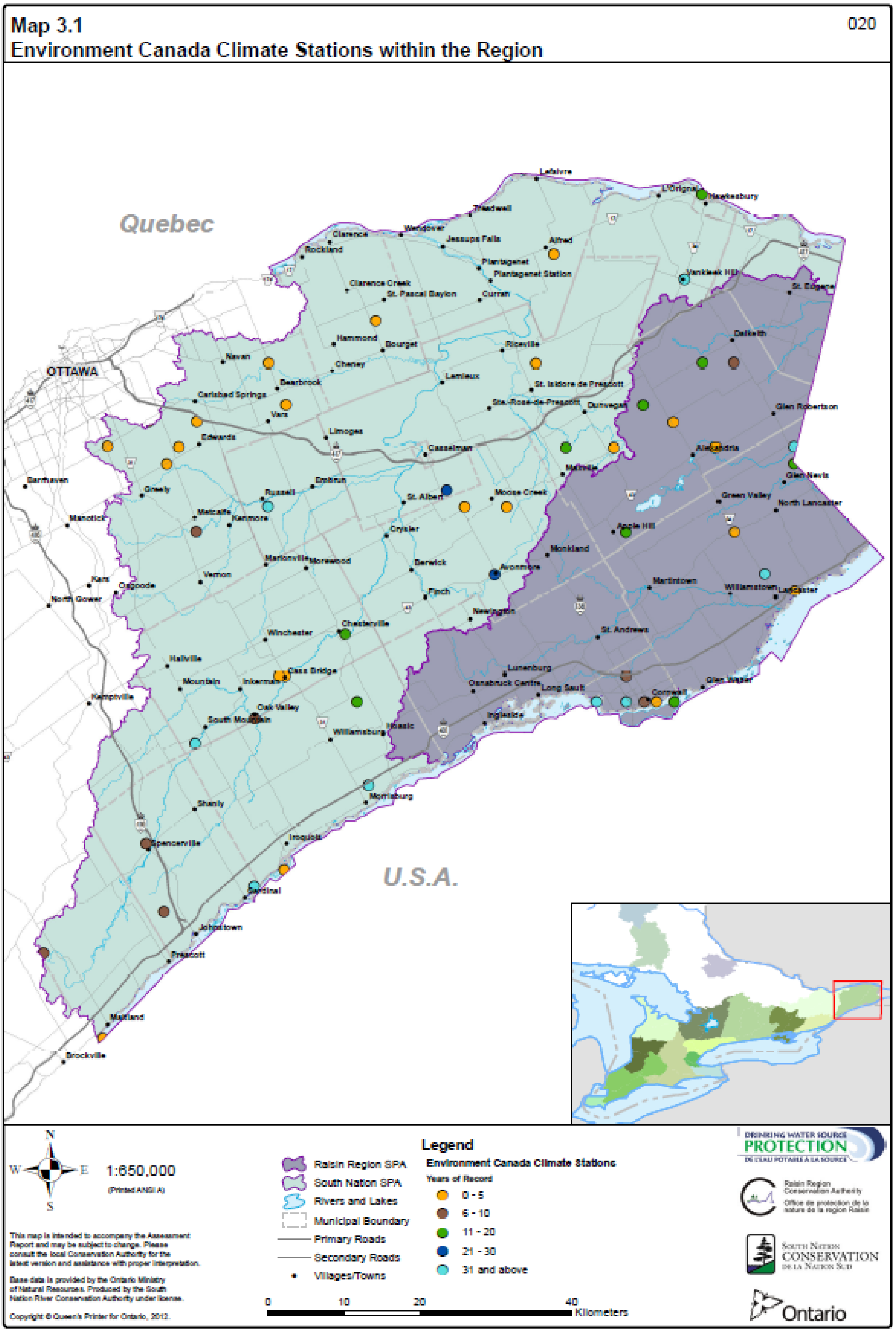
Table 0.45: Significant Groundwater Recharge Area, Raisin Region Source Protection Area

Source Protection Area	Total Area of Source Protection Area (km²)	Significant Groundwater Recharge Area (km²)	Percentage of Source Protection Area
Raisin Region Source Protection Area	1,860	395	21%

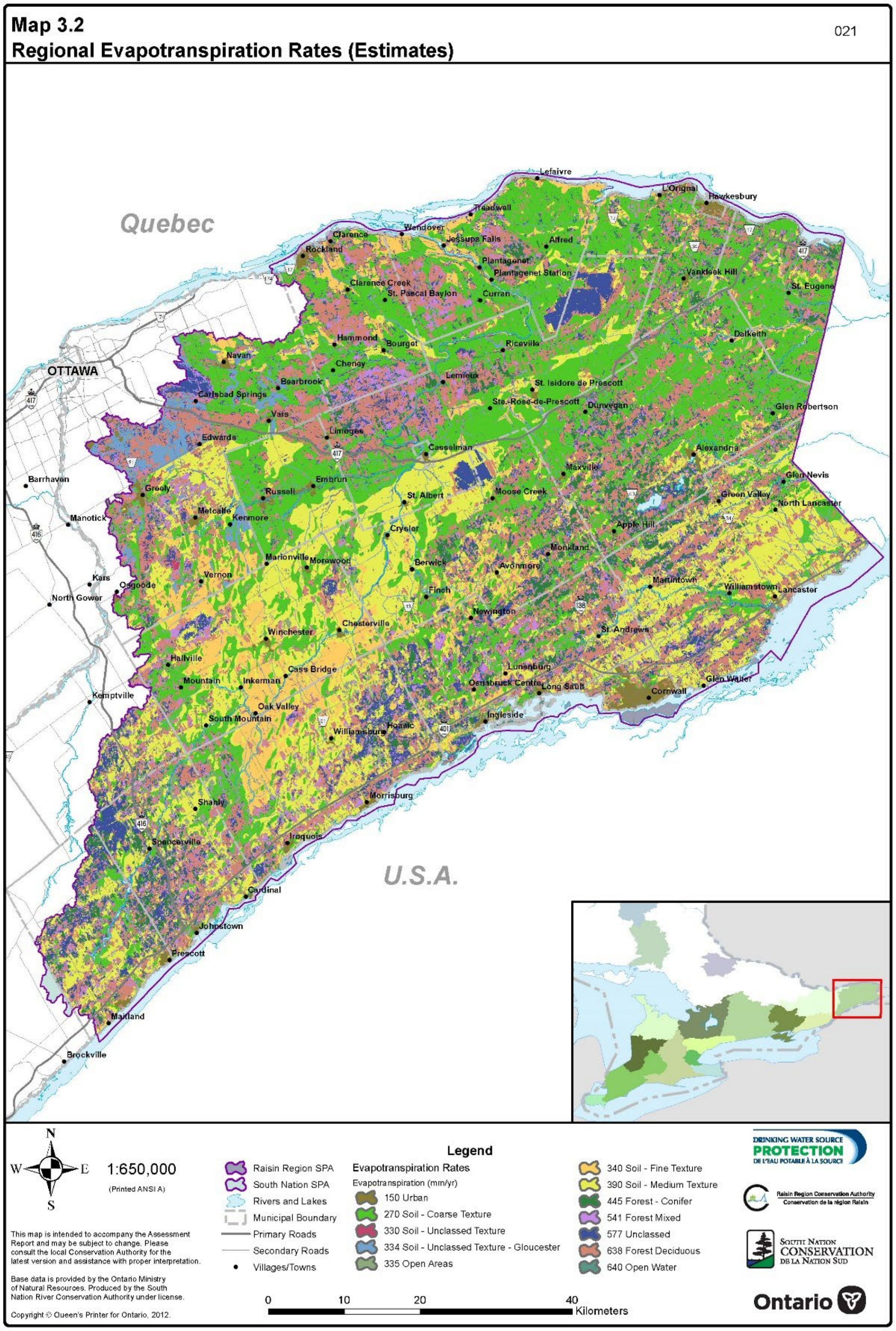
3.6.2 Tier 2 Significant Groundwater Recharge Areas

A Tier-2 water budget was undertaken for subwatershed #7, as it was sufficiently stressed in terms of surface water. Groundwater recharge was not re-calculated and therefore a Tier 2 SGRA was not required to be completed. For the purpose of this *Assessment Report*, the Tier 2 SGRAs for this subwatershed are equivalent to the Tier 1 SGRAs.

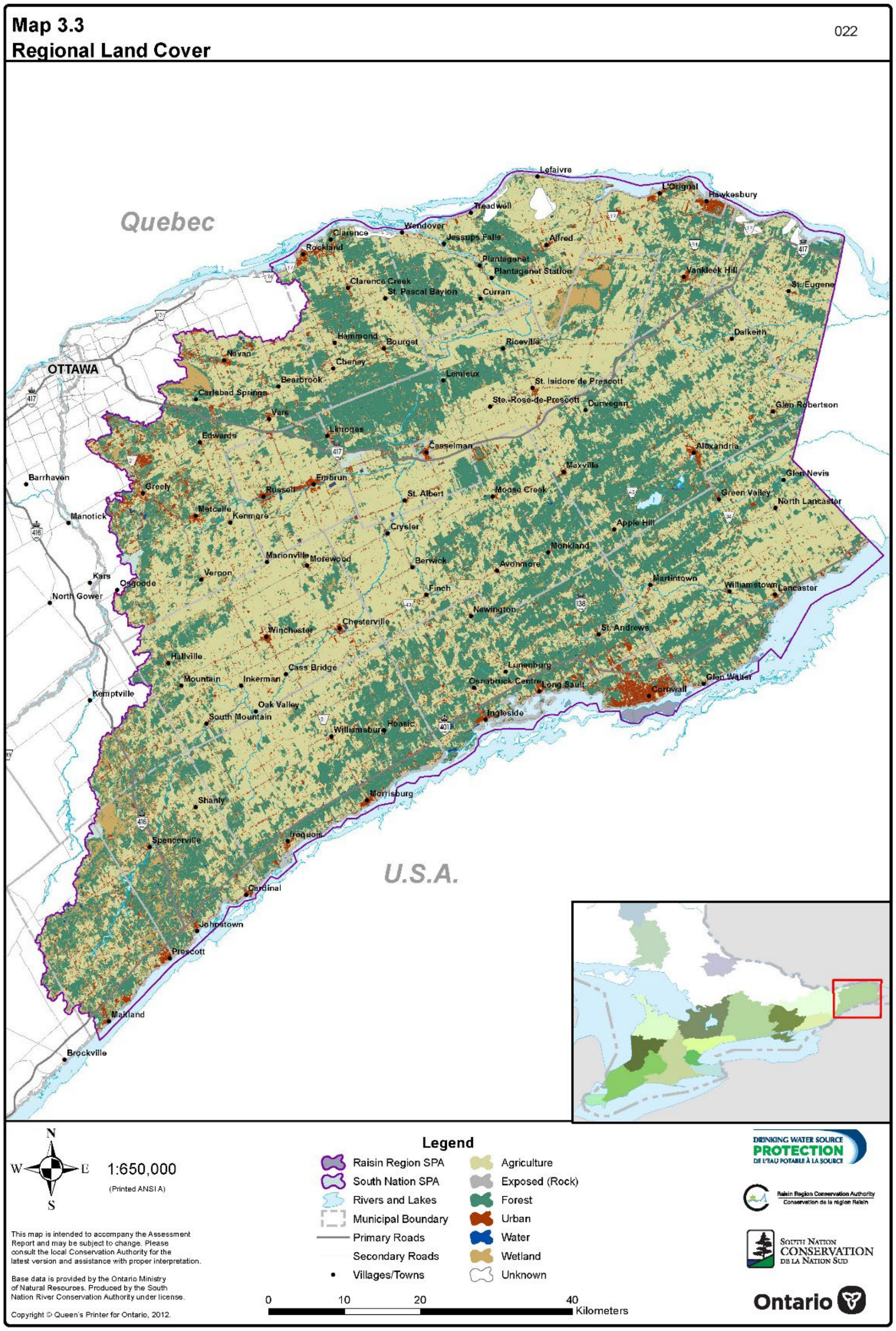
Map 3.1: Environment Canada Climate Stations within the Source Protection Region



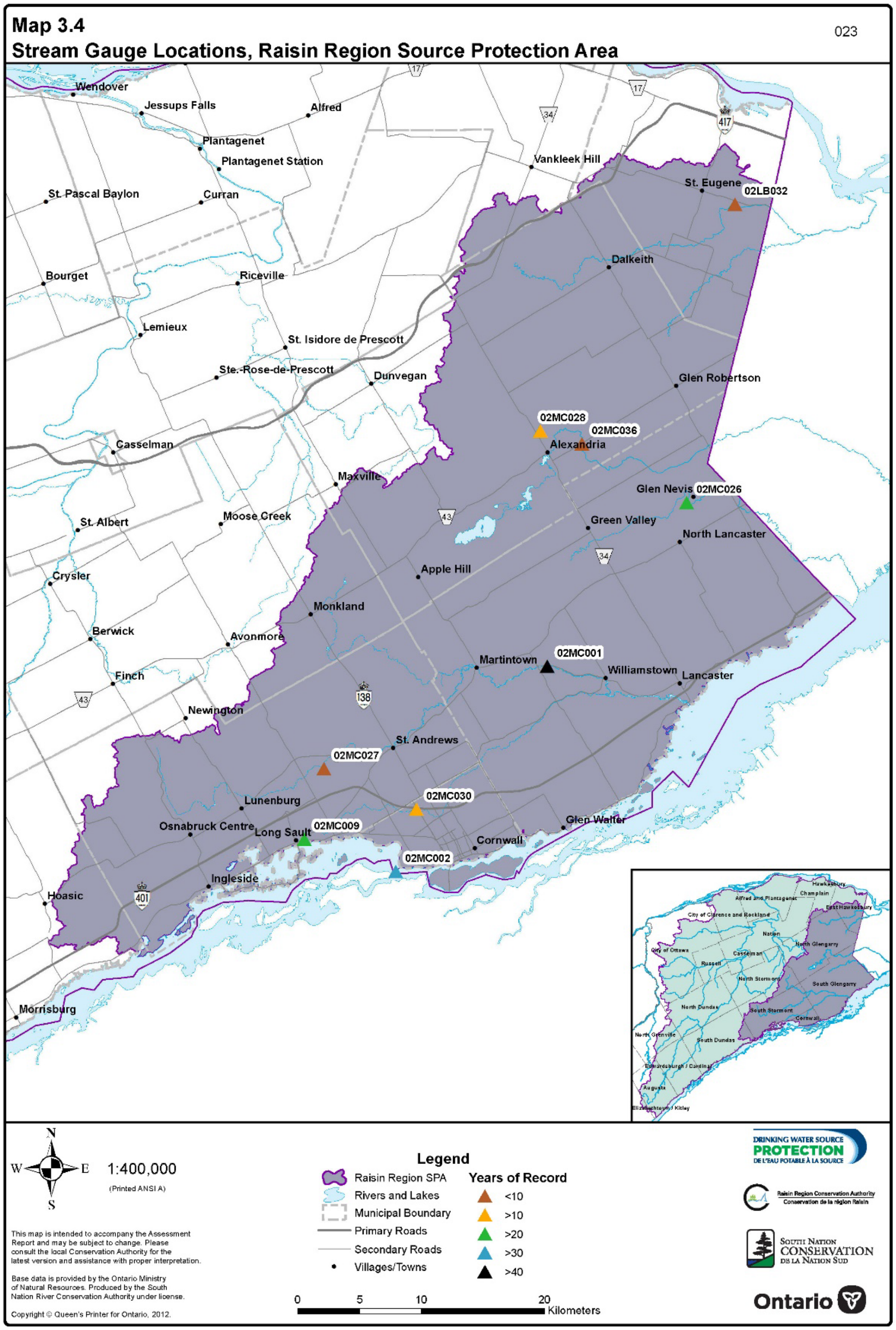
Map 3.2: Estimated Evapotranspiration Rates of the Source Protection Region



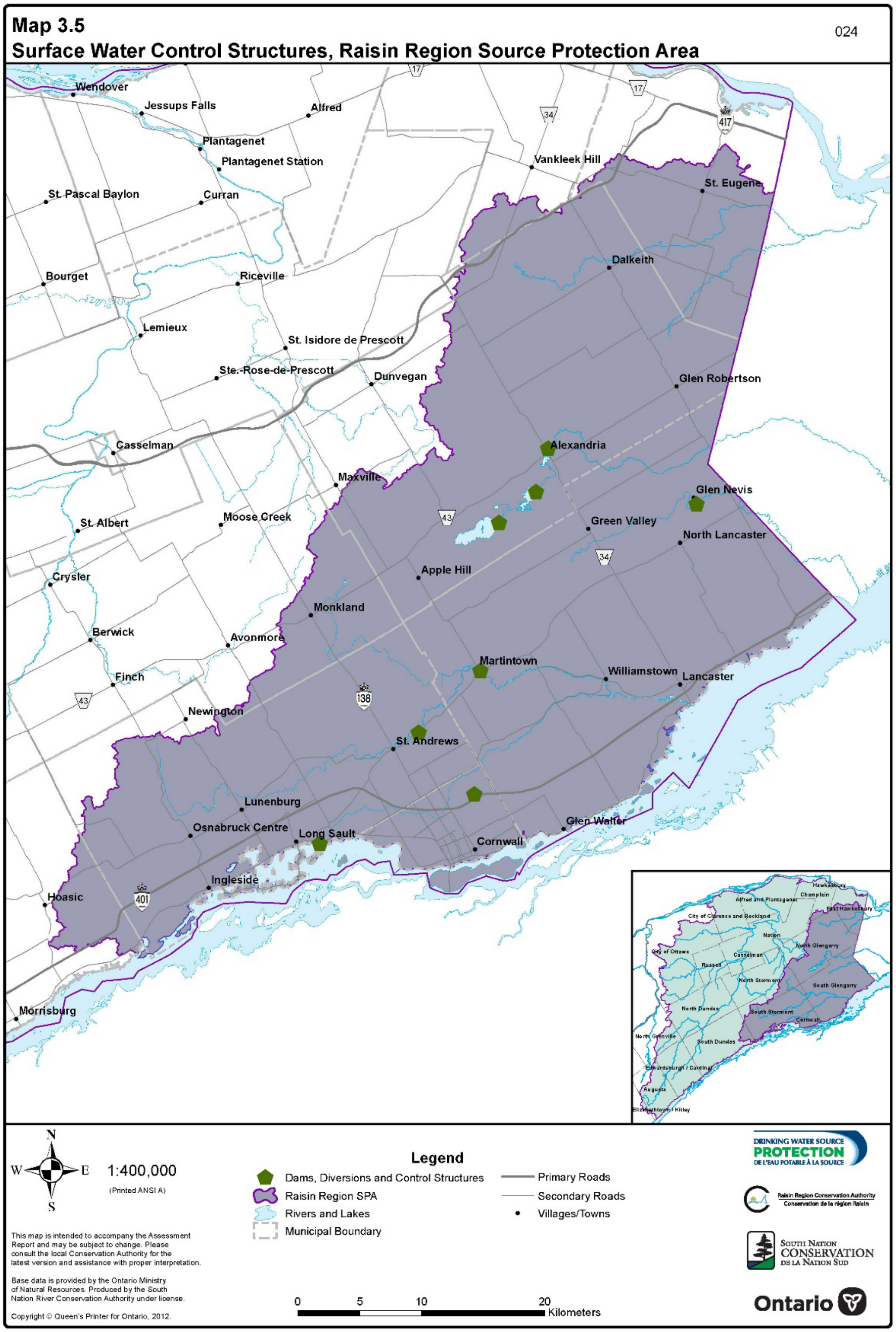
Map 3.3: Land Cover of the Source Protection Region



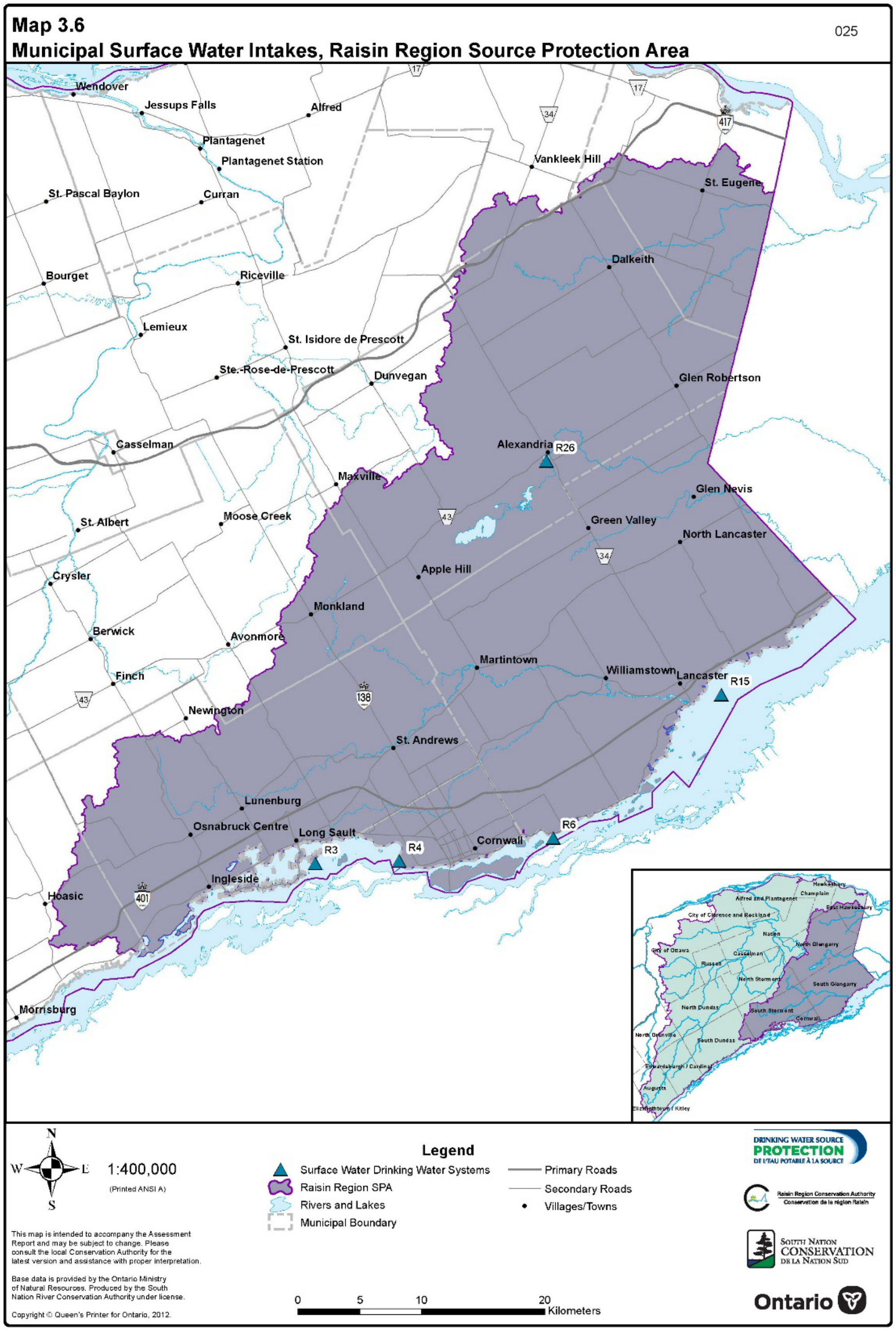
Map 3.4: Stream Gauge Locations, Raisin Region Source Protection Area



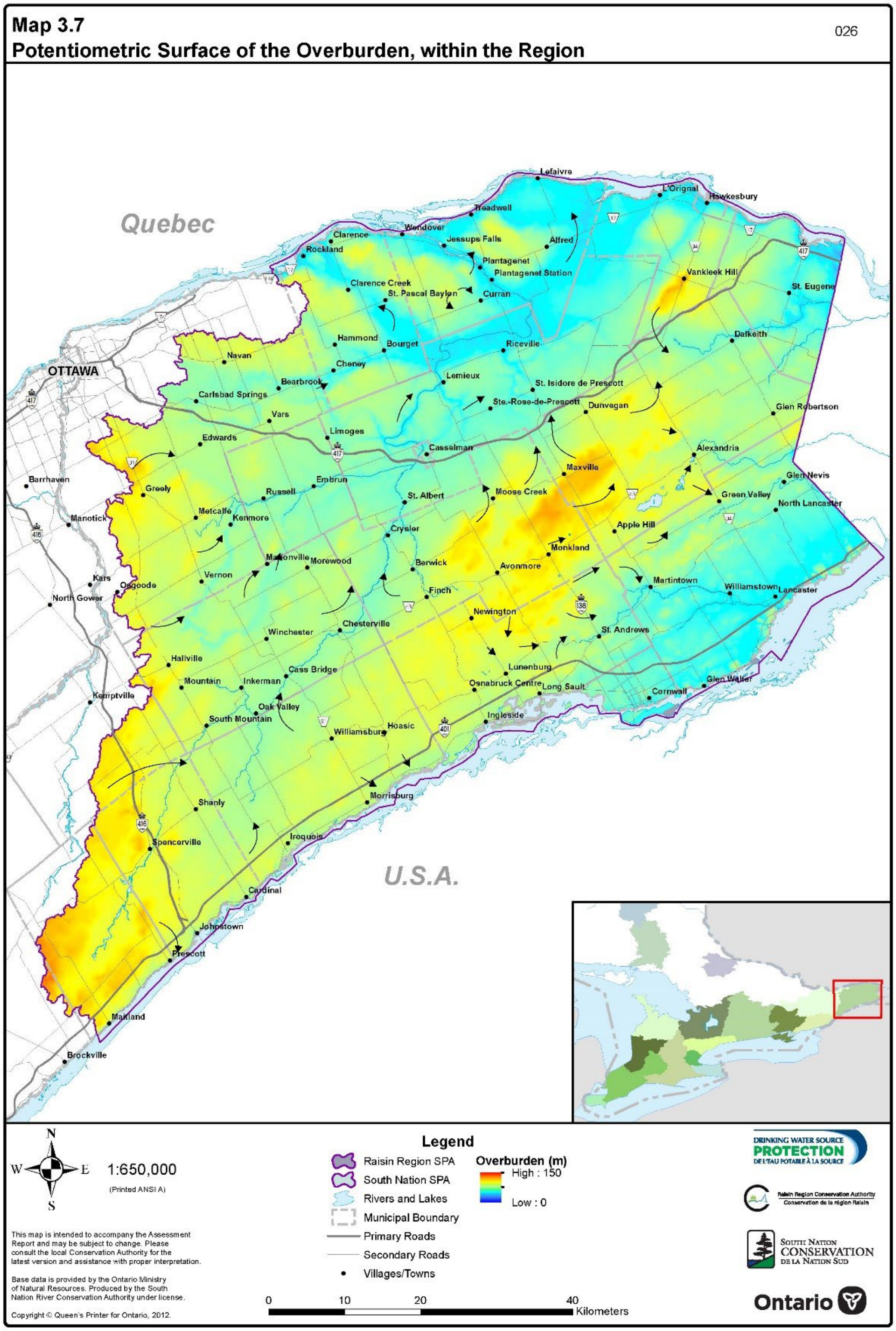
Map 3.5: Surface Water Control Structures, Raisin Region Source Protection Area



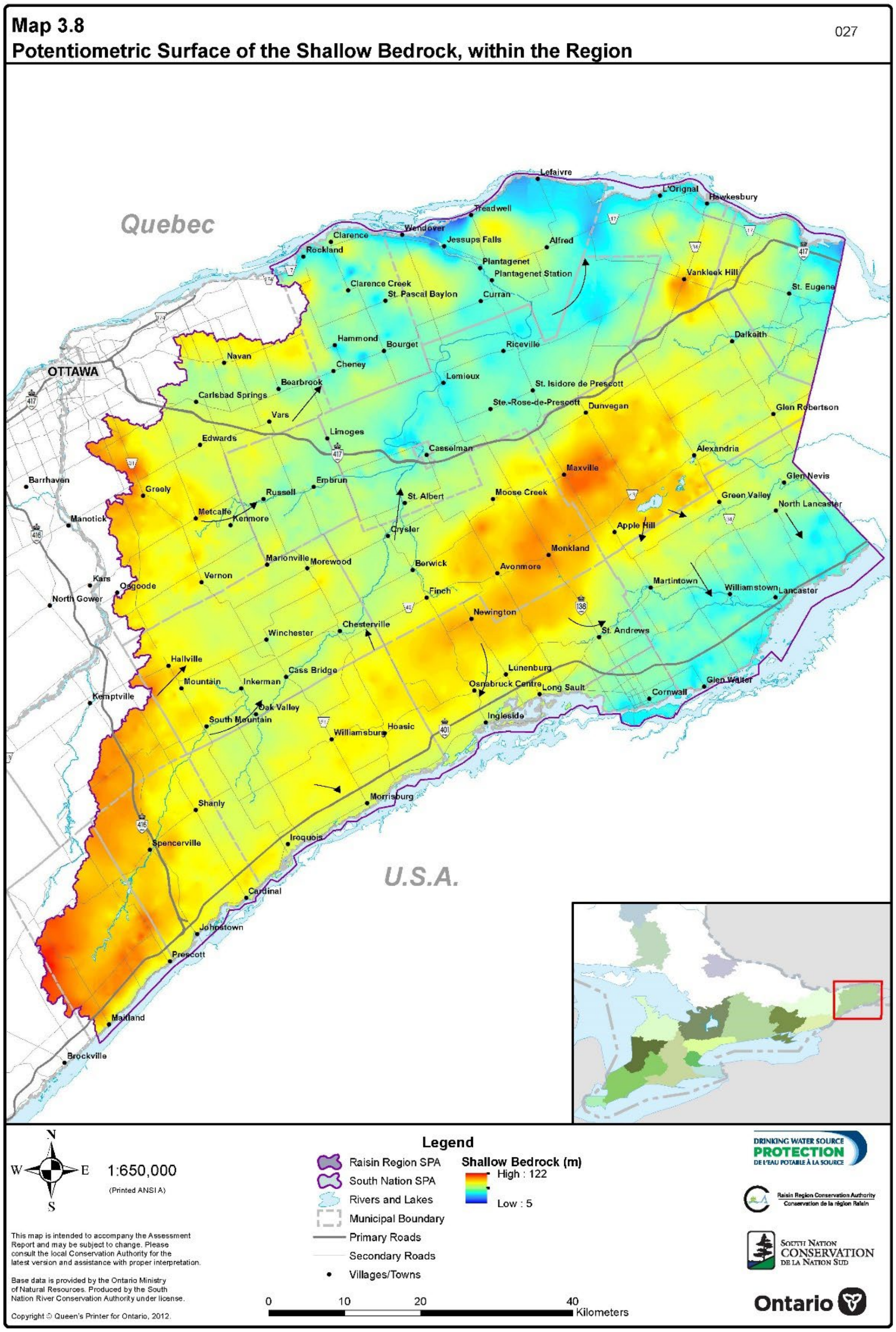
Map 3.6: Surface Water Intakes, Drinking Water Systems, Raisin Region Source Protection Area



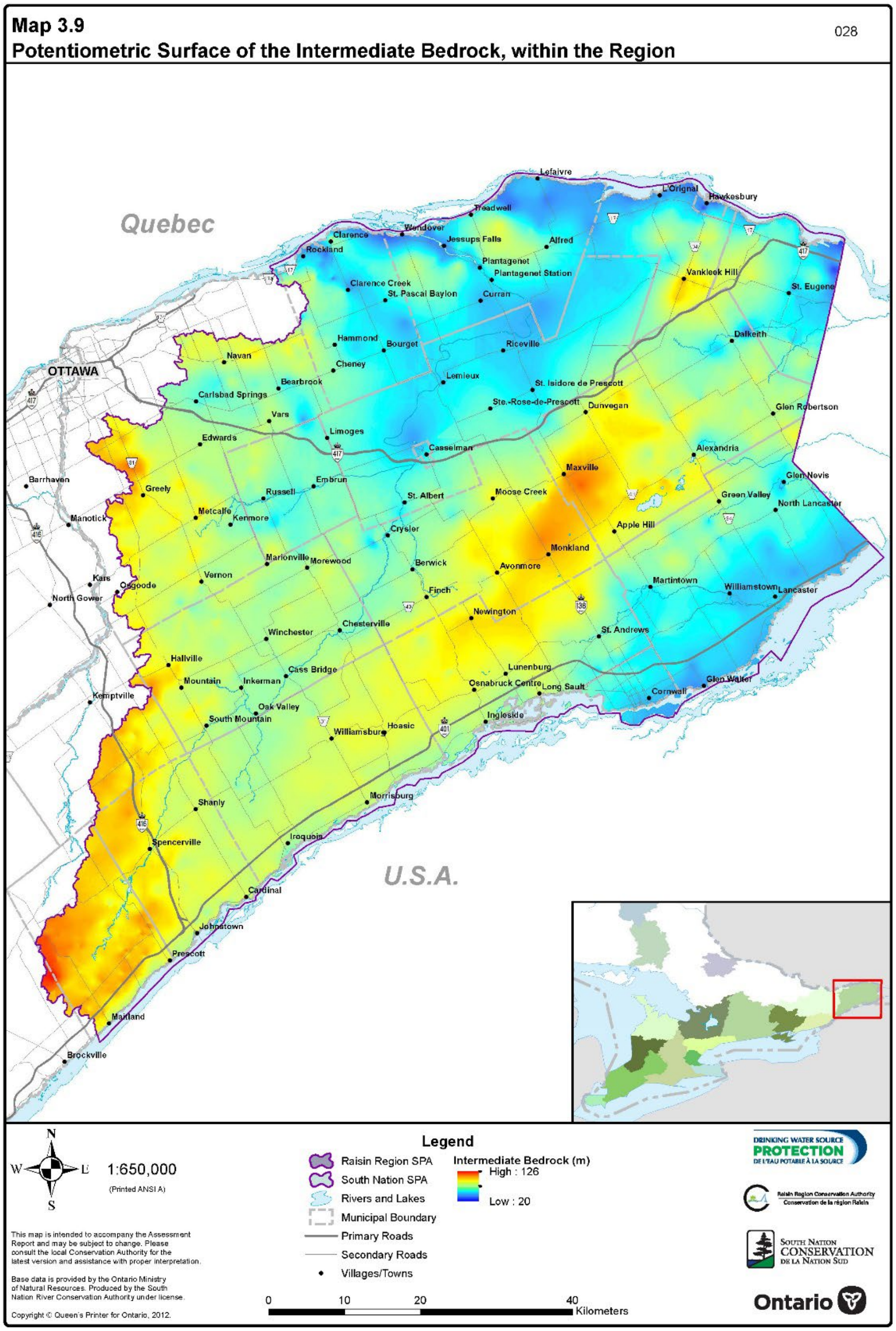
Map 3.7: Potentiometric Surface of the Overburden for the Source Protection Region



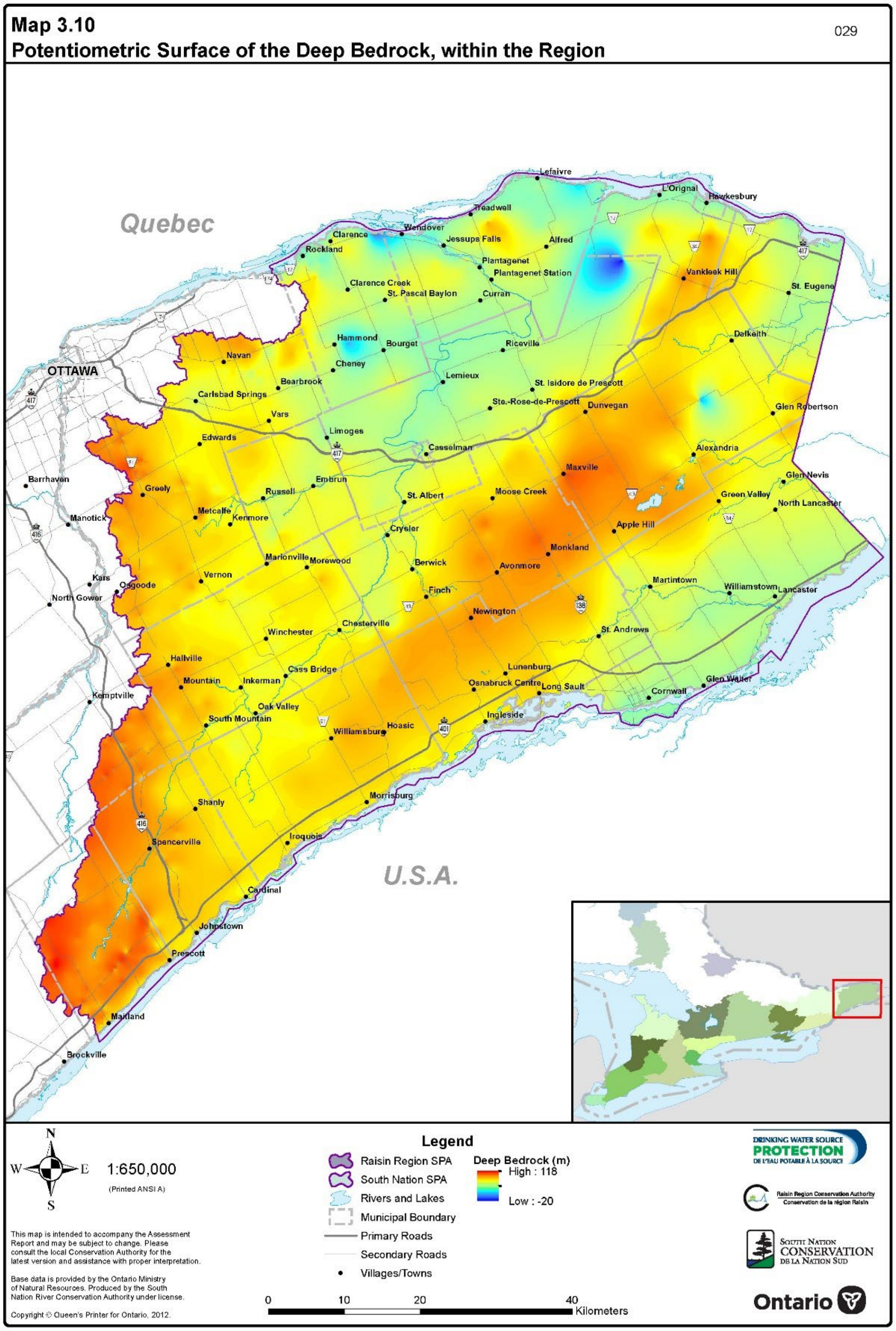
Map 3.8: Potentiometric Surface of the Shallow Bedrock for the Source Protection Region



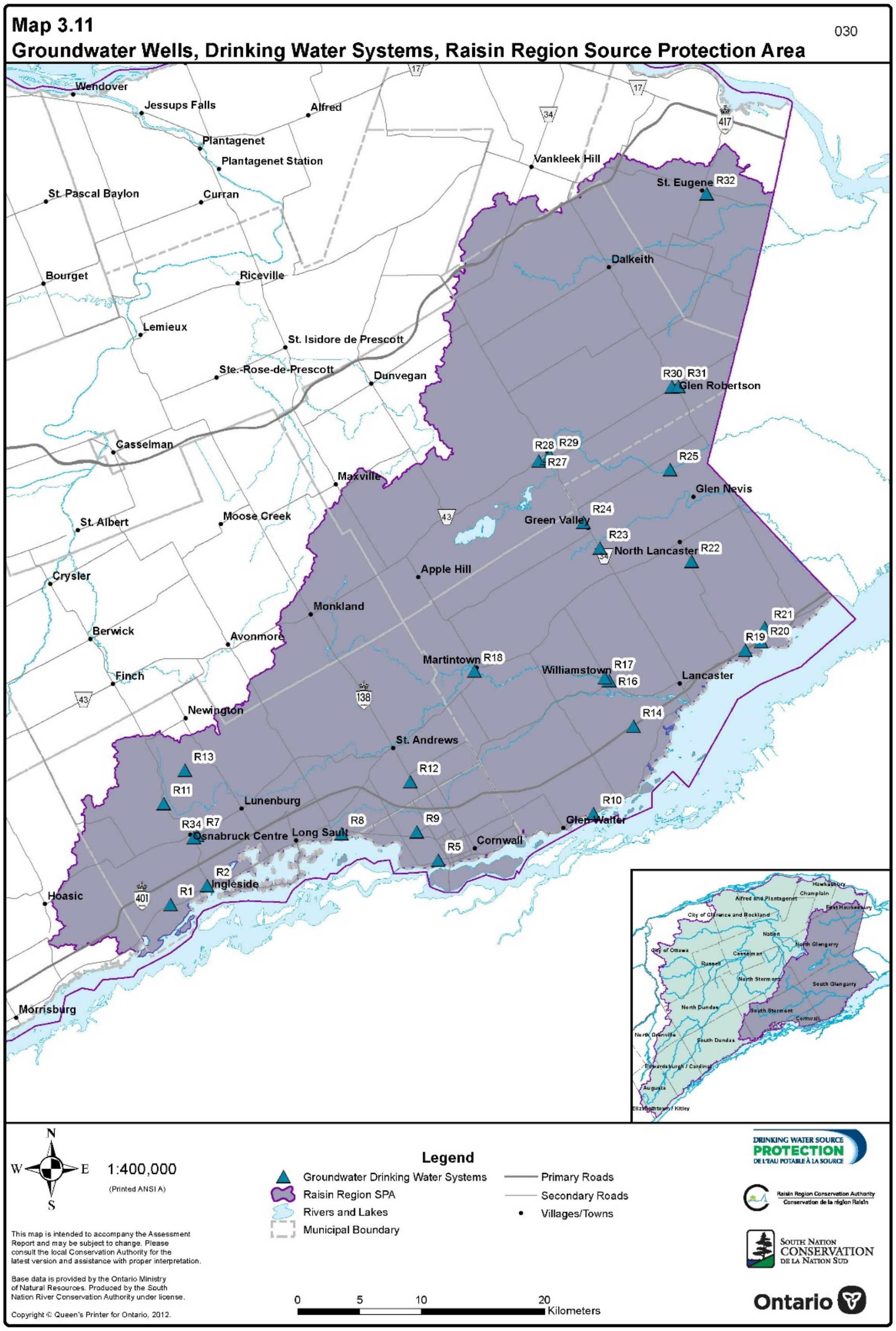
Map 3.9: Potentiometric Surface of the Intermediate Bedrock for the Source Protection Region



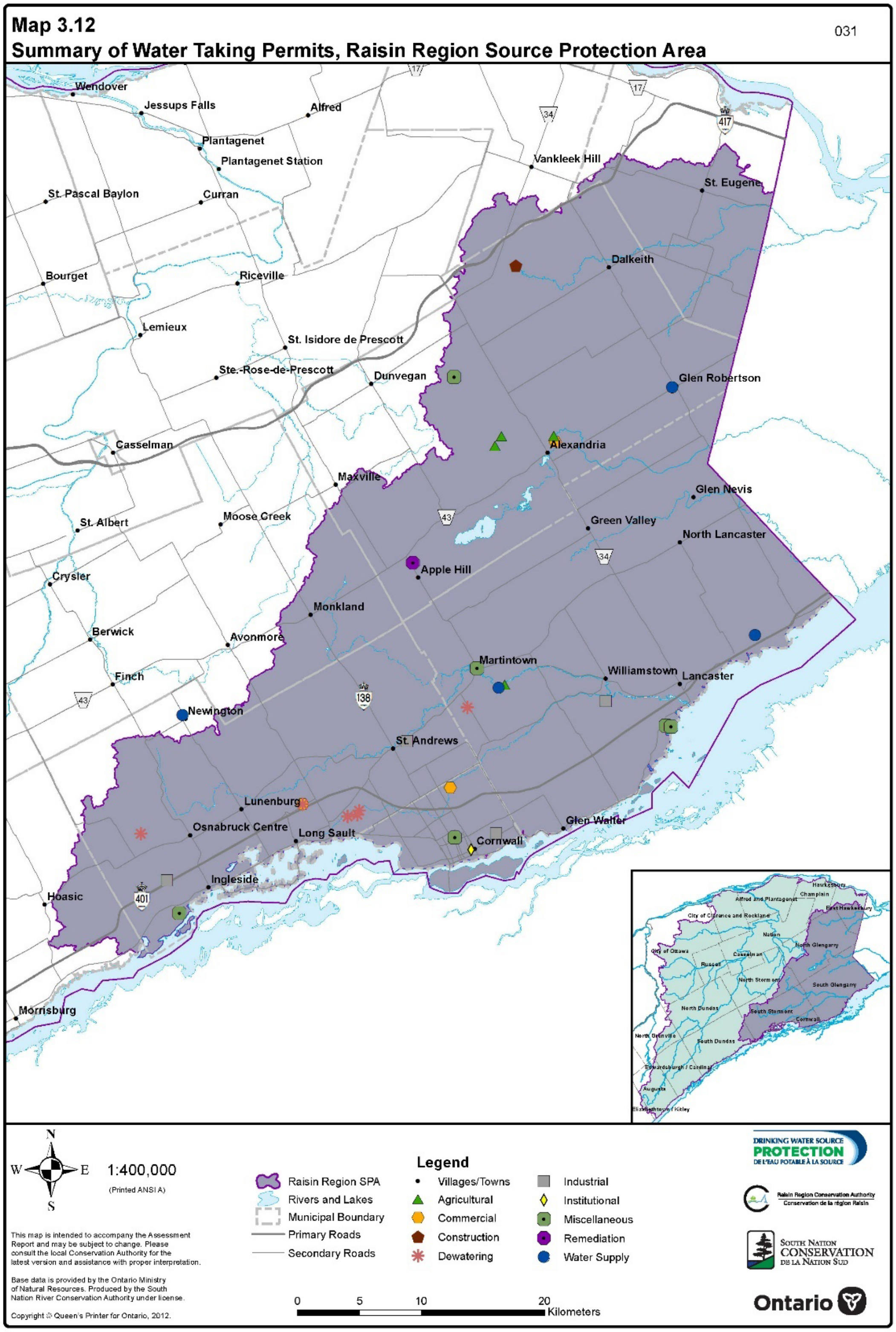
Map 3.10: Potentiometric Surface of the Deep Bedrock for the Source Protection Region



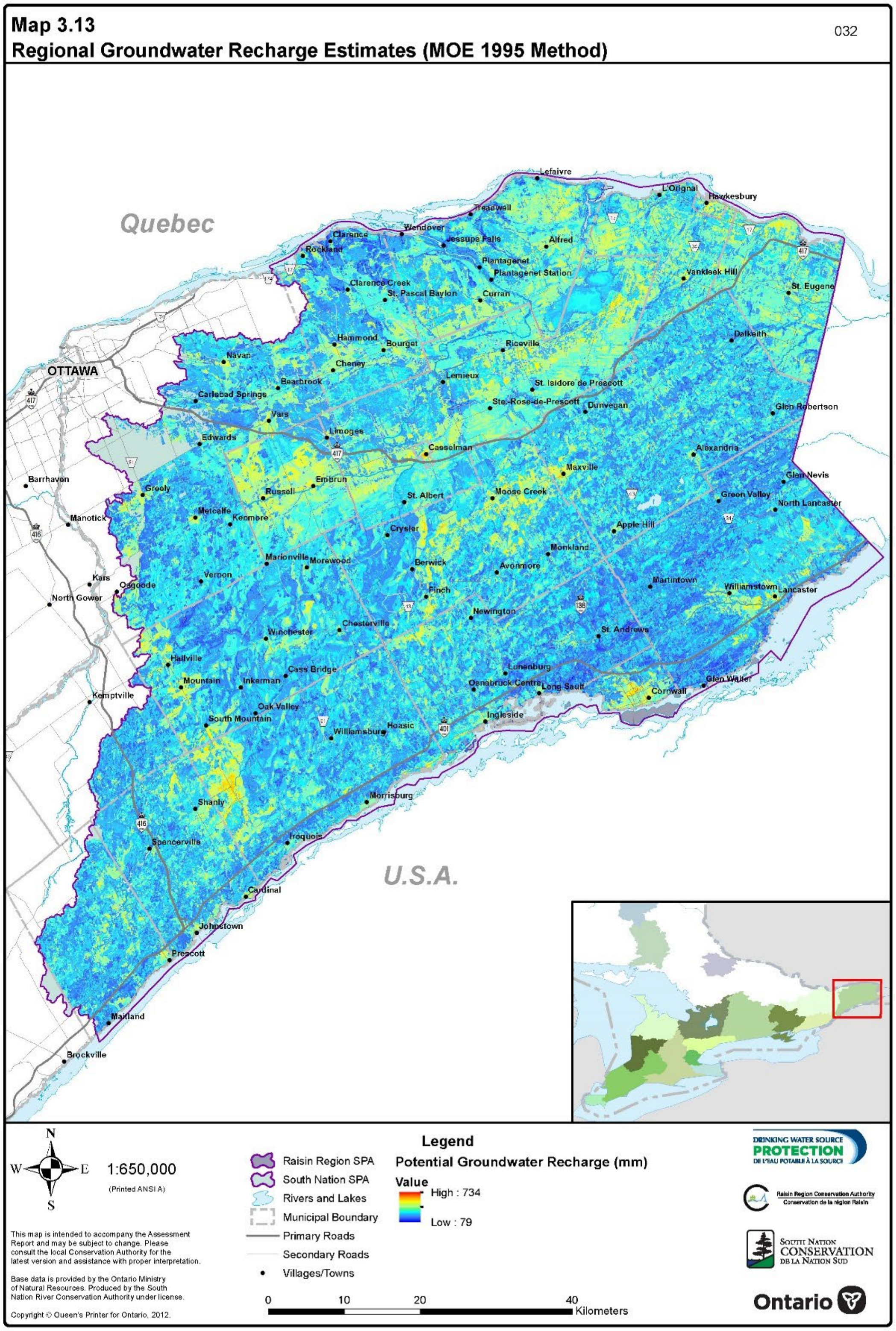
Map 3.11: Groundwater Wells, Drinking Water Systems, Raisin Region Source Protection Area



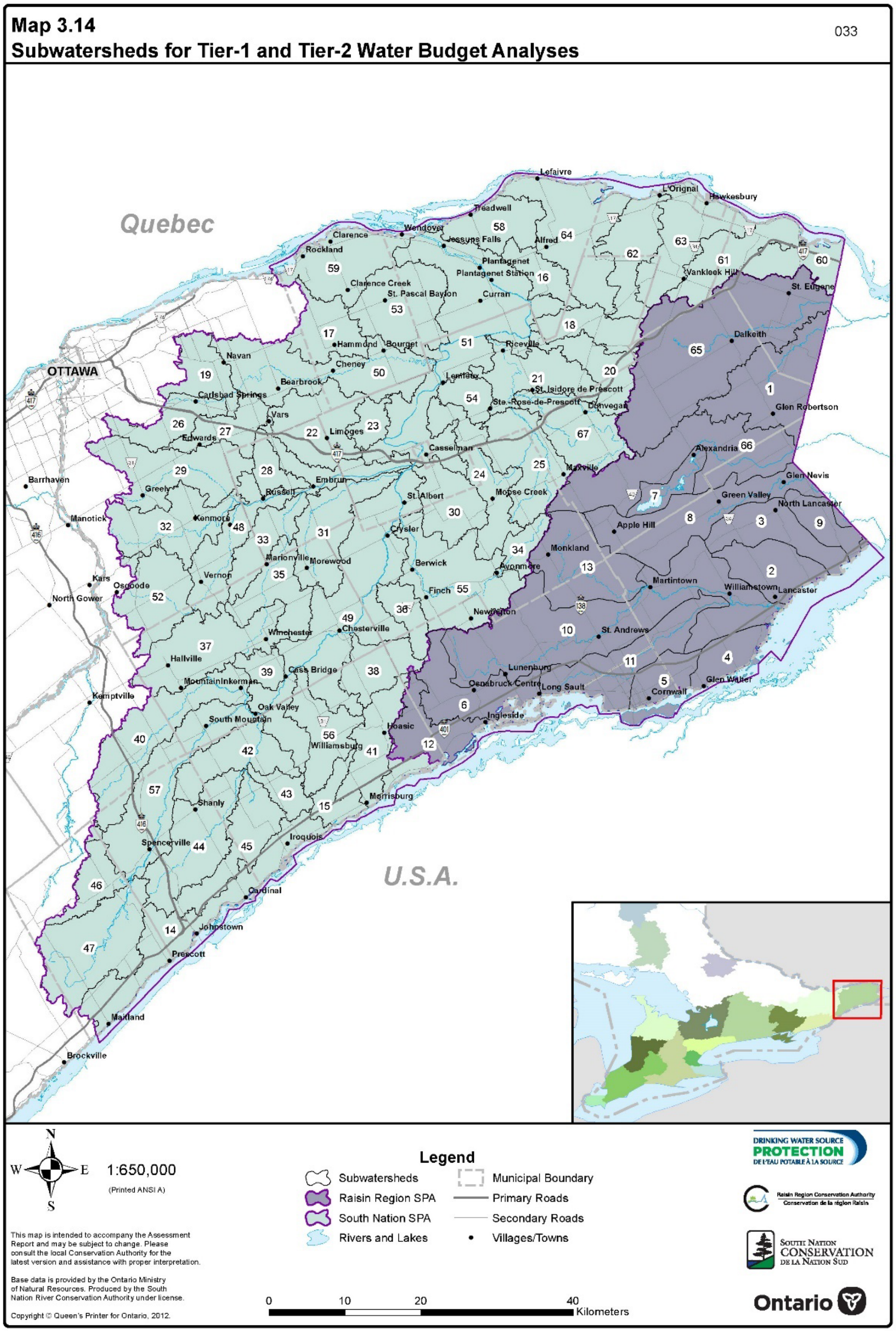
Map 3.12: Summary of Water Taking Permits, Raisin Region Source Protection Area



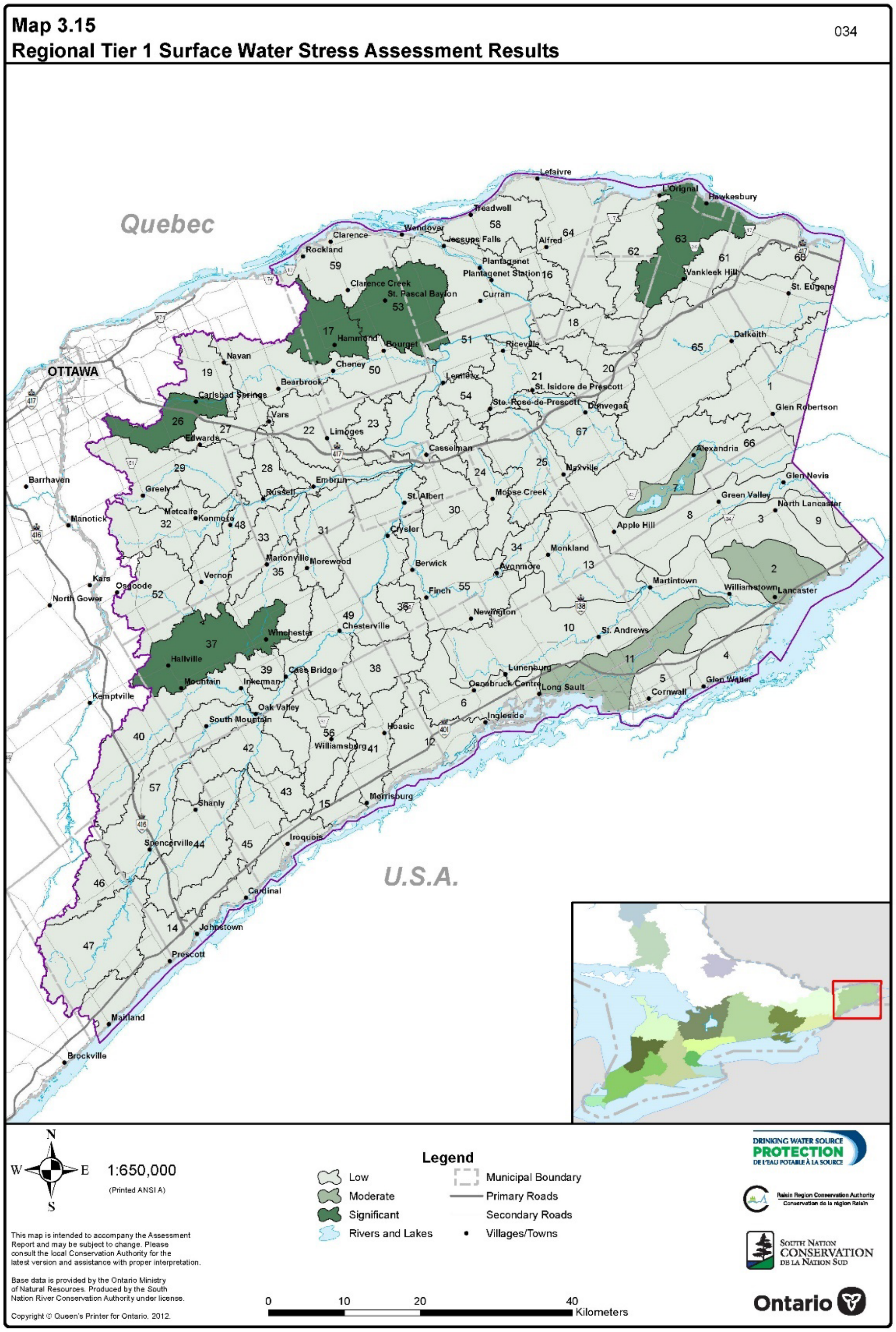
Map 3.13: Preliminary Estimate of Recharge (MOE 1995 Methodology), Source Protection Region



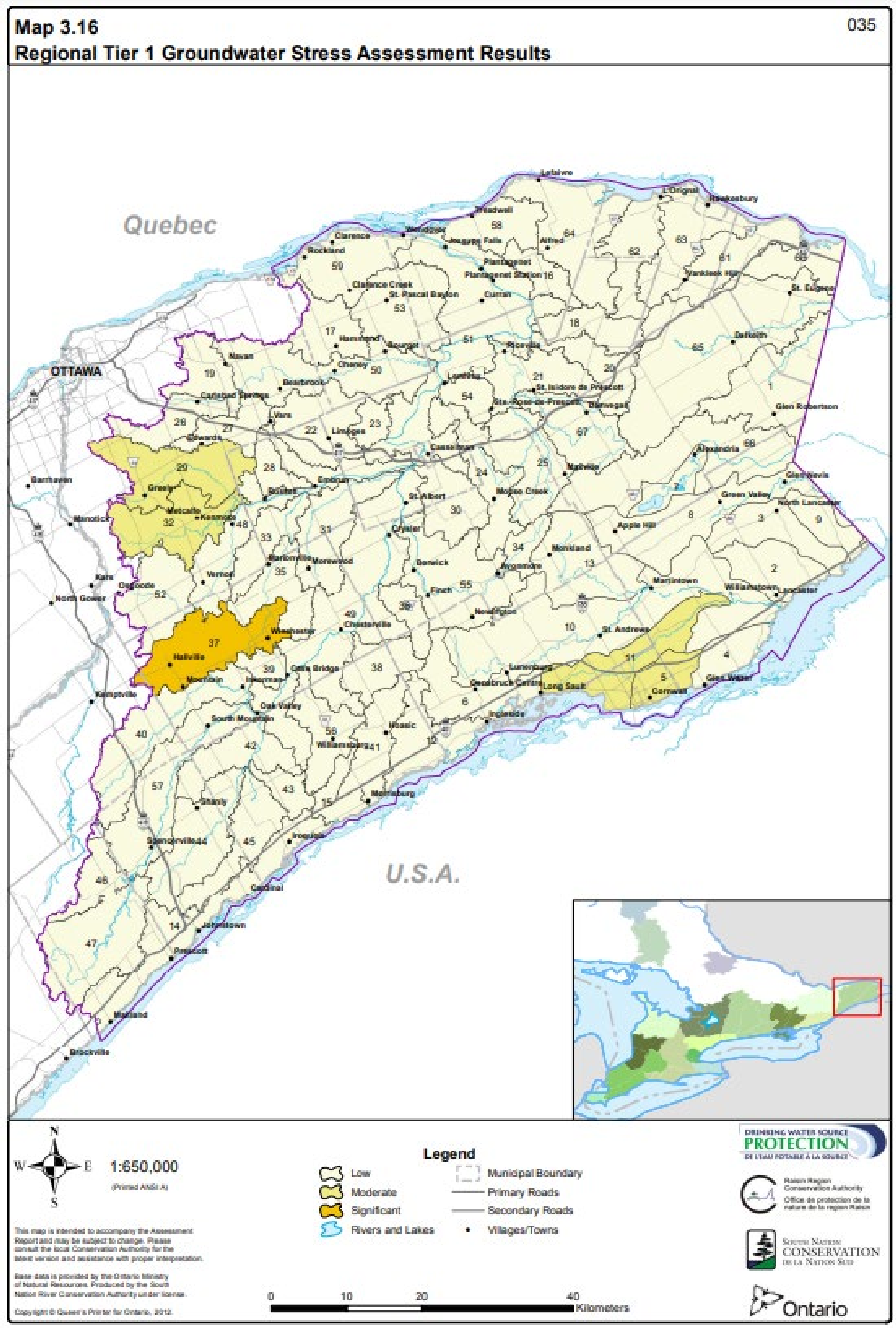
Map 3.14: Subwatersheds for Tier 1 Water Budget Analysis, Raisin Region Source Protection Area



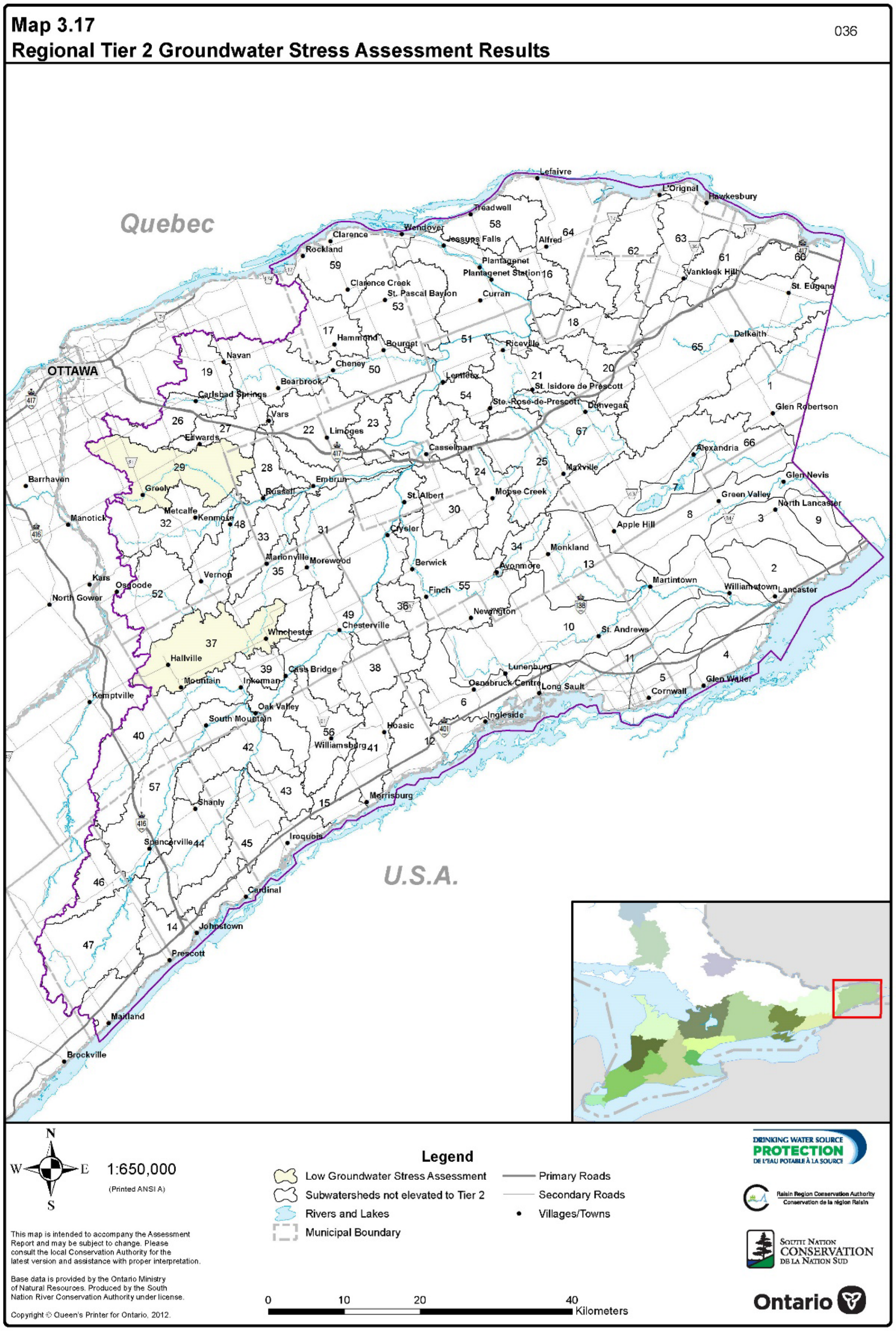
Map 3.15: Tier 1 Surface Water Stress Assessment Results



Map 3.16: Tier 1 Groundwater Stress Assessment Results



Map 3.17: Significant Groundwater Recharge Areas, Raisin-South Nation Source Protection Region



4 Water Quality Threats Assessment and Issues Evaluation

Water quality issues are problems that currently exist in the source water, or that can be reasonably predicted to be a problem in the near term if rising trends continue. Water quality threats are activities on the landscape that, if not managed properly, may cause an issue to occur in the future. Activities or conditions that are drinking water threats are categorized as Significant, Moderate or Low. Categorization of threats is achieved using one of or a combination of three approaches:

1. Threats Based Approach;
2. Issues Based Approach;
3. Events Based Approach.

There are four specific requirements set out in O. Reg. 297/07 (*the Regulations*) and Technical Rules: Assessment Report (*the Rules)* for the completion of a threats and issues assessment:

1. Identification of the activities or conditions that are or would be drinking water threats;
2. A list of circumstances under which each activity makes or would make the activity a significant, moderate or low drinking water threat;
3. Show the areas and the relevant circumstances where an activity or condition is or would be significant, moderate or low drinking water threat;
4. Determine the number of locations at which an activity is a significant drinking water threat or where there is a condition that is a significant drinking water threat

Drinking water quality threats assessment is to be carried out for each of the following four types of vulnerable areas:

1. Highly Vulnerable Aquifers (HVAs);
2. Wellhead Protection Areas (WHPAs);
3. Intake Protection Zones (IPZs).

4.1 Vulnerable Area Delineation and Scoring

A prerequisite for the threats assessment and issues evaluation is the identification and delineation of vulnerable areas. Vulnerability scores are assigned to the vulnerable areas representing the susceptibility to contamination.

4.1.1 Highly Vulnerable Aquifers

Aquifers are areas of soil and rock under the ground where cracks and spaces allow water to pool. A “highly vulnerable aquifer” (HVA) means an aquifer on which external sources have or are likely to have a significant adverse effect, and includes the land above the aquifer. They are considered highly vulnerable based upon a number of factors, including how deep it is located underground, what sort of soil or rock is covering it and the characteristics of the soil or rock surrounding it. The faster water is able to flow through the ground to an aquifer, the more vulnerable it is to contamination.

In addition to rain and melting snow seeping into the ground to recharge an aquifer, pollutants can also seep into the ground, contaminate the groundwater in an aquifer and possibly contaminate the water in a drinking water well. Protecting HVAs is a way to prevent drinking water from becoming polluted.

A peer-reviewed technical study was completed in 2010 assessing HVAs in the region: "Delineation of Highly Vulnerable Aquifers in the Raisin-South Nation Source Protection Region" (Intera Engineering, 2010). The results of that study are summarized below.

4.1.1.1 Vulnerable Area Delineation

A target aquifer was selected for vulnerability analysis after considering:

1. The use of the aquifer as a drinking water source
2. The linkage the aquifer may have to deeper aquifers

Throughout the Raisin-South Nation Source Protection Region, most of the wells are completed in the shallow bedrock, contact zone and overburden aquifers. Due to the hydraulic linkage between these units, and the complicated subsurface stratigraphy in the region, these aquifers are conceptualized to be a single aquifer unit for the purposes of analyzing aquifer vulnerability. Therefore, the target aquifer is considered to be the uppermost aquifer, including aquifers consisting of coarse-textured glaciomarine deposits, glaciofluvial deposits, recent and shallow bedrock units.

4.1.1.2 Vulnerability Scoring

The Groundwater Intrinsic Susceptibility Index (ISI) method was used to assess aquifer vulnerability throughout the Raisin-South Nation Source Protection Region. The ISI method examines how well an aquifer is protected by overlying geological units (bedrock or overburden). Areas where thick clays overlie an aquifer represent low aquifer vulnerability since less permeable materials inhibit the migration of contaminants into underlying aquifers. Thin soils or sand and gravel units afford little protection and represent areas where contamination can readily travel into underlying aquifers.

An ISI score is computed based on the thickness of the material above the aquifer, and an approximation of how easily water moves through that material (i.e., K-Factors). High ISI scores relate to lower vulnerability. Low ISI scores suggest an aquifer is vulnerable to contamination. ISI scores are related to vulnerability in *Table 0.46*. Areas of high vulnerability are those areas with scores that are less than 30.

Table 0.46: Vulnerability Scoring for Aquifers

Vulnerability Category	ISI Score	Vulnerability Score
Low	> 80	2
Medium	30 to 80	4
High (i.e., HVA)	< 30	6

A GIS program at a 100m × 100m grid scale (cell) was used to compute the ISI score across the region. The program used surficial geology maps and isopach maps for the various deposits in conjunction with accepted K-Factors to produce the final vulnerability score map.

The final aquifer vulnerability assessment is shown on *Map 4.1* and listed in *Table 0.47*.

Table 0.47: Aquifer Vulnerability Assessment, Raisin Region Source Protection Area

Vulnerability Category	Total Area (km²)	Percentage of Total Area
Low	65	4 %
Medium	688	37 %
High (i.e., HVA)	1101	59 %

4.1.2 Wellhead Protection Areas

Many municipalities rely on wells to supply drinking water to its residents. Wells of all types, municipal and private, urban and rural, pump water from under the ground. This groundwater comes from rain or snow that seeps below ground and pools in cracks or spaces in the soil, sand and rock. These underground sources of water are sometimes known as aquifers. The level of groundwater, the water table, rises and falls depending on the season, temperature, amount of rain or snow and the amount of water withdrawn from the aquifer.

More than 20% of Ontarians use groundwater to meet their daily water needs. In the Raisin-South Nation Source Protection Region, approximately 54% of the population use groundwater as their drinking water source. Approximately 9% of the region’s total population is serviced by municipal groundwater systems.

In the Raisin Region Source Protection Area, there are two municipal groundwater systems:

1. Redwood Estates (Township of South Glengarry)
2. Glen Robertson (Township of North Glengarry)

A wellhead is the physical structure of the well above ground. A wellhead protection area (WHPA) is the area around the wellhead where land use activities have the potential to affect the quality of water that flows into the well.

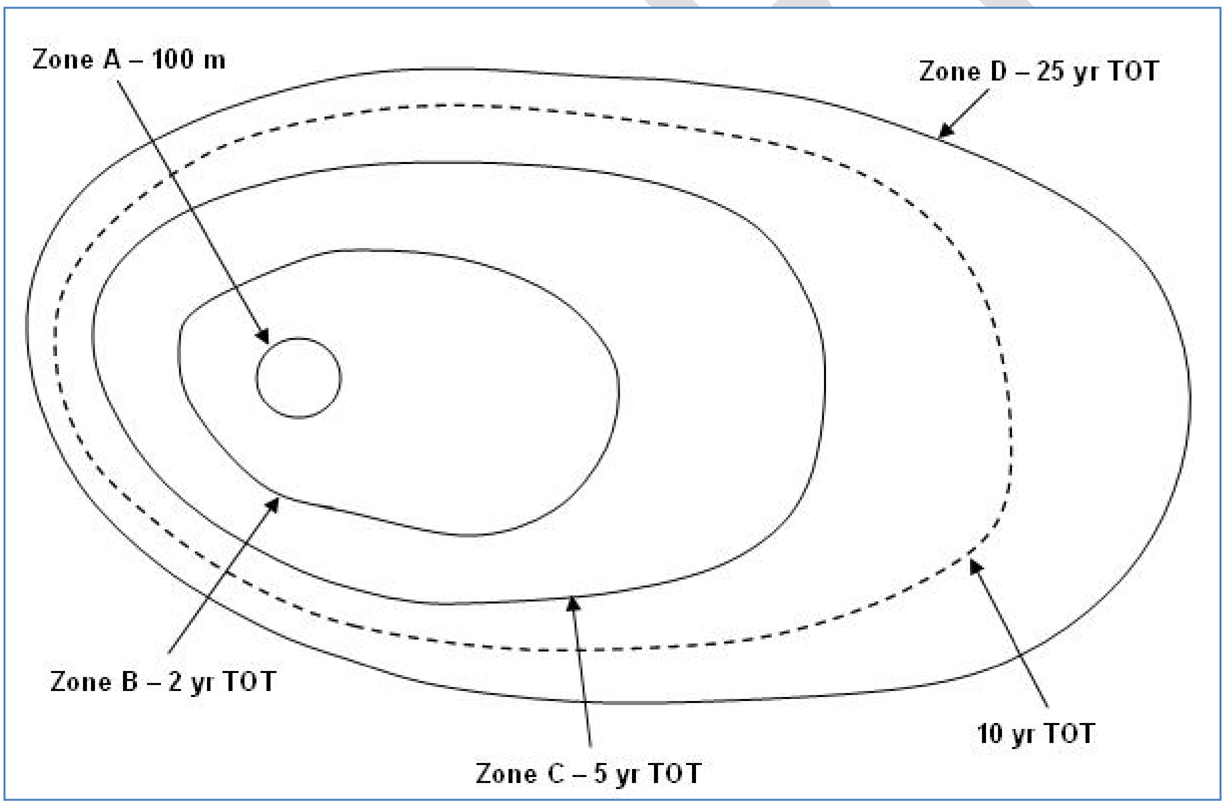
Pollutants can sometimes seep into the ground and contaminate the water in the well. Wellhead protection is a way to prevent municipal drinking water from becoming polluted because it requires landowners to manage activities that could become potential sources of contamination in the area supplying water to the well.

4.1.2.1 Vulnerable Area Delineation

The amount of land involved in a Wellhead Protection Area (WHPA) is determined by a variety of factors such as the way the land rises or falls, the amount of water being pumped, the type of aquifer, the type of soil surrounding the well, and the direction and speed that groundwater travels. All of these factors help determine how long it takes water to move underground to the well itself and how much land around the wellhead should be protected.

The Rules prescribe the framework for delineating vulnerable areas, or WHPAs, for groundwater systems. In general, four primary areas are identified, WHPA-A, WHPA-B, WHPA-C and WHPA-D; each representing an increase in time of travel to the well. An illustration of the how the different zone might look is shown in *Figure 0.24*.

Figure 0.24: Illustration of WHPA Zones



The WHPA area is delineated using a calibrated hydrogeologic computer model. Particle tracking analyses are conducted for a given pumping rate. The particle advective time of travel (TOT) to the supply well within the aquifer is projected at the surface. The final WHPAs are delineated by taking the composite of all reasonable scenarios simulated during the calibration and sensitivity analysis process.

Some municipal drinking water systems blend their municipal supply from two or more wells. Where the wellheads are not close to each other, or draw from differing depths, the vulnerable area for each well needs to be delineated.

Wellhead Protection Area A

Wellhead Protection Area A (WHPA-A), the Pathogen Security / Pathogen Prohibition Zone, is the area immediately surrounding the well. It is defined as the surface and subsurface area centered on the well with an outer boundary identified by a radius of 100 metres.

Wellhead Protection Area B

Wellhead Protection Area B (WHPA-B), the Pathogen Management Zone, is identified as the surface and subsurface areas within which the time of travel to the well is less than or equal to two years. WHPA-B excludes any area already within WHPA-A.

Wellhead Protection Area C

Wellhead Protection Area C (WHPA-C), the DNAPL / contaminant protection zone, is identified as the surface and subsurface areas within which the time of travel to the well is less than or equal to five years, but greater than two years.

Wellhead Protection Area D

Wellhead Protection Area D (WHPA-D), the Secondary Protection Zone, is identified as the surface and subsurface areas within which the time of travel to the well is less than or equal to twenty-five years, but greater than five years.

Wellhead Protection Area E

Wellhead Protection Area E (WHPA-E), is an additional area to be delineated where a groundwater source is under the direct influence of surface water (GUDI), or where there is a hydraulic connection between surface water and groundwater with the potential to impact the water quality.

4.1.2.2 Vulnerability Scoring

The Rules allow various methodologies for assessing the vulnerability of WHPAs. Vulnerability assessment for each wellhead in the Raisin-South Nation Source Protection Region used the “Surface to Well Advection Time” (SWAT) method. This approach represents vulnerability as a function of the total travel time that includes both horizontal and vertical flow. The SWAT calculation provides a comprehensible estimation of the potential travel, and hence vulnerability, to the well. The SWAT calculation also accounts for the direction of the vertical gradient. In areas of groundwater discharge, where the direction of vertical groundwater movement is in the upward direction, potential dissolved contaminants will not reach the underlying aquifer by advective transport. Consequently, areas where upward gradients exist, lower vulnerability scores were assigned to reflect the lesser likelihood of downward migration of potential dissolved phase contaminants.

The vertical travel time is represented as the Surface to Aquifer Advective Time (SAAT). For all wells in the Source Protection Region, the travel time through the unsaturated zone was assumed to be zero. As travel time through the unsaturated zone is not included in the SAAT, the resulting SWAT is slightly more conservative (underestimates the overall travel time).

In areas where there is no confining layer on top of the aquifer, the horizontal time of travel (TOT) calculated using the numerical model to delineate the WHPAs would be equivalent to the SWAT value, as there is no additional vertical travel time.

In areas where there is a confining layer, vertical travel times were computed and added to the underlying TOT estimates. To calculate the vertical travel times through the aquitard materials overlying the aquifer, the downward velocity was calculated using a computer model. Vertical velocities were calculated for each successive model grid cell from the upper most active cell down to the top of the aquifer. A vertical average linear velocity for each cell was calculated by dividing the vertical flux from each cell (obtained from the modelling results) by the area of the cell and the porosity.

To calculate the travel time, the thickness of the unit was divided by the average linear velocity. The vertical travel times of all successive vertical cells, between the top active cell and the aquifer, were summed together. This total vertical travel time was then added to the horizontal travel time (TOT) to estimate a SWAT.

Final vulnerability scores for areas within each WHPA were assigned based on the table of values prescribed in *The Rules*. The possible vulnerability scores are shown in *Table 0.48*.

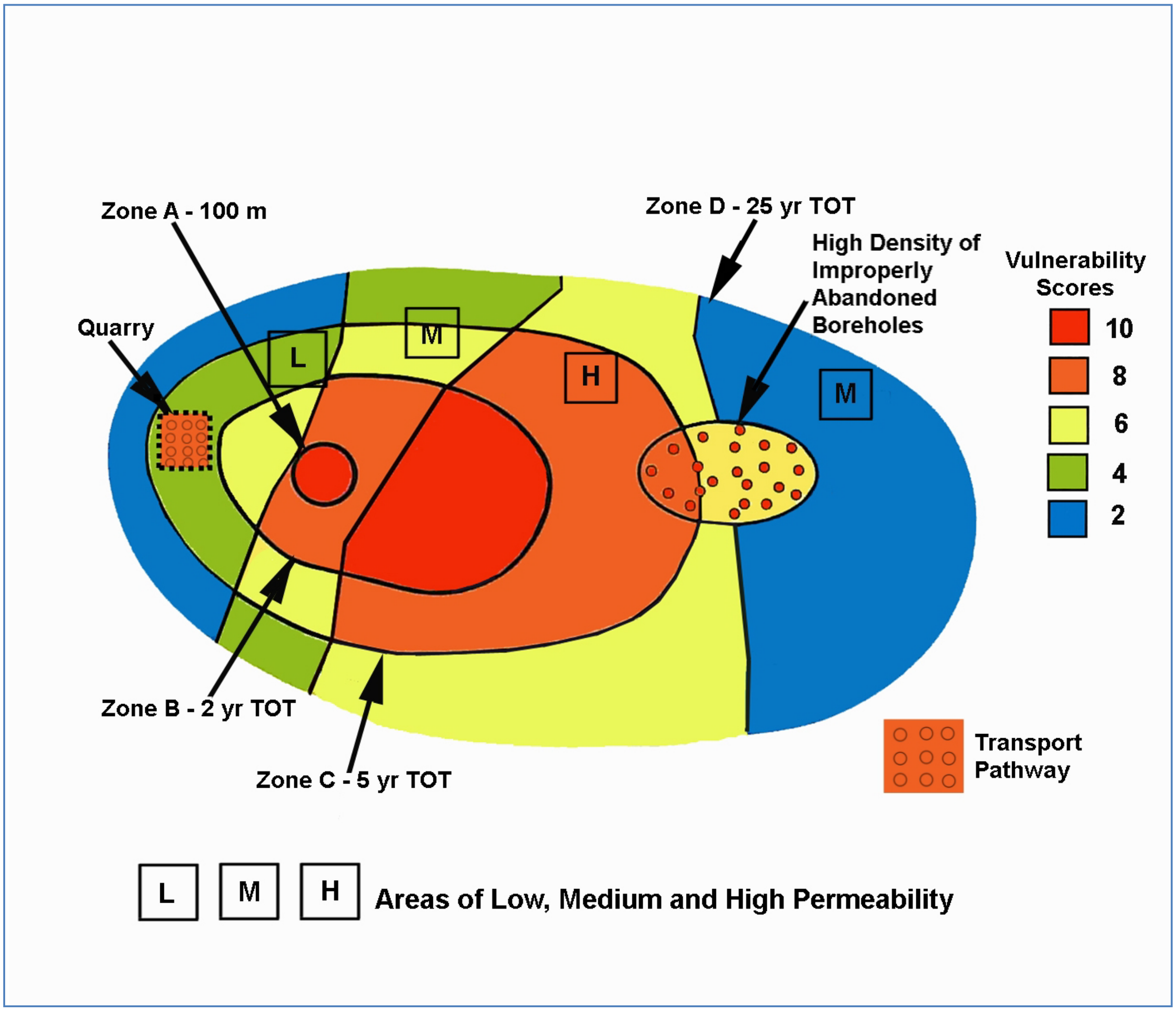
Table 0.48: Prescribed Wellhead Protection Vulnerability Scores (SWAT Approach)

Vulnerability Assessment		**Vulnerability Score**			
Category	SWAT	WHPA-A (100 m circle)	WHPA-B (2-year TOT)	WHPA-C (5-year TOT)	WHPA-D (25-year TOT)
High	< 5 Years	10	10	8	6
Medium	5 to 25 Years	10	8	6	4
Low	> 25 Years	10	6	2	2

4.1.2.3 Transport Pathways

Natural transport pathways, such as fractured bedrock, are to be considered in the preliminary assessment of vulnerability. Anthropogenic transport pathways, resulting from human activity, are “short cuts” where a surface contaminant could bypass the natural protective layers above an aquifer and enter a drinking water source. Examples of transport pathways include large and small diameter wells, and excavations. Where an anthropogenic transport pathway exists within a WHPA, the vulnerability category for the area may be increased accordingly, thus the vulnerability scores would rise in accordance with the prescribed table of vulnerability scores. An example of final vulnerability scoring taking into consideration area vulnerability and transport pathways is shown in *Figure 0.25*.

Figure 0.25: Illustration of Vulnerability Scoring, considering Area Vulnerability and Transport Pathways



4.1.2.4 Municipal Studies

A series of technical studies has been completed for each municipal groundwater well in the Source Protection Area. The studies have characterized the wells, delineated the applicable vulnerable areas and assessed the vulnerability in accordance with *the Rules*. The studies were guided by working groups consisting of local officials, plant operators, municipal and CA staff. A technical advisory team consisting of geology and hydrogeology experts reviewed the methodologies and results. The studies' outputs are used as input into each municipal groundwater system's assessment in *Section* 5.

4.1.3 Intake Protection Zones

Many municipalities rely on surface water to supply drinking water to their residents. Surface water is water that is visible on the landscape. In Ontario this includes lakes, rivers and streams.

The majority of Ontario's population draws its drinking water directly from the Great Lakes and large rivers, such as the Ottawa River and the St. Lawrence River. Surface water is transported through an intake pipe directly from the lake, river or stream and into a water treatment system. Fortunately, many of these drinking water intakes are located far from shore in deep water like in the Great Lakes, where contamination is less likely. However, many other municipal surface water intakes in Ontario are located in areas where there are greater risks of contamination.

In the Raisin Region Source Protection Area, there are five municipal water treatment plants that draw water from surface water:

1. Long Sault (Township of South Stormont)
2. Cornwall (City of Cornwall)
3. Glen Walter (Township of South Glengarry)
4. Lancaster (Township of South Glengarry)
5. Alexandria (Township of North Glengarry)

Protecting surface water from contamination involves protecting the surrounding water and, in most cases, the land that surrounds the water. The area, which is vulnerable to contamination, is known as an intake protection zone, or IPZ. Protecting it ensures a healthy supply of water now and in the future. Intake protection zones in a large lake, such as a Great Lake, may end up in the shape of a circle and never touch shore, however, intake protection zones in smaller lakes or on rivers may also include the land surrounding it, as well as several smaller feeder rivers or tributaries.

If not managed properly, pollutants from a variety of activities on or near surface water intakes can negatively affect the quality of municipal drinking water. Pollutants can seep into the ground, contaminate groundwater and therefore contaminate the water in a surface source. Runoff from rain or melting snow can also pick up and carry contaminants directly into a surface water drinking source. Surface water intake protection is a way of preventing drinking water from becoming polluted because it manages potential sources of contamination on both the land and water.

Special Note:
The Director's Technical Rules prescribe the framework for delineating and scoring Intake Protection Zones (IPZs). The Rules are updated from time-to-time to accommodate matters such as updated science, and unique or previously unforeseen situations. Updated technical rules have included accepted variations of IPZ delineation and scoring to be used where warranted. The IPZ techniques described below for delineation and scoring are consistent with the 2009 Director's Technical Rules, and they remain valid under the 2021 Technical Rules.

4.1.3.1 Vulnerable Area Delineation

The Rules prescribe the framework for delineating vulnerable areas, or IPZs, for surface water systems depending on the "type" of intake. Each municipal intake is classified as a:

- Type A intake, if the intake is located in a Great Lake;
- Type B intake, if the intake is located in a Great Lake connecting channel, or St. Lawrence River;
- Type C intake, if the intake is located in a river (and neither the direction nor velocity of the flow of water at the intake is affected by a water impoundment structure); or
- Type D intake, if the intake is not described at Type A, Type B or Type C.

Intake Protection Zone 1

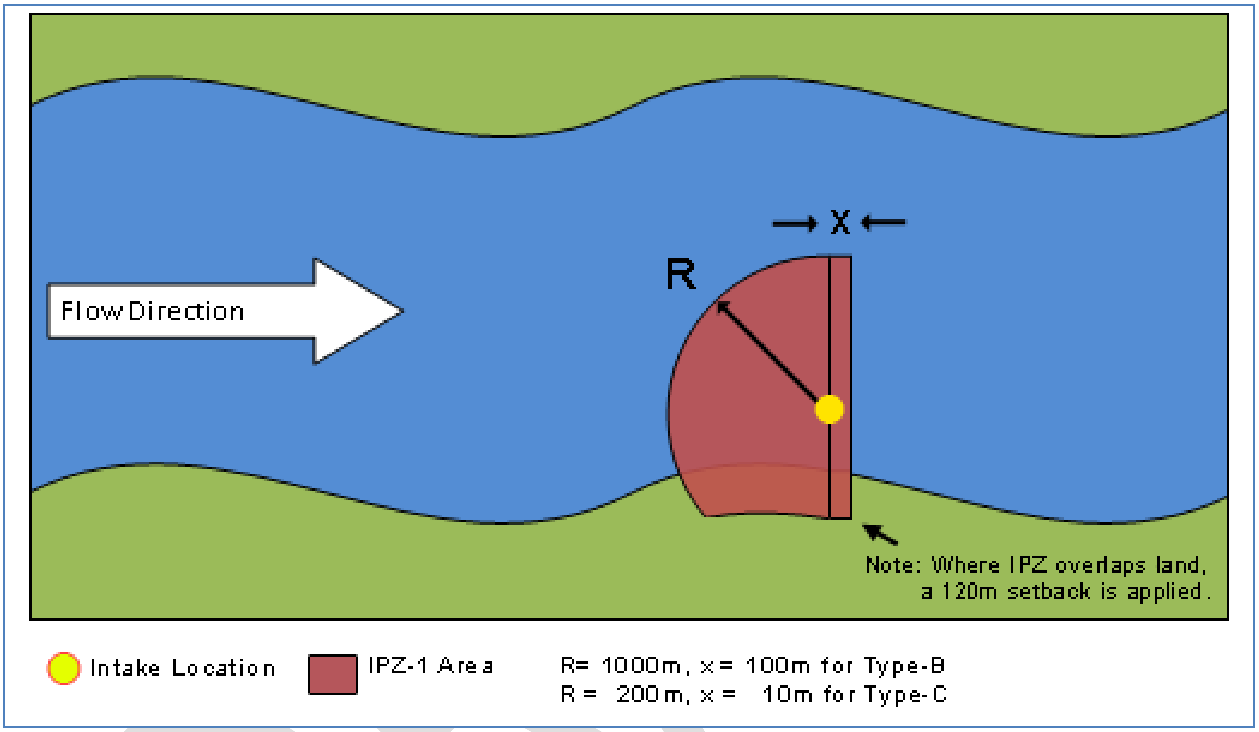
This zone is the area directly adjacent to the drinking water intake. Due to its close proximity to the intake, this area is considered the most vulnerable as it offers little or no dilution and there is a high potential for contaminants to enter the drinking water system undetected. This zone applies to all intakes; however, the methodology for delineating it varies by setting. In all situations, an effective 120-meter setback measured from the high water mark, or Regulation Limit, whichever is greater applies where the zone includes contributing land area. IPZ-1 delineation techniques are listed in *Table* 0.49.

Table 0.49: Delineation Techniques for Intake Protection Zone 1

Intake Type	IPZ-1 Delineation Methodology
Type A, Type D or Type C (if reasonable to protect the raw water quality)	A circle that has a radius of 1000 metres from the center point of the intake opening.
Type B	A semi-circle with a radius of 1000 metres extending upstream from the center point of the intake, and a rectangle with a length of 2000 metres and a width of 100 metres extending downstream from the center point of the intake. The zone may be modified based on local hydrodynamic conditions.

Intake Type	IPZ-1 Delineation Methodology
Type C	A semi-circle with a radius of 200 metres extending upstream from the centre point of the intake and a rectangle with a length of 400 metres and a width of 10 metres extending downstream from the center point. The zone may be modified based on local hydrodynamic conditions.

Figure 0.26: Default Geometry for Intake Protection Zone 1, Type-B and Type-C Systems



4.1.3.2 Intake Protection Zone 2

The area included within IPZ-2 is governed by the time to respond to a spill or other event that may impair the quality of water at the intake. *The Rules* prescribe a minimum of 2 hours or greater based on the operator response time. The zone includes the area of each surface water body that may contribute water to the intake plus a 120m setback onto land that drains into the surface water body. The area may be extended to include any transport pathways (e.g., storm sewers, tile drainage networks, ditches, gullies and swales). This zone applies to all intakes (i.e., Type A, Type B, Type C and Type D).

IPZ-2 does not include any area already accounted for within IPZ-1.

4.1.3.3 Intake Protection Zone 3

This zone exists as a protective zone where over the long term, chronic exposure of contaminants and other materials can impact the water quality at the intake. *The Rules* define this area as a) the entire water body that contributes to the intake (for Type C and D intakes);or

b) the contributing area within each surface water body through which contaminants released during an extreme event (100 year windstorm, 100 year flood event or significant storm event) may be transported to the intake (for Type A and B intakes, or Type C and D intakes located in certain settings – including the Ottawa River). In both instances, an effective inland setback of 120m along abutted area where the land drains towards the water body. This area may also consider contaminant transport pathways (e.g., storm sewers, tile drainage networks, ditches, gullies and swales).

IPZ-3 does not include any area already accounted for within IPZ-1 or IPZ-2.

In the Raisin-South Nation Source Protection Region, IPZ-3s were delineated only for Type D intakes, as there were no indicators that extreme events would lead to contaminants impacting the quality of the other types of drinking water systems.

4.1.3.4 High Water Mark

For all assessed drinking water systems drawing from a surface water body, the high water mark, in the absence of a Regulatory Limit, for basing on-shore setbacks was determined to be the edge of the Water Virtual Flow – Seamless Provincial Data Set layer or the Water Poly Segment data layer housed in the Ontario Land Information Warehouse as per *the Rules*. Water levels can fluctuate with various discharges however these fluctuations were considered negligible in comparison with a 120 m buffer.

4.1.4 Vulnerability Scoring

A vulnerability score is assigned to each IPZ-1, IPZ-2 and each area of an IPZ-3 that is associated with a type C or type D intake. The vulnerability assessment considers two separate factors: Area Vulnerability and Source Vulnerability. The vulnerability score is the product of these two factors and is a representative measure of the drinking water source’s susceptibility to contamination.

Equation 4.1: Vulnerability Score

$$\text{Vulnerability Score} = \text{Area Vulnerability Factor} \times \text{Source Vulnerability Factor}$$

4.1.4.1 Area Vulnerability Factor

The Area Vulnerability Factor is a measure of the susceptibility to contamination due to the physical landscape, independent of conditions at the drinking water intake. A higher score suggests higher susceptibility to source water impairment. Factors that are considered when determining the Area Vulnerability Factor are:

- The percentage of land within an IPZ;
- The land cover, soil type, permeability of the land and the slope of any setbacks;

- The hydrological and hydrogeological conditions in the area that contributes water to the area through transport pathways; and
- For IPZ-3, the proximity of the area to the intake.

The Rules prescribe the permissible values for the area vulnerability factor scores based on the vulnerable area or IPZ. The area vulnerability factor is expressed as a positive whole number. Possible Area Vulnerability Factors are listed in *Table 0.50*.

Table 0.50: Area Vulnerability Factors

Vulnerable Area	Possible Area Vulnerability Factors									
	1	2	3	4	5	6	7	8	9	10
IPZ-1										X
IPZ-2							X	X	X	
IPZ-3	X	X	X	X	X	X	X	X	X	

4.1.4.2 Source Vulnerability Factor

The Source Vulnerability Factor is a measure of the susceptibility to contamination due to the physical conditions directly at the intake, independent of the surrounding landscape. A higher score suggests higher susceptibility to source water impairment. Factors that are considered when determining the Source Vulnerability Factor are:

- The depth of the intake from the top of the water surface;
- The distance of the intake from land; and
- The number of recorded drinking water issues related to the intake, if any.

The Rules prescribe the permissible values for the source vulnerability factor scores based on the type of intake. The source vulnerability factor is expressed to a maximum of one decimal place, and is not greater than 1. Possible Source Vulnerability Factors are listed in Table 0.51.

Table 0.51: Source Vulnerability Factors

Intake Type	Possible Source Vulnerability Factors									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Type A intake					X	X	X	(X)	(X)	(X)
Type B intake							X	X	X	(X)
Type C intake									X	X
Type D intake								X	X	X
Note: Under certain circumstances, the Source Vulnerability Factor for a Type A or Type B intake may vary from 0.5 to 1.0, as per the Technical Rules.										

4.1.4.3 Final Vulnerability Score

The final vulnerability score for each vulnerable area is the product of the area vulnerability factor and the source vulnerability factor. The resulting possible vulnerability scores are shown in *Table 0.52*. Knowing the range of possible vulnerability scores is useful in assessing the assigned score of one intake relative to another intake.

Table 0.52: Possible Vulnerability Scores for Intake Protection Zones

Intake Type	**Vulnerable Area**		
	IPZ-1	IPZ-2	IPZ-3
Type A intake	5, 6 or 7 (or 5 to 10 under certain circumstances)	3.5 to 6.3	n.a.
Type B intake	7, 8 or 9 (or 7 to 10 under certain circumstances)	4.9 to 8.1	n.a.
Type C intake	9 or 10	6.3 to 9	0.9 to 9
Type D intake	8, 9 or 10	5.6 to 9	0.8 to 9

4.1.5 Municipal Studies

A series of technical studies has been completed for each municipal surface water intake in the Source Protection Area. The studies have characterized the intake, delineated the applicable vulnerable areas and assessed the vulnerability in accordance with *the Rules*. The studies were guided by working groups consisting of local officials, plant operators, municipal and CA staff. The study results are used as input into each municipal surface water system's assessment in *Section 5*.

4.2 Water Quality Threats Based Approach

To determine whether an activity is a significant, moderate or low drinking water threat, the following details are required:

1. If the activity is identified as a prescribed drinking water threat, a locally added threat or a pre-existing condition;
2. The circumstances related to the presence of a contaminant and/or release;
3. Which vulnerable area it is located; and
4. The vulnerability score of the area where the activity is located.

The Regulations require that the total number of significant water quality threats is to be determined for each vulnerable area.

4.2.1 Identification of Prescribed Activities, Local Activities and Conditions

Ontario Regulation (O. Reg.) 287/07 (General) lists 20 activities that are prescribed as drinking water threats (PDWTs) with respect to water quality:

1. The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.
2. The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.
6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.
15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid.
17. The handling and storage of an organic solvent.
18. The management of runoff that contains chemicals used in the de-icing of aircraft.
19. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.
20. The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.

The Source Protection Committee can add locally based activities other than those listed in the regulation as prescribed drinking water threats. These threats are to be listed separately from the prescribed activities. Local activities are to be supported by information provided by the Director to indicate that the hazard rating of any associated pathogen or chemical is sufficiently high enough to pose a risk. Currently, the Source Water Protection Committee has not added additional activities as threats to local drinking water systems.

The following conditions that result from past activities are to be listed as drinking water threats also:

1. The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.
2. The presence of a single mass of more than 100 litres of one or more dense non-aqueous phase liquids in surface water in a surface water intake protection zone.
3. The presence of a contaminant in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.
4. The presence of a contaminant in surface soil in a surface water intake protection zone if, the contaminant is listed in Table 4 of the Soil, Ground Water and Sediment Standards is present at a concentration that exceeds the surface soil standard for industrial/commercial/community property use set out for the contaminant in that Table.
5. The presence of a contaminant in sediment, if the contaminant is listed in Table 1 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the sediment standard set out for the contaminant in that Table.
6. The presence of a contaminant in groundwater that is discharging into an intake protection zone, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards, the concentration of the contaminant exceeds the potable groundwater standard set out for that contaminant in the Table, and the presence of the contaminant in groundwater could result in the deterioration of the surface water for use as a source of drinking water.

4.2.1.1 Threat Geometry

The geometry provides information regarding the physical shape of the drinking water threat. Documented threats can be classified as point, line (polyline) or polygon. The description “point” refers to a single identifiable threat location (e.g., location of a fuel storage tank). Also, “polyline” refers to a threat that has several linear features of (e.g., a sanitary sewer line) and “polygon” indicates the threat is a shape such as a square or rectangle (e.g., a land parcel that could receive agricultural source material).

4.2.2 Water Quality Threats Circumstances

The Technical Rules, under the *Clean Water Act*, include Tables of drinking water quality threats, *the Tables*. *The Tables* describe circumstances where an activity would be considered a significant, moderate, or low risk. These circumstances are provided for chemicals and pathogens, and for each vulnerable area where the vulnerability score is such to substantiate the risk.

The Source Protection Committee can add locally relevant circumstances other than those listed in *the Tables*. Currently, the Source Water Protection Committee has not identified additional circumstances.

For certain activities, the reference of additional mapping, "Percentage Managed Lands", "Livestock Density" and "Percent Impervious Surface Areas" is required to verify a particular circumstance.

4.2.2.1 Managed Lands

Managed Land is land to which nutrients (Agricultural Source Material, fertilizer, Non-Agricultural Source Materials) are applied. It includes, but is not limited to, cropland, fallow land, improved pasture, golf courses, sports fields, and lawns.

Managed Lands can be broken into 2 subsets: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow, and improved pasture that may receive nutrients. Non-agricultural managed lands include golf courses (turf), sports fields, lawns (turf) and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer).

The percentage of managed lands is to be identified (mapped) within each of the vulnerable area where the vulnerability score for that area is high enough for activities to be considered a significant, moderate or low drinking water threat. Based on *the Tables*, this equates to any WHPA or HVA with a score of 6 or higher.

The thresholds defined to evaluate the risk in a vulnerable area are:

- If managed lands in total account for less than 40% of the vulnerable area or subsets of this area, the area is considered to have a low potential for nutrient application to be causing contamination of drinking water sources,
- If managed lands in total account from 40% to 80% of the vulnerable area or subsets of this area, the area is considered to have a moderate potential for nutrient application to be causing contamination of drinking water sources, and

- If managed lands in total account for over 80% of the vulnerable area or subsets of this area, the area is considered to have a high potential for nutrient application to be causing contamination of drinking water sources.

The percent managed lands map is considered when evaluating the chemical contaminants associated with the circumstances related to the following prescribed drinking water threats:

- The application of agricultural source material to land.
- The application of commercial fertilizer to land.
- The application of non-agricultural source material to land.

Agricultural and non-agricultural managed land areas were delineated using land use classification data from the Municipal Property Assessment Corporation (MPAC). Land uses associated with the application of nutrients were considered to be managed lands and were confirmed using aerial imagery. Improperly classified properties were re-classified to an appropriate property code within the IPZs and WHPAs.

The percent managed lands have been mapped and categorized for each assessed drinking water system. The results are presented in *Section* 5. The percent managed lands in the Highly Vulnerable Aquifers (HVAs) is between 40% and 80%, which indicates a moderate potential for nutrient application to cause contamination on a regional average. HVAs with vulnerability scores of 2 and 4 are below the threshold for consideration.

A regional assessment of Managed Lands is shown in *Table 0.53*.

Table 0.53: Regional Assessment of Managed Lands, Raisin Region Source Protection Area

Vulnerable Area	Vulnerability Score	Percent Managed Land	Area (km^2)
HVA	6	40% to 80%	1,100.9

4.2.2.2 Livestock Density

Livestock density is used as a surrogate measure of the potential for generating, storing, and land applying agricultural source material (ASM) as a source of nutrients within a defined area. The livestock density is expressed in NU/Acre.

For land application of ASM, a high livestock density in an area suggests an increased potential that over-application of ASM may occur as adequate land base to properly dispose of all the ASM may not exist. In areas with low livestock density adequate land-base is more likely to exist to properly dispose of the ASM. Commercial fertilizers will likely be used to compensate for any under supply of ASM-based nutrients. The amounts applied, however, are regulated by the fact that this is a purchased crop input. The rationale is that growers will want to closely match commercial fertilizer applications to crop requirements to minimize their cost of crop production.

The thresholds defined to evaluate the risk of over-application of ASM are:

- If livestock density in the vulnerable area is less than 0.5 NU/acre, the area is considered to have a low potential for nutrient application exceeding crop requirements,
- If livestock density in the vulnerable areas is over 0.5 and less than 1.0 NU/acre, the area is considered to have a moderate potential for nutrient application exceeding crop requirements, and
- If livestock density in the vulnerable areas is over 1.0 NU/acre, the area is considered to have a high potential for nutrient application exceeding crop requirements.

The livestock density mapping is considered when evaluating the chemical contaminants associated with the circumstances related to the following prescribed drinking water threats:

- The application of agricultural source material to land.
- The application of commercial fertilizer to land.
- The application of non-agricultural source material to land.

The approach used to calculate Livestock Density followed the recommended methodology outlined by the MOE Technical Bulletin. Agriculture census data was used to determine the number of nutrient units in each consolidated census subdivision. Livestock density was calculated by dividing the number of nutrient units by the area of agricultural managed lands.

The livestock density calculations have been mapped and categorized for each assessed drinking water system. The results are presented in *Section* 5. The livestock density in Highly Vulnerable Areas (HVAs) was <0.5 NU/acre, which indicates a low potential for nutrient application exceeding crop requirements on a regional average. HVAs with vulnerability scores of 2 and 4 are below the threshold for consideration.

A regional assessment of Livestock Density is shown in *Table 0.54*.

Table 0.54: Regional Assessment of Livestock Density, Raisin Region Source Protection Area

Vulnerable Area	Vulnerability Score	Livestock Density (NU/Acre)	Area (km^2)
HVA	6	<0.5	1,100.9

4.2.2.3 Impervious Surfaces

For the purpose of the Assessment Report, total impervious surface area means the surface area of all highways and other impervious land surfaces used for vehicular traffic and parking, and all pedestrian paths.

Mapping the percentage of impervious surface area is not required for an area in a vulnerable area where the vulnerability scores for that area is less than the vulnerability score necessary for the application of road salt to be considered a significant, moderate or low threat in the

Table of Drinking Water Threats. Based on the tables, this equates to any WHPA with a score of 6 or higher.

The impervious surface area calculation is considered when evaluating the potential for contamination of water from Sodium and Chloride due to the application of road salt.

4.2.3 Areas where Threats are Significant, Moderate or Low

Areas within each vulnerable area where an activity or condition is or would be a significant, moderate or low drinking water threat can be illustrated on a map. The final threat assessment can be made by locating the activity within the vulnerable area and reviewing the pertinent circumstance tables. The vulnerable sub areas where it is possible to locate significant, moderate or low threats under various vulnerability scores are highlighted in *Table 0.55*, *Table 0.56* and *Table* 0.57.

The circumstances are such that pathogens are not a threat inside WHPA-C, WHPA-D, or IPZ-3 and DNAPLs are a not a threat to IPZs.

Table 0.55: Potential Threat Areas depending on the nature of the contaminant, HVAs

Vulnerable Area	Vulnerability Score	Chemical Threats			Pathogen Threats			DNAPL Threats		
		Sig.	Mod.	Low	Sig.	Mod.	Low	Sig.	Mod.	Low
HVA	6		X	X					X	X

X	Denotes some activities could or would be Significant, Moderate or Low threats.

Table 0.56: Potential Threat Areas depending on the nature of the contaminant, WHPAs

Vulnerable Area	Vulnerability Score	Chemical Threats			Pathogen Threats			DNAPL Threats		
		Sig.	**Mod.**	**Low**	**Sig.**	**Mod.**	**Low**	**Sig.**	**Mod.**	**Low**
WHPA-A	10	X	X	X	X	X		X		
WHPA-B	10	X	X	X	X	X		X		
WHPA-B	8	X	X	X		X	X	X		
WHPA-B	6		X	X		X	X	X		
WHPA-C	8	X	X	X				X		
WHPA-C	6		X	X				X		
WHPA-C	2			X				X		
WHPA-D	6		X	X					X	X
WHPA-D	4									
WHPA-D	2									

X	Denotes some activities could or would be Significant, Moderate or Low threats.

Table 0.57: Potential Threat Areas depending on the nature of the contaminant, IPZs

Vulnerable Area	Vulnerability Score	Chemical Threats			Pathogen Threats			DNAPL Threats		
		Sig.	Mod.	Low	Sig.	Mod.	Low	Sig.	Mod.	Low
IPZ-1	8,9,10	X	X	X	X	X	X			
IPZ-1	6, 7		X	X		X	X			
IPZ-1	5			X			X			
IPZ-2	8, 8.1, 9	X	X	X	X	X	X			
IPZ-2	6.3 to 7.2		X	X		X	X			
IPZ-2	4.2 to 5.6			X			X			
IPZ-2	3.5, 4									
IPZ-3	8, 8.1, 9	X	X	X						
IPZ-3	6 to 7.2		X	X						
IPZ-3	4.5 to 5.6			X						
IPZ-3	0.8 to 4									

X	Denotes some activities could or would be Significant, Moderate or Low threats.

4.3 Water Quality Issues Based Approach

A drinking water quality issue is a substantiated condition relating to the quality of water that interferes, or that can be reasonably predicted to interfere in the near term with the use of a drinking water source if rising trends continue. Issues are assessed at the surface water intake or at the well, although issues may also be identified a distance away from the point of extraction (e.g., monitoring wells). A drinking water issues assessment is intended to connect problems in a drinking water source to specific drinking water threats so that these threats can be managed appropriately.

For municipal drinking water sources, the parameters in schedules 1, 2 and 3 of *Ontario Drinking Water Quality Standards* (ODWQS) and Table 4 of the *Technical Support Document for Ontario Drinking Water Standards*, Objectives and Guidelines are considered in the issues evaluation. (Microbial risk assessment is not considered for monitoring wells).

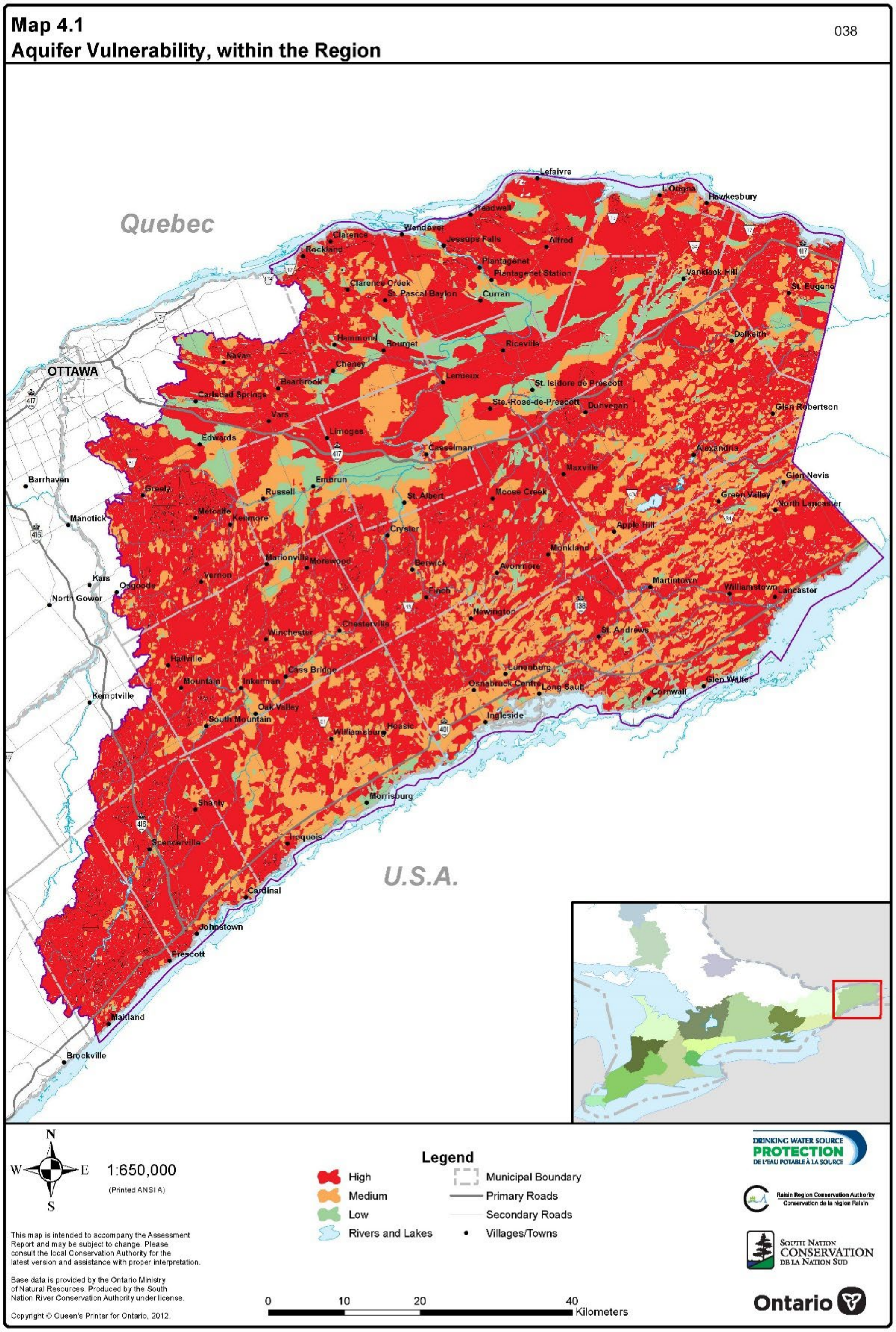
Where an elevated parameter is identified, the Source Protection Committee can choose not to elevate the parameter as an “issue” if the water treatment plant is adequately dealing with the problem. If the issue is formally identified, the “Issue Contributing Area” (ICA) is to be delineated, or a plan to delineate the area shall be included in the Assessment Report. Once the issues and ICA’s are defined, areas where threats are significant, moderate or low drinking water threats can be defined.

4.4 Events Based Approach

The Events Based Approach is reserved for surface water systems, specifically, Type A and B intakes (Great Lakes and Connecting Channels) and Types C and D intakes in Lake Nipissing, Lake Simcoe, Lake St. Clair or the Ottawa River. In the Raisin Region Source Protection Area, this approach is limited to surface water intakes on the St. Lawrence River.

The events based approach is used to identify activities, which under an extreme event (high runoff) could cause a drinking water issue at an intake. Extreme event modelling is used to identify activities or conditions that are significant drinking water threats in IPZ-1 and IPZ-2. Extreme event modelling can be used to delineate an IPZ-3 if contaminants can be shown to reach the intake.

Map 4.1: Aquifer Vulnerability, Raisin-South Nation Source Protection Region



5 Assessment of Drinking Water Systems

Water quality threats assessments have been completed for each drinking water system identified in the Raisin Region Source Protection Authority's Terms of Reference. The drinking water systems that have been assessed are:

1. Redwood Estates (Township of South Glengarry), 1 groundwater well
2. Glen Robertson (Township of North Glengarry), 1 groundwater well
3. Long Sault (Township of South Stormont), 1 surface water intake
4. Cornwall (City of Cornwall), 1 surface water intake
5. Glen Walter (Township of South Glengarry), 1 surface water intake
6. Lancaster (Township of South Glengarry), 1 surface water intake
7. Alexandria (Township of North Glengarry), 1 surface water intake

These drinking water systems are shown on *Map 5.1*.

5.1 Redwood Estates

The Redwood Estates drinking water system services a small residential development in the Township of South Glengarry, approximately 10 km east of the Town of Lancaster. The municipal supply well consists of a single 250 mm diameter drilled well completed to a depth of 16.2 m below grade. The well was drilled in March 1993. The well construction includes 15.85 metres of steel casing and 14 metres of concrete grout. The system is designed for a total population of 150 (39 lots). The distribution system servicing Redwood Estates is a single loop consisting of a water main originating at the treatment plant and running along Karen Drive and Shannon Lane. The system was designed without fire flow allowance. All houses within the subdivision and their associated sewage disposal systems are located south and down-gradient of the municipal supply well. The Redwood Estates municipal supply well is owned and operated by the Corporation of the Township of South Glengarry. The water treatment and distribution system were constructed in 1995 and is operated by the Corporation of the Township of South Glengarry.

The site location is shown on *Map 5.1.1*. Drinking water system information is presented in *Table 5.1*.

Table 5.1: Drinking Water System Information, Redwood Estates

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	250002311
Drinking Water System Name	Redwood Estates Well Supply
Owner	South Glengarry, The Corporation of the Township of
Operating Authority	South Glengarry, The Corporation of the Township of

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Source Water Type	Groundwater
Number of Wells	1
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	545772 Easting, 5002267 Northing (UTM NAD-83, Zone 18)
Location of Monitoring Wells	n/a
Area served by System	Community of Redwood Estates
Number of Users (approx. residents)	150
Average Daily Taking	21 m^3/day
Maximum Daily Taking	59 m^3/day
WHPA Delineation Pumping Rate	68 m^3/day
Permit to Take Water	8854-9GQQNL
Maximum Permitted Taking	151.2 m^3/day

5.1.1 Vulnerable Area Delineation

The vulnerable area for this system comprises the Wellhead Protection Area (WHPA), which was delineated in accordance with the Technical Rules: Assessment Report (*the Rules*). Delineations were accomplished by conducting particle tracking analyses on a *computer based three-dimensional groundwater flow model*. The particle advective time of travel (TOT) to the supply well within the aquifer was projected at the surface.

The WHPA for this system is the area created by combining the following four sub-areas:

1. WHPA-A: Pathogen Security/ Prohibition Zone (100m fixed radius)
2. WHPA-B: Pathogen Management Zone (2-year TOT capture zone)
3. WHPA-C: DNAPL / Contaminant Protection Zone (5-year TOT capture zone); and
4. WHPA-D: Secondary Protection Zone (25-year TOT capture zone).

This drinking water system is not directly influenced by a surface water body, and therefore area WHPA-E, as defined by *the Rules* do not apply.

The various WHPAs for this drinking water system are shown on *Map 5.1.2*. The respective area calculations are summarized in *Table* 5.2.

Table 5.2: Total Area by Vulnerable Area, Redwood Estates

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	11 %
WHPA-B	13.8	50 %
WHPA-C	8.8	32 %
WHPA-D	2.0	7 %
Total	**27.7**	**100 %**

It should be noted that the delineation of vulnerable area does not imply that land use activities within that area pose a threat to drinking water.

5.1.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method considers vertical groundwater flow through the formations overlying the gravel aquifer. The Surface to Aquifer Advection time (SAAT) is used to compute the vertical velocity. SAAT is directly related to the characteristics and thickness of the overburden material and whether or not there is a confining layer.

The geologic model suggests there is varying thickness of Fine Textured Glaciomarine deposits (clay) and till deposits within the WHPA delineation, generally thickest closest to the municipal supply well and then thinning toward the northwest. Protection of the bedrock aquifer is therefore greatest in the immediate vicinity of the municipal well (and therefore lowest intrinsic groundwater vulnerability).

SWAT assessment is shown on *Map 5.1.3*.

The value of the groundwater vulnerability is 10 at the well head (WHPA-A). Immediately outside WHPA-A the vulnerability decreases to 6 due to the presence of the protective clay layer. The vulnerability within WHPA- B ranges from 6 to 10 depending on the thickness of the protective Fine Textured Glaciomarine layer. In WHPA-C the vulnerability is 8 and in WHPA-D the vulnerability is 4. WHPA-D (25-yr) extends approximately 2.4 km to the northwest.

WHPA vulnerability scoring is shown on *Map 5.1.4*. A distribution of vulnerability scores by sub-area is presented in Table 5.3.

Table 5.3: Distribution of Vulnerability Scores, Redwood Estates

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-A	3.1	3.1	*n.a.*	*n.a.*	*n.a.*	*n.a.*
WHPA-B	13.8	6.7	5.2	1.9	*n.a.*	*n.a.*

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-C	8.8	*n.a.*	7.8	0.8	*n.a.*	0.2
WHPA-D	2.0	*n.a.*	*n.a.*	0.1	1.9	0.0
Total	**27.7**	**19.8**	**13.0**	**2.8**	**1.9**	**0.2**

5.1.2.1 Transport Pathways

Anthropogenic transport pathways, resulting from human activity, are "short cuts" where a surface contaminant could bypass the natural protective layers above an aquifer.

Highway 401 has been identified as a transport pathway as some of the protective clay layer may have been removed or disturbed during construction of the highway. The vulnerability around the highway has been increased from Low to High (SWAT would be less than 5 years).

5.1.3 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.1.3.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.1.3.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is a significant, moderate or low drinking water threat. *Table 5.4*, *Table 5.5* and *Table 5.6* can be used to determine which areas are vulnerable to chemical, pathogen and DNAPL threats. These are also referenced visually on *Map 5.1.5.*

Table 5.4: Risk of Chemical Threats, Redwood Estates

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	10	Yes	Yes	Yes
WHPA-B	10	Yes	Yes	Yes
WHPA-B	8	Yes	Yes	Yes
WHPA-B	6	*Below threshold*	Yes	Yes
WHPA-C	8	Yes	Yes	Yes
WHPA-C	6	*Below threshold*	Yes	Yes
WHPA-D	6	*Below threshold*	Yes	Yes
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.5: Risk of Pathogen Threats, Redwood Estates

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	10	Yes	Yes	*None*
WHPA-B	10	Yes	Yes	*None*
WHPA-B	8	*None*	Yes	Yes
WHPA-B	6	*Below threshold*	*None*	Yes
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.6: Risk of DNAPL Threats, Redwood Estates

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	All Scores	Yes	*None*	*None*
WHPA-B	All Scores	Yes	*None*	*None*
WHPA-C	All Scores	Yes	*None*	*None*
WHPA-D	6	*Below threshold*	Yes	Yes
WHPA-D	4,2	*Below threshold*	*Below threshold*	*Below threshold*

5.1.3.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.1.6* and is tabulated in *Table 5.7*. The vulnerability score for WHPA-D is less than the vulnerability scores necessary for the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land to be considered a low threat; therefore, that area is not considered for this evaluation.

Table 5.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Redwood Estates

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	3.1	0.6	0	0.6	19%
WHPA-B	13.8	10.8	0	10.8	78%
WHPA-C	8.8	7.4	0	7.4	84%

5.1.3.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 5.1.7* and is tabulated in *Table 5.8*. The vulnerability score for WHPA-D is less than the vulnerability scores necessary for the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land to be considered a low threat; therefore, that area is not considered for this evaluation.

Table 5.8: Livestock Density Assessment, Redwood Estates

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area (NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.2	0.2		
8		0.2	0.2	
6		0.2	0.2	0.2

5.1.3.5 Impervious Surface Area

The impervious area within each WHPA where the application of road salt could pose a low risk at minimum is shown on *Map 5.1.8* and tabulated in *Table 5.9*. The area vulnerability score for WHPA-D is less than the vulnerability scores necessary for the application of road salt to be considered a significant, moderate or low threat and therefore, that area is not considered for this evaluation.

Table 5.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Redwood Estates

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	More than 80%
WHPA-A	0	0	3.14	0
WHPA-B	2.77	0	10.73	0
WHPA-C	6.98	1.86	0	0

5.1.3.6 Issues Evaluation

A review of water quality data at the well suggests that there is no evidence that a parameter is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water.

There are no issues therefore requiring further assessment or the delineation of an issues contributing area.

5.1.3.7 Conditions from Past Activities

Various data sets were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition to be considered a threat as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.1.3.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official's 2020 report, there are 7 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 5 unique locations (one location could possibly account for multiple threat activities). Specific activities and location counts are listed in Table 5.10.

Table 5.10: Significant Drinking Water Threat Activities, Redwood Estates

Activity	Sub Threat, if Applicable	Count
The application of commercial fertilizer to land.		2
The application of pesticide to land.		2
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Septic System or Holding Tank	3
*The application of road salt. **		*3**
Total – All Activities		**10**

*This table has not been revised to reflect updated threat counts, threat counts remain unchanged and are those enumerated in 2020, instead it has been updated to account for the new threats and threat subcategories per the Technical Rules updates in 2021.

5.1.4 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards for assessing drinking water systems throughout the Source Protection Authority and Source Protection Region. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.1.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table* 5.11

These reports and technical studies are built on the foundation of various pre-existing reports, maps and data-sets. Each information source quoted below contains its own complete table of references.

Table 5.11: Key Information Sources, Redwood Estates

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2019. *Redwood Estates Drinking Water System 2019-20 Inspection Report*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analysis – Redwood Estates Water Supply.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analysis – Redwood Estates Water Supply.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	Raisin Region Conservation Authority. 2021. *Managed Lands in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Report.*	Report	Assessment, Spatial Analyses
	WESA. 2010. *Groundwater Threats Assessment - Redwood Estates Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Assessment - Redwood Estates Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Assessment - Redwood Estates Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses

Section	Source(s)	Type	Analysis Method(s)
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
Water Quality Threats Assessment	WESA. 2010. *Groundwater Threats Assessment - Redwood Estates Water Supply.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.1.4.2 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The well is completed in the bedrock and groundwater flow is predominantly through the bedrock aquifer. There is a low permeability layer overlying the aquifer just north of the well, this layer appears to become thinner towards the north. SAAT calculations were completed.

The technical study to identify the WHPA included various scenarios to identify the WHPA shape, direction and length. The final WHPA shape is a conservative composite of plausible modeled scenarios. Where scenarios overlapped, the uncertainty was defined as low.

There was very little site specific data available for the development of the numerical model for the Redwood Estates. The primary data source was the MOE well records, and this data had relatively low density within the model domain. This information supports the relative uncertainty attributed to this assessment. However, it must be noted that the direction of groundwater flow can be confidently assumed to be approximately perpendicular to the St Lawrence River, and therefore the conceptual understanding of the shape of the WHPA has relatively low uncertainty.

The uncertainty relating to scoring of WHPAs is directly related to the uncertainty in SAAT calculation and the identification of transport pathways. Overall, the SAAT approach had high uncertainty; therefore, the vulnerability scoring is assumed to have high uncertainty.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

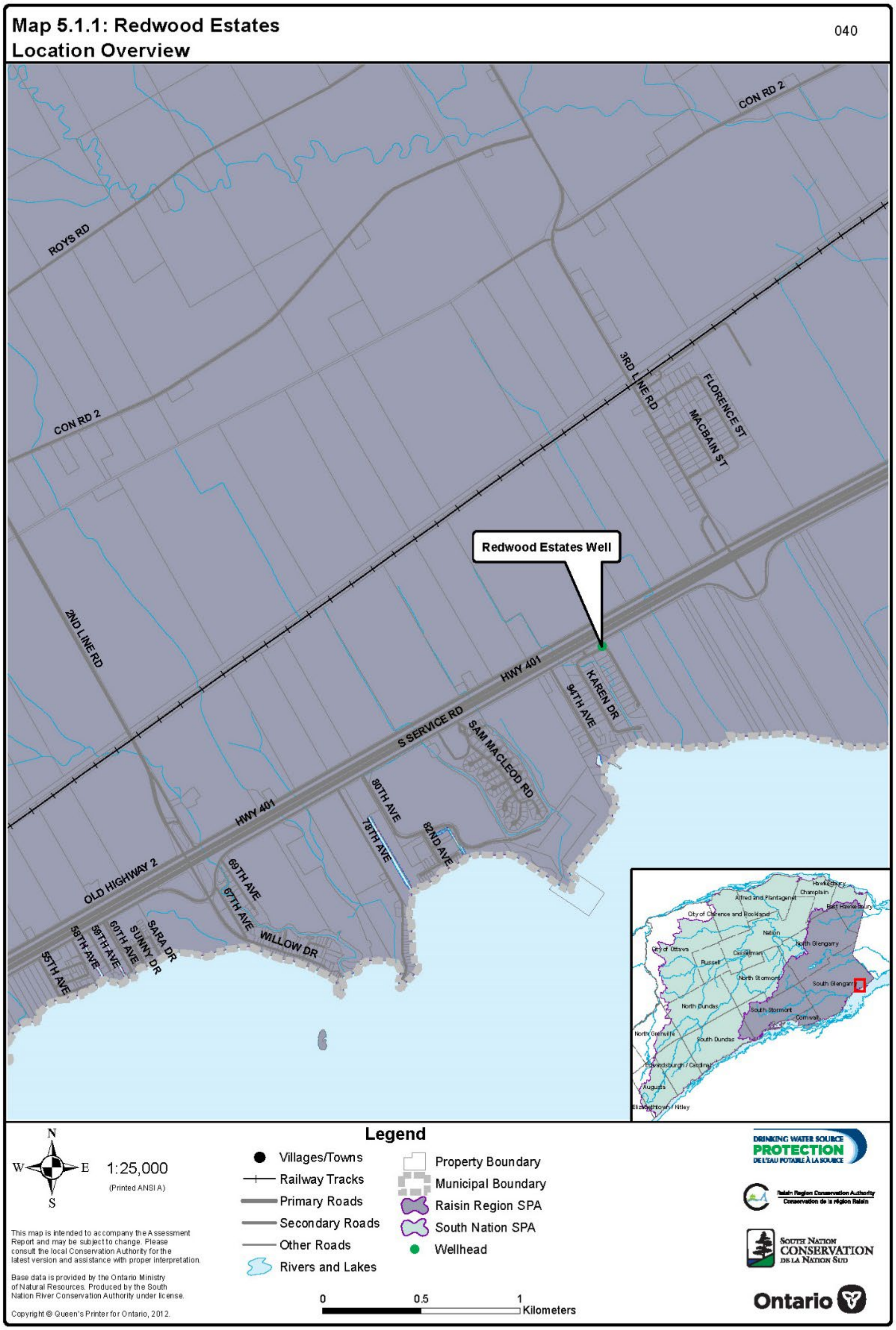
The enumeration of threats has been validated through site visits and/or communications with the landowner by either a Risk Management Official or Risk Management Inspector which included a review of the activity's location and circumstances and is therefore considered to have low uncertainty.

A summary of uncertainty is listed in *Table 5.12*.

Table 5.12: Summary of Uncertainty Analyses, Redwood Estates

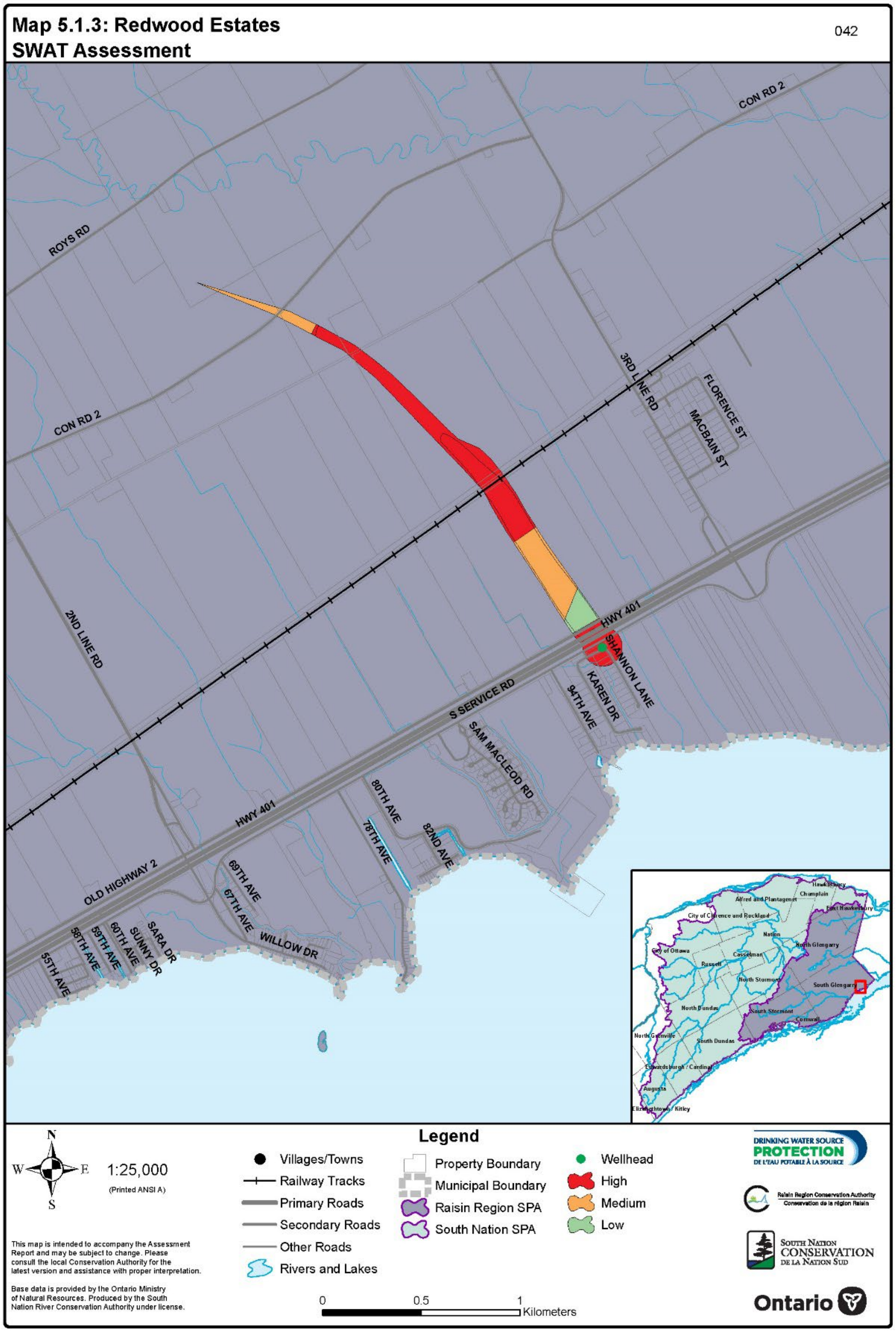
Component	**Uncertainty Assessment**			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
WHPA Delineation (shape and direction)	Low	Low	Low	Low
WHPA Delineation (length)	Low	High	High	High
Surface to Aquifer Advection Time	n/a	High	High	High
Vulnerability Scoring	Low	High	High	High
Issues Evaluation	Low	Low	Low	Low
Managed Lands Evaluation	Low	Low	Low	n/a
Livestock Density Evaluation	Low	Low	Low	n/a
Impervious Surface Evaluation	Low	Low	Low	n/a
Threats Assessment	Low	Low	Low	Low

Map 5.1.1: Location Overview, Redwood Estates

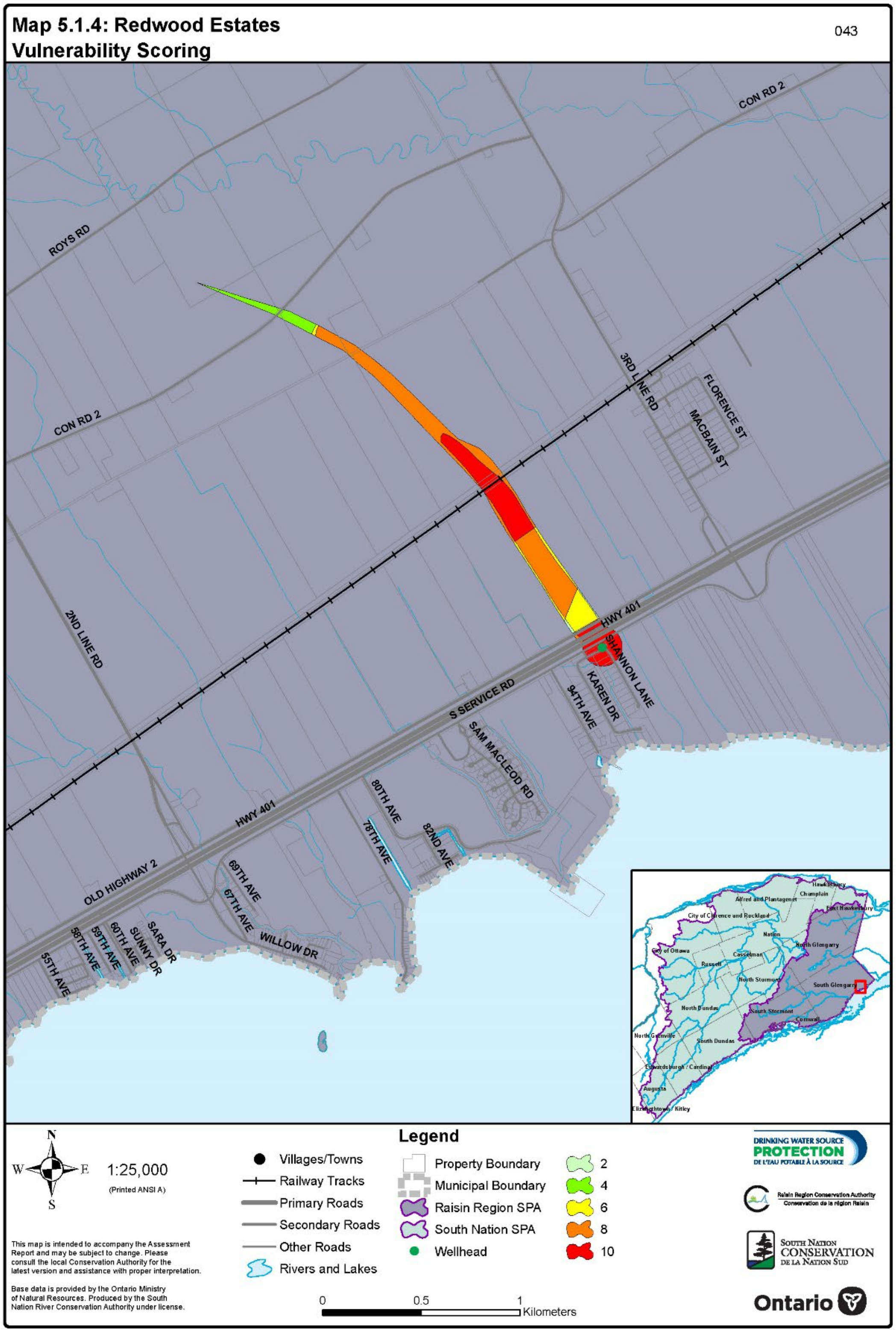


Map 5.1.2: Vulnerable Area Delineations, Redwood Estates

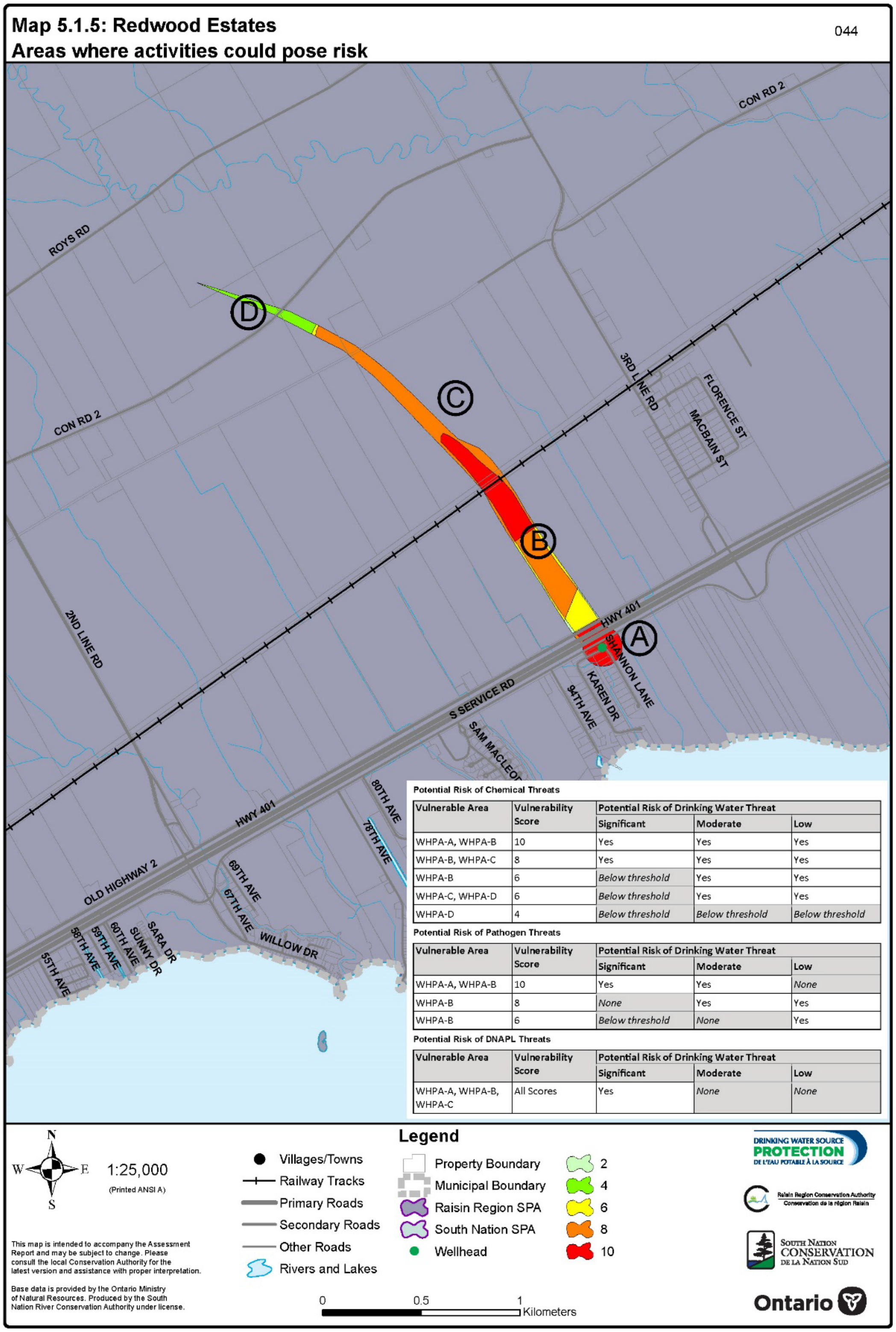
Map 5.1.3: SWAT Assessment, Redwood Estates



Map 5.1.4: Vulnerability Scoring, Redwood Estates



Map 5.1.5: Areas where Activities are or would be Drinking Water Threats, Redwood Estates



Potential Risk of Chemical Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A, WHPA-B	10	Yes	Yes	Yes
WHPA-B, WHPA-C	8	Yes	Yes	Yes
WHPA-B	6	*Below threshold*	Yes	Yes
WHPA-C, WHPA-D	6	*Below threshold*	Yes	Yes
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

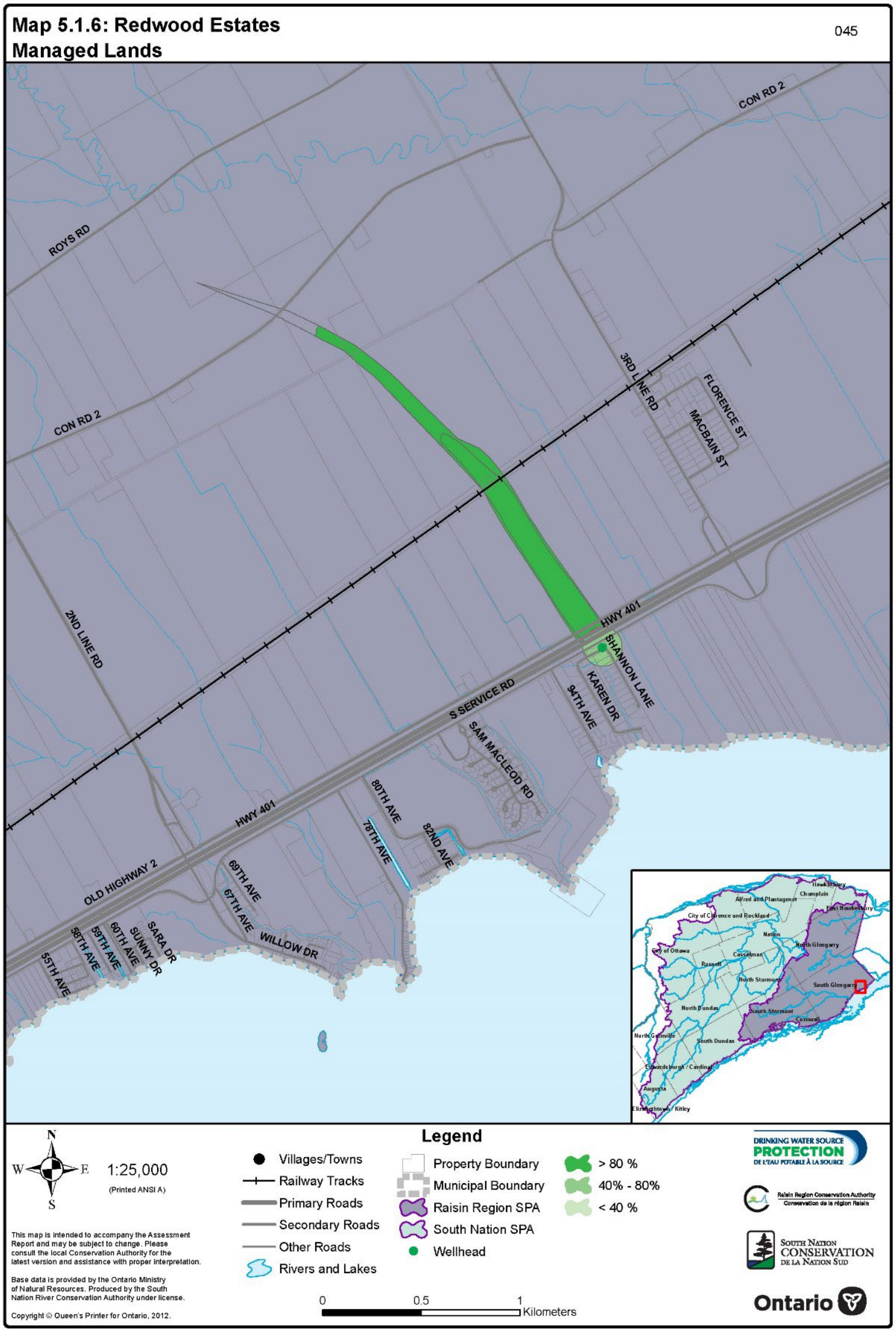
Potential Risk of Pathogen Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A, WHPA-B	10	Yes	Yes	*None*
WHPA-B	8	*None*	Yes	Yes
WHPA-B	6	*Below threshold*	*None*	Yes

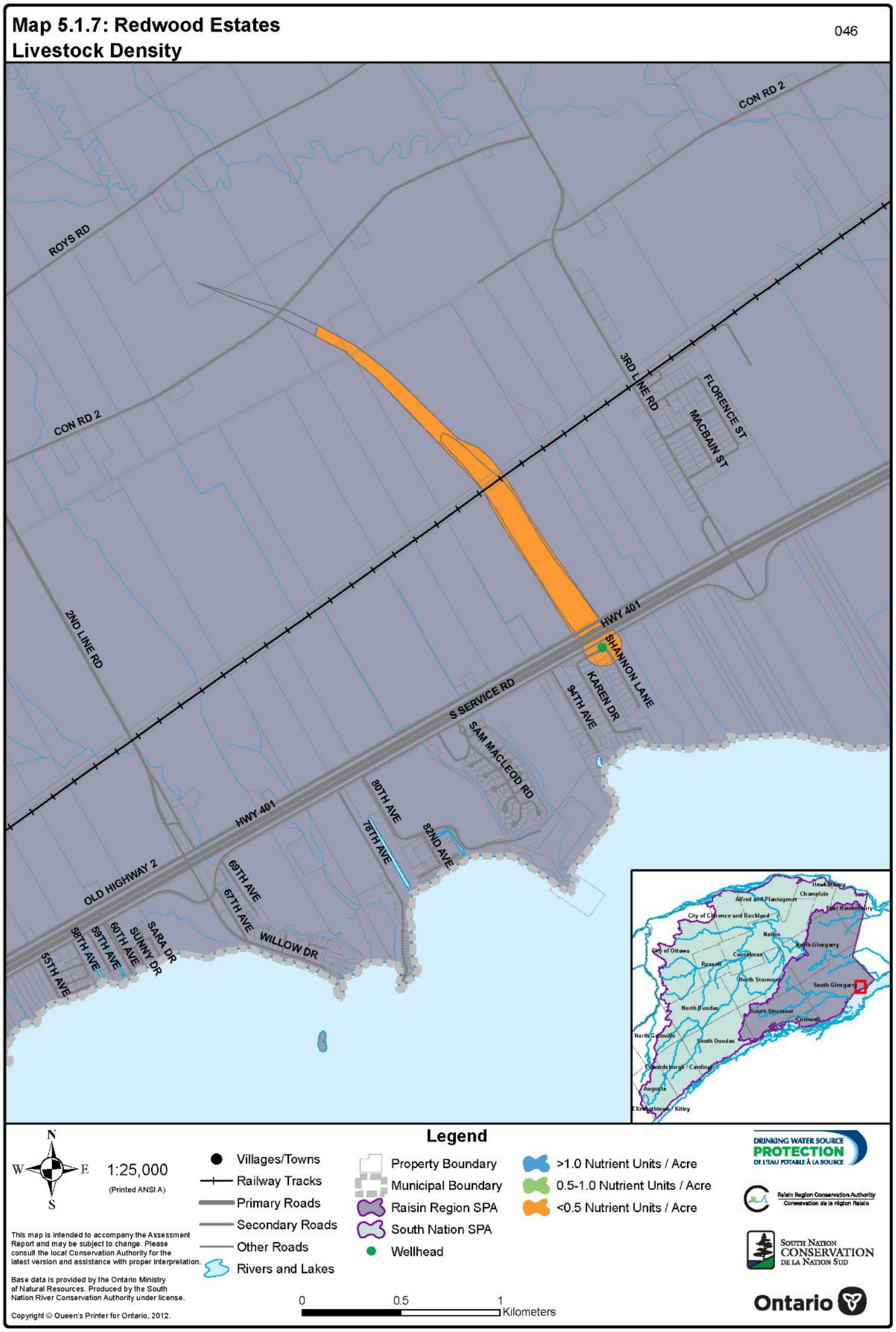
Potential Risk of DNAPL Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A, WHPA-B, WHPA-C	All Scores	Yes	*None*	*None*

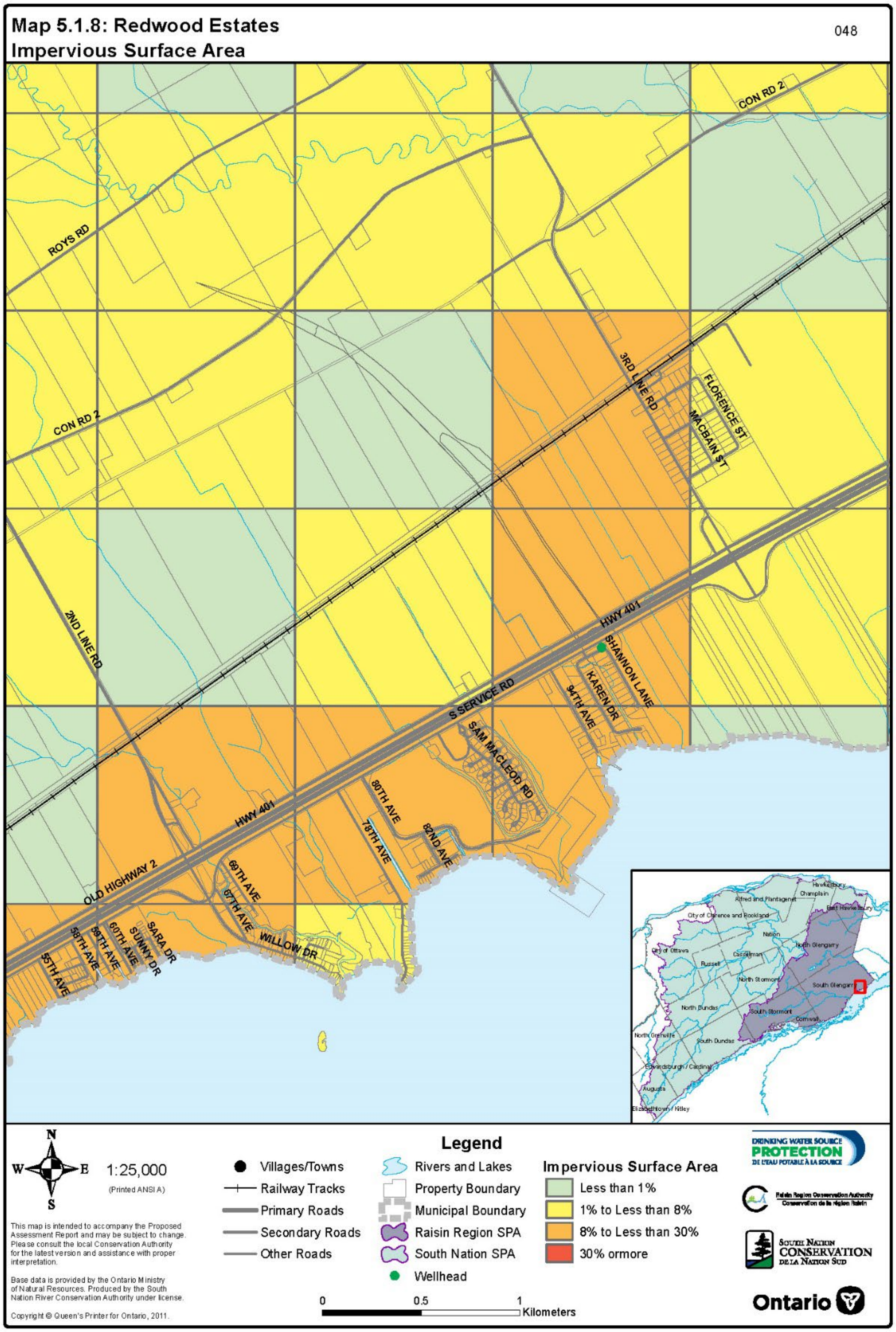
Map 5.1.6: Managed Lands, Redwood Estates



Map 5.1.7: Livestock Density, Redwood Estates



Map 5.1.8: Impervious Surface Area, Redwood Estates



5.2 Glen Robertson

Glen Robertson is a small community located approximately 12km east of Alexandria and 6km west of the Quebec border. The Glen Robertson municipal supply well is owned and operated by the Township of North Glengarry and supplies about 100 residents with potable water. The well is located at 3342 Irwin Street, in Glen Robertson. The supply well consists of a single 300mm diameter drilled well. The well is screened between a depth of 7.8 m and 10.9 m and it exploits a gravel aquifer (lower sediments) that overlies limestone bedrock.

The site location is shown on *Map 5.2.1*. Drinking water system information is presented in *Table 5.13*.

Table 5.13: Drinking Water System Information, Glen Robertson

Drinking Water System Type (MOE)	Existing, Small Municipal Residential System
Drinking Water System Number (MOE)	220008408
Drinking Water System Name	Glen Robertson Well Supply
Owner	Township of North Glengarry
Operating Authority	Township of North Glengarry
Source Water Type	Groundwater
Number of Wells	1
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	Yes
Coordinates of Well	538526 Easting, 5022908 Northing (NAD 83, Zone-18)
Location of Monitoring Wells	N/A
Area served by System	Glen Robertson
Number of Users (approx. residents)	100
Average Daily Taking	23 m^3/day
Maximum Daily Taking	50 m^3/day
WHPA Delineation Pumping Rate	51 m^3/day
Permit to Take Water	3330-9UNQ2Q
Maximum Permitted Taking	224 m^3/day

5.2.1 Vulnerable Area Delineation

The vulnerable area for this system comprises the Wellhead Protection Area (WHPA), which was delineated in accordance with the Technical Rules: Assessment Report (*the Rules*). Delineations were accomplished by conducting particle tracking analyses on a *computer based three-dimensional groundwater flow model*. The particle advective time of travel (TOT) to the supply well within the aquifer was projected at the surface.

The WHPA for this system is the area created by combining the following four sub-areas:

1. WHPA-A: Pathogen Security/ Prohibition Zone (100m fixed radius)
2. WHPA-B: Pathogen Management Zone (2-year TOT capture zone)
3. WHPA-C: DNAPL / Contaminant Protection Zone (5-year TOT capture zone); and
4. WHPA-D: Secondary Protection Zone (25-year TOT capture zone).

This drinking water system has not been confirmed to be directly influenced by a surface water body. An updated treatment process (filtration, UV, disinfection) has been put in place as a preventative measure in lieu of GUDI study to comply with MOE water treatment requirements. Area WHPA-E, as defined by *the Rules* have not been delineated. An updated Assessment Report would be required if a subsequent GUDI study confirmed that the groundwater source was under the influence of surface water.

The three-dimensional model MODFLOW was used to delineate the Well Head Protection Area (WHPA). Model calibration was measured by comparing simulated results of the potentiometric surface and comparing with the observed water elevations recorded at the location of MOE well records. To achieve model calibration, close attention was also given to the generated potentiometric surface, model mass balance and calculated discharge to streams.

To define the extent of the WHPA, multiple scenarios were completed. Results attained from plausible scenarios were plotted and the composite of all the scenarios was delineated as the resulting WHPA. WHPA-D (25-yr) extends 1.2 km to the southeast, to the groundwater divide. The various WHPAs for this drinking water system are shown on *Map 5.9*. The respective area calculations are summarized in Table 5.14.

Table 5.14: Total Area by Vulnerable Area, Glen Robertson

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	5%
WHPA-B	22.8	40%
WHPA-C	19.7	34%
WHPA-D	11.7	20%
Total	**57.3**	**100%**

It should be noted that the delineation of vulnerable area does not imply that land use activities within that area pose a threat to drinking water.

5.2.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method considers vertical groundwater flow through the formations overlying the gravel aquifer. The Surface to Aquifer Advection time (SAAT) is used to compute the vertical velocity. SAAT is directly related to the characteristics and thickness of the overburden material and whether or not there is a confining layer.

Recharge is through the overlying tills to the gravel aquifer. There is no confining layer protecting the aquifer. Aquifer intrinsic vulnerability is therefore high.

The SWAT assessment is shown on *Map 5.2.3*.

The vulnerability score for WHPA-A is automatically set at 10. WHPA-B and WHPA-C were scored at the upper end of the possible ranges (10 and 8 respectively). WHPA-D was assessed as having medium vulnerability and therefore assigned a score of 4.

WHPA vulnerability scoring is shown on *Map 5.*. A distribution of vulnerability scores by sub-area is presented in *Table 5.15*.

Table 5.15: Distribution of Vulnerability Scores, Glen Robertson

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-A	3.1	3.1				
WHPA-B	22.8	22.8	0	0		
WHPA-C	19.7		19.7	0		0
WHPA-D	11.7			0	11.7	0
Total	**57.3**	**25.9**	**19.7**	**0**	**11.7**	**0**

5.2.2.1 Transport Pathways

Anthropogenic transport pathways, resulting from human activity, are “short cuts” where a surface contaminant could bypass the natural protective layers above an aquifer. Apart from a few private wells, there were no significant transport pathways identified in the area. The wells were not considered to be a large enough cluster to raise or alter SWAT vulnerability. Regardless, SWAT vulnerability was already defined as high.

5.2.3 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.2.3.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.2.3.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is a significant, moderate or low drinking water threat. *Table 5.4,* can be used to determine which areas are vulnerable to chemical, pathogen and DNAPL threats. These are also referenced visually on *Map 5.10.*

Table 5.16: Risk of Chemical Threats, Glen Robertson

Vulnerable Area	**Vulnerability Score**	**Risk of Drinking Water Threat**		
		Significant	Moderate	Low
WHPA-A	10	Yes	Yes	Yes
WHPA-B	10	Yes	Yes	Yes
WHPA-C	8	Yes	Yes	Yes
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.17: Risk of Pathogen Threats, Glen Robertson

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	10	Yes	Yes	*None*
WHPA-B	10	Yes	Yes	*None*
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.18: Risk of DNAPL Threats, Glen Robertson

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	All Scores	Yes	*None*	*None*
WHPA-B	All Scores	Yes	*None*	*None*
WHPA-C	All Scores	Yes	*None*	*None*
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

5.2.3.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.* and is tabulated in *Table 5.19*. The vulnerability score for WHPA-D is less than the vulnerability scores necessary for the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land to be considered a low threat; therefore, that area is not considered for this evaluation.

Table 5.19: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Glen Robertson

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	3.1	0.7	0	0.7	23%
WHPA-B	22.9	11.3	0	11.3	49%
WHPA-C	19.7	2.9	0	2.9	15%

5.2.3.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 511* and is tabulated in *Table 5.20*. The vulnerability score for WHPA-D is less than the vulnerability scores necessary for the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land to be considered a low threat; therefore, that area is not considered for this evaluation.

Table 5.20: Livestock Density Assessment, Glen Robertson

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area (NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.2	0.2		
8		n.a.	0.2	
6		n.a.	n.a.	n.a.

5.2.3.5 Impervious Surface Area

The impervious area within each WHPA where the application of road salt could pose a low risk at minimum is shown on *Map 5.* and tabulated in *Table 5.21*. The area vulnerability score for WHPA-D is less than the vulnerability scores necessary for the application of road salt to be considered a significant, moderate or low threat and therefore, that area is not considered for this evaluation.

Table 5.21: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Glen Robertson

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	More than 80%
WHPA-A	0	0	3.1	0
WHPA-B	0	1.9	21.0	0
WHPA-C	0	7.9	11.8	0

5.2.3.6 Issues Evaluation

There is no evidence that a parameter is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water. There are no issues therefore requiring further assessment or the delineation of an issues contributing area.

5.2.3.7 Conditions from Past Activities

Various data sets were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition to be considered a threat as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.2.3.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official's 2020 report, there are 22 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 19 unique locations (one location could possibly account for multiple threat activities). Specific activities and location counts are listed in *Table 5.22*.

Table 5.22: Significant Drinking Water Threat Activities, Glen Robertson

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		1
The application of pesticide to land.		3
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Septic System or Holding Tank	17
The handling and storage of fuel.		1
*The application of road salt**		*3**
Total – All Activities		25

*This table has not been revised to reflect updated threat counts, threat counts remain unchanged and are those enumerated in 2020, instead it has been updated to account for the new threats and threat subcategories per the Technical Rules updates in 2021.

5.2.3.9 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards for assessing drinking water systems throughout the Source Protection Authority and Source Protection Region. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.2.3.10 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.23*. These reports and technical studies are built on the foundation of various pre-existing reports, maps and data-sets. Each information source quoted below contains its own complete table of references.

Table 5.23: Key Information Sources, Glen Robertson

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2018. *Glen Robertson Drinking Water System Inspection Report 2018-2019*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analysis – Glen Robertson Water Supply.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analysis – Glen Robertson Water Supply.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	Raisin Region Conservation Authority. 2021. *Managed Lands in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Report.*	Report	Assessment, Spatial Analyses
	WESA. 2010. *Groundwater Threats Assessment – Glen Robertson Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Assessment – Glen Robertson Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Assessment – Glen Robertson Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses

Section	Source(s)	Type	Analysis Method(s)
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
Water Quality Threats Assessment	WESA. 2010. *Groundwater Threats Assessment – Glen Robertson Water Supply.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.2.3.11 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The technical study to identify the WHPA included various scenarios to identify the WHPA shape, direction and length. The final WHPA shape is a conservative composite of plausible modeled scenarios. Where scenarios overlapped, the uncertainty was defined as low.

The well is completed in the bedrock, however water supplying the well seems to come from both the bedrock and the overlying sub-till and till deposits. There are some irregularities in the topography and geometry of the geology resulting in slightly varying directions of groundwater flow depending on the contrasting hydraulic conductivity of the various layers. The shape and direction of the WHPA is uncertain. The WHPA-D intersects a groundwater divide and therefore the length of the WHPA-D has low uncertainty.

The uncertainty relating to scoring of WHPAs is directly related to the uncertainty in SAAT calculation and the identification of transport pathways. Overall, the SAAT approach had high uncertainty; therefore, the vulnerability scoring is assumed to have high uncertainty.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

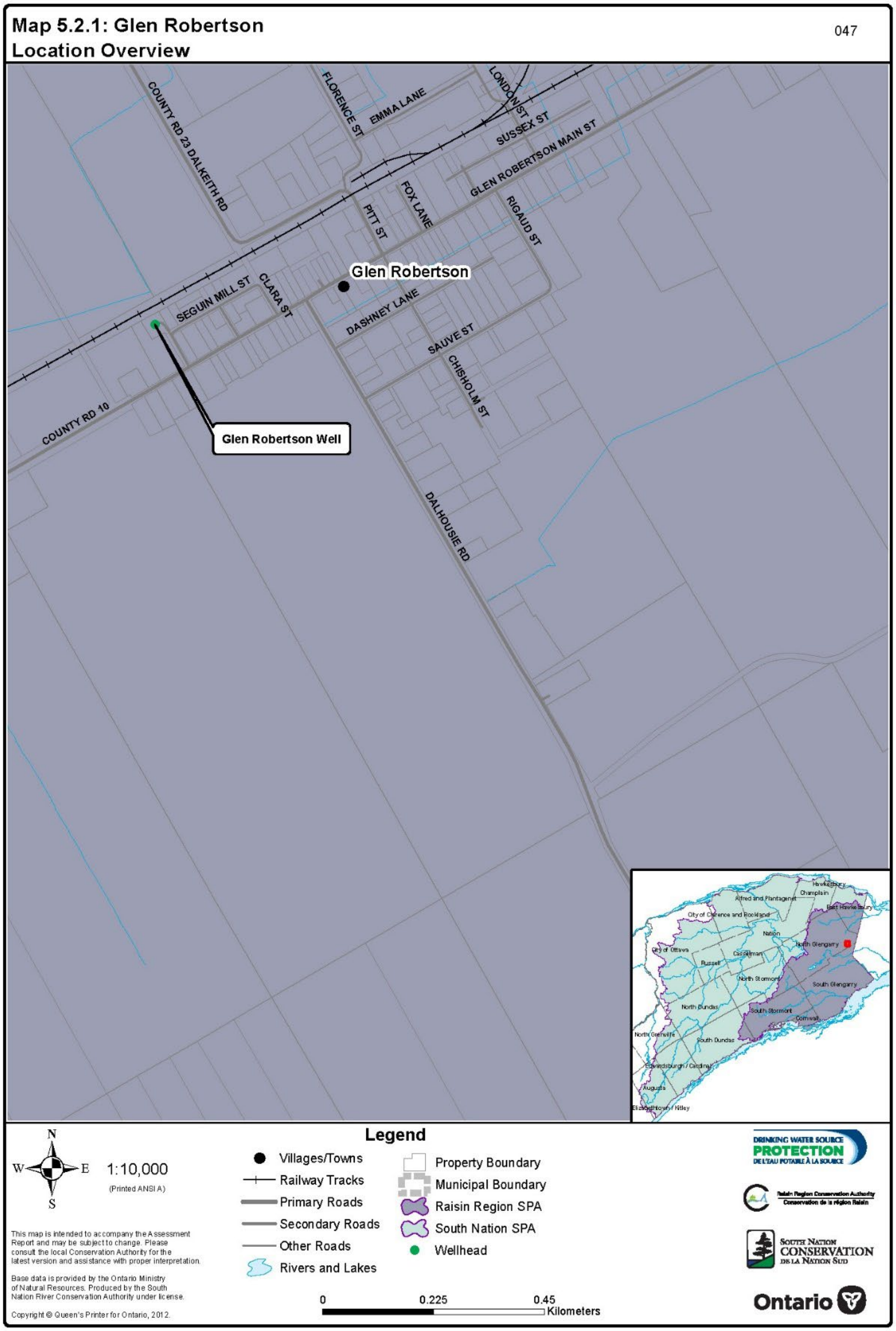
The enumeration of threats has been validated through site visits and/or communications with the landowner by either a Risk Management Official or Risk Management Inspector which included a review of the activity's location and circumstances, and is therefore considered to have low uncertainty.

A summary of uncertainty is listed in *Table 5.24*.

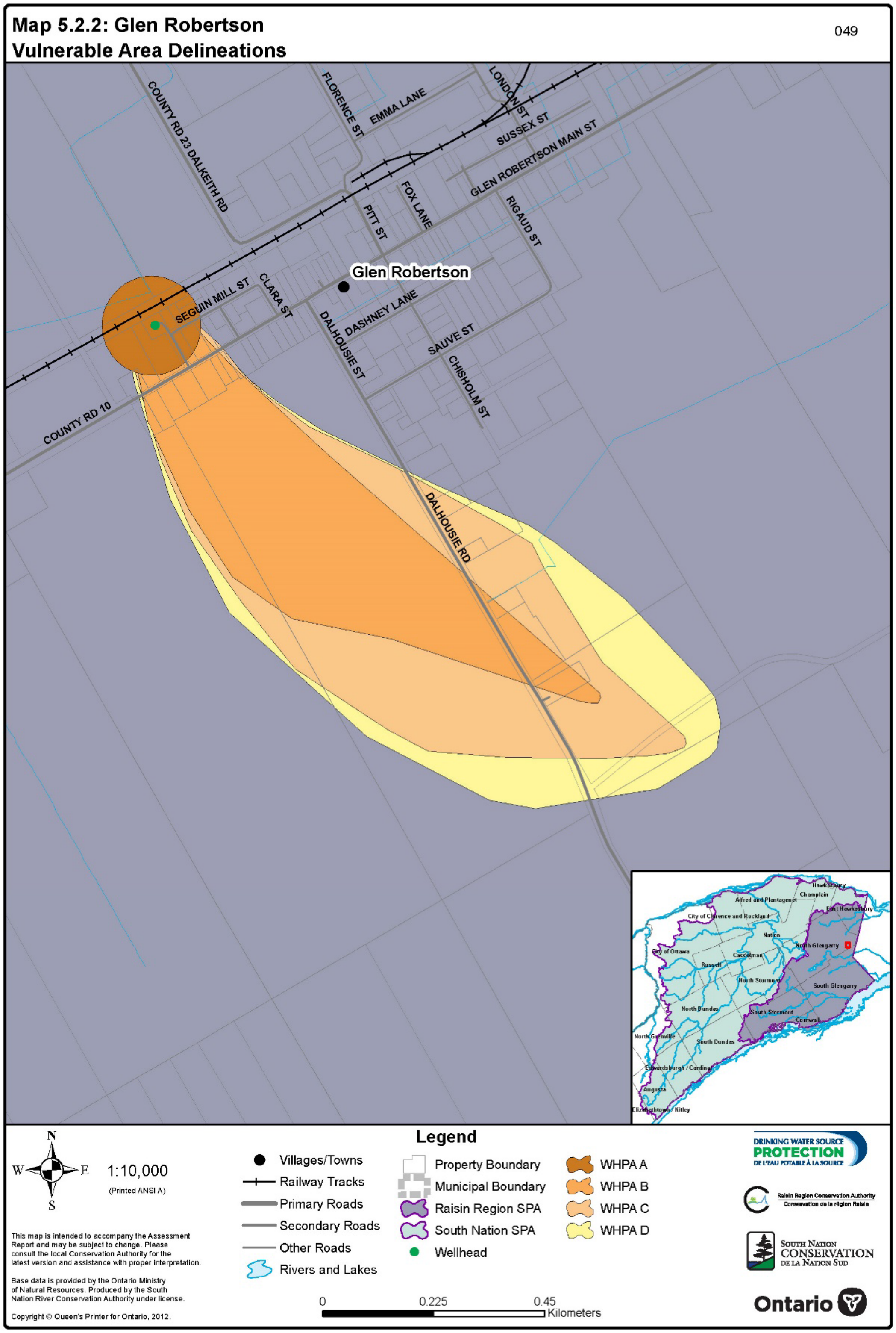
Table 5.24: Summary of Uncertainty Analyses, Glen Robertson

Component	**Uncertainty Assessment**			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
WHPA Delineation (shape and direction)	Low	High	High	High
WHPA Delineation (length)	Low	High	High	Low
Surface to Aquifer Advection Time	n/a	High	High	High
Vulnerability Scoring	Low	High	High	High
Issues Evaluation	Low	Low	Low	Low
Managed Lands Evaluation	Low	Low	Low	n/a
Livestock Density Evaluation	Low	Low	Low	n/a
Impervious Surface Evaluation	Low	Low	Low	n/a
Threats Assessment	Low	Low	Low	Low

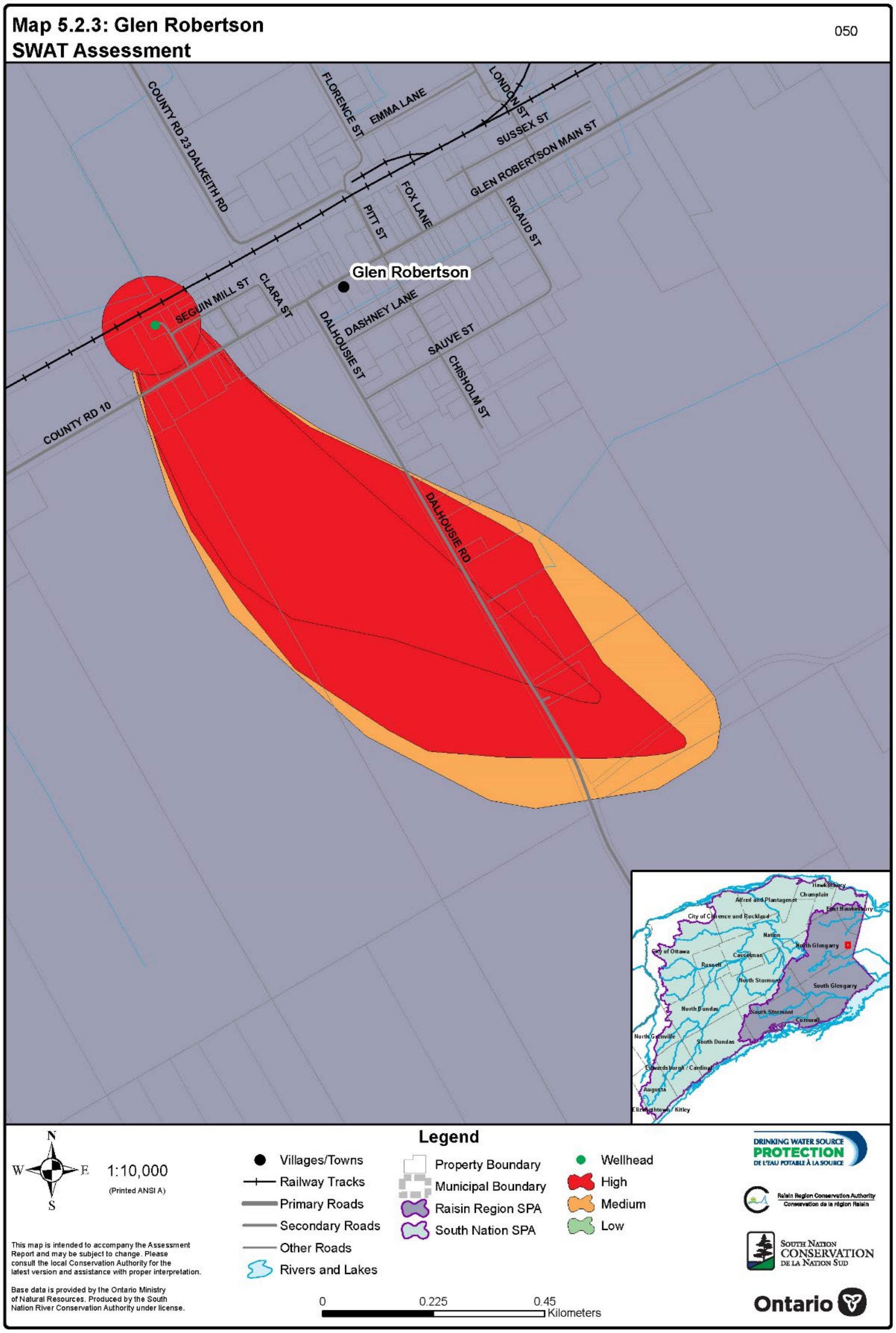
Map 5.2.1: Location Overview, Glen Robertson



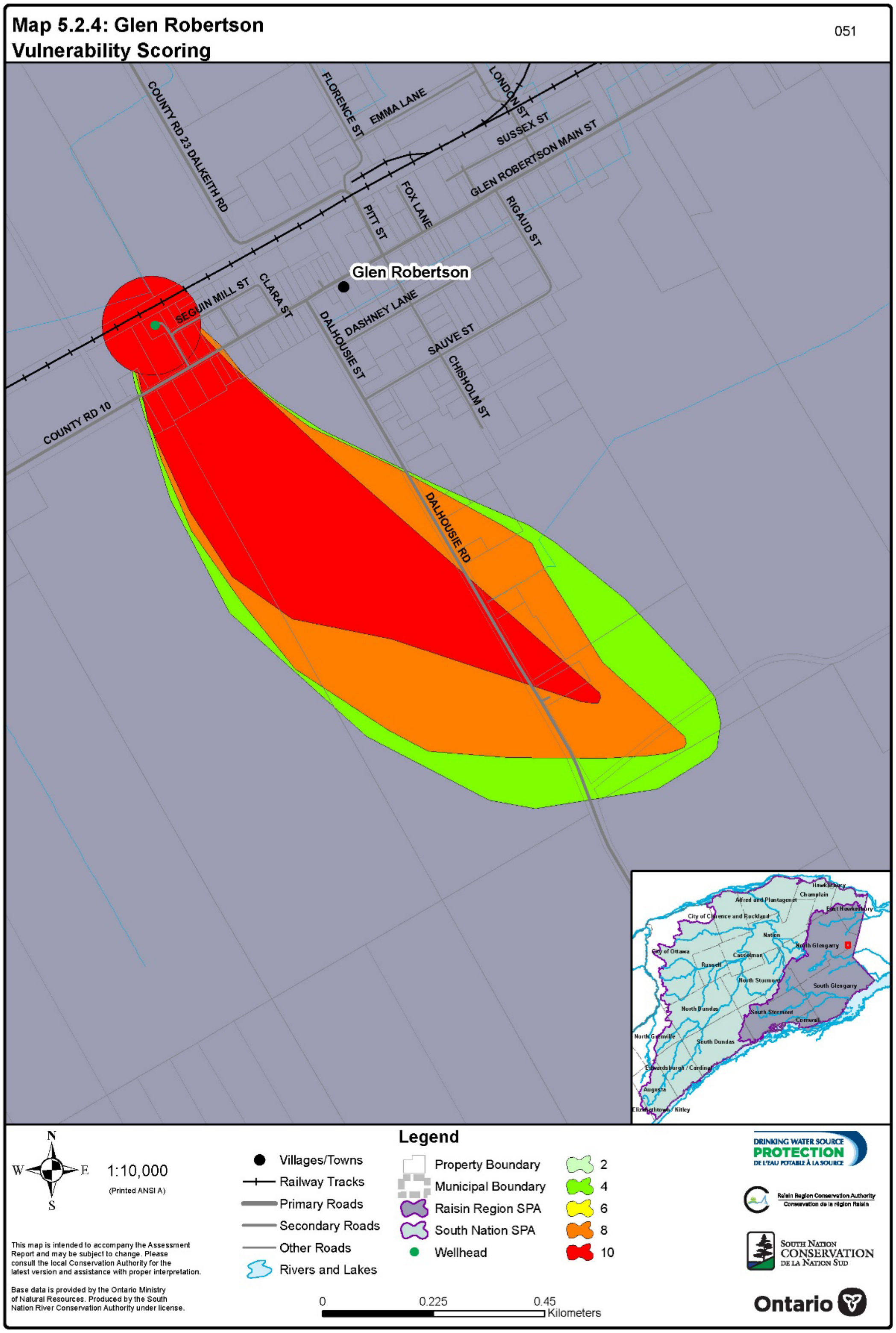
Map 5.9: Vulnerable Area Delineations, Glen Robertson



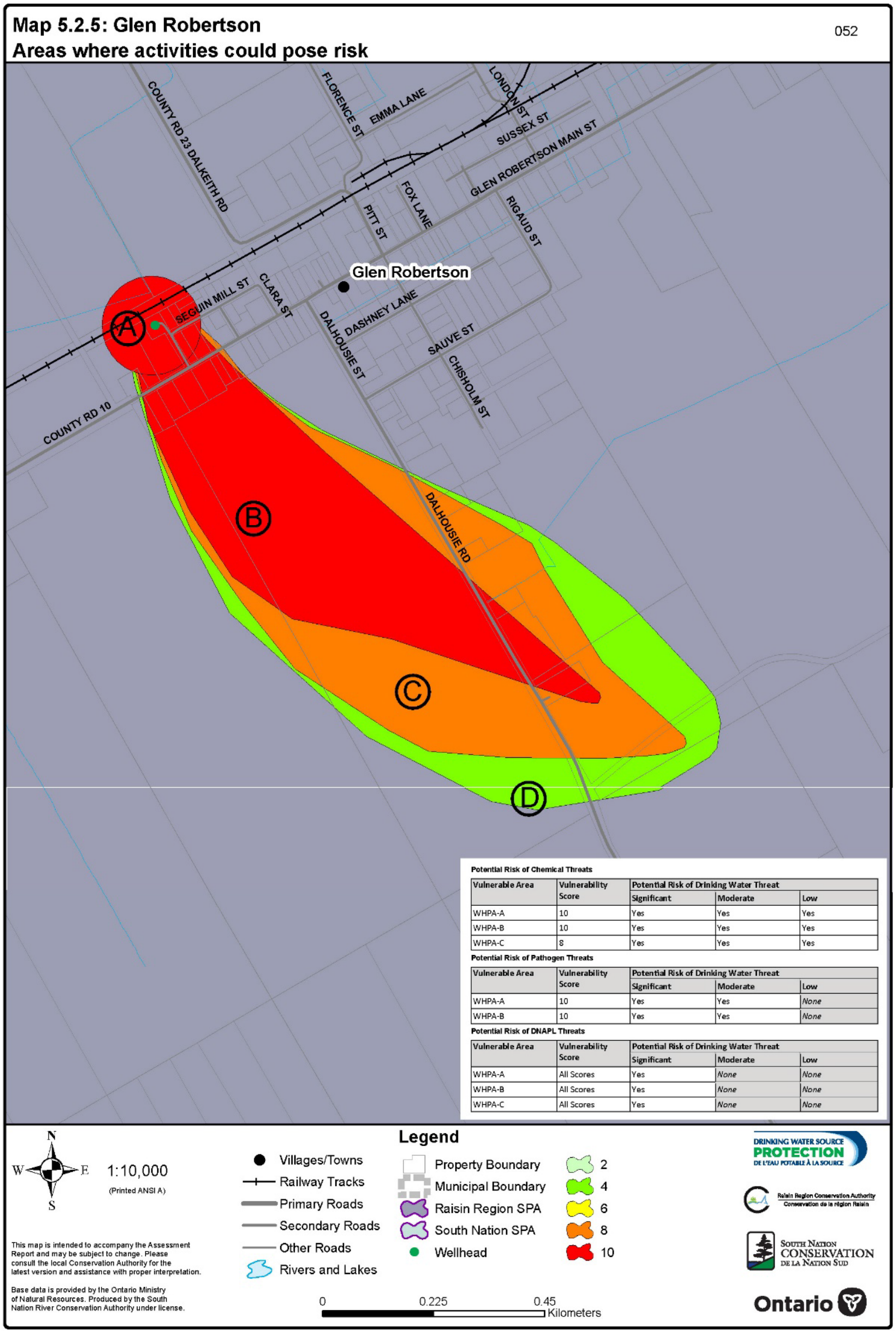
Map 5.2.3: SWAT Assessment, Glen Robertson



Map 5.2.4: Vulnerability Scoring, Glen Robertson



Map 5.10: Areas where Activities are or would be Drinking Water Threats, Glen Robertson



Potential Risk of Chemical Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	10	Yes	Yes	Yes
WHPA-B	10	Yes	Yes	Yes
WHPA-C	8	Yes	Yes	Yes

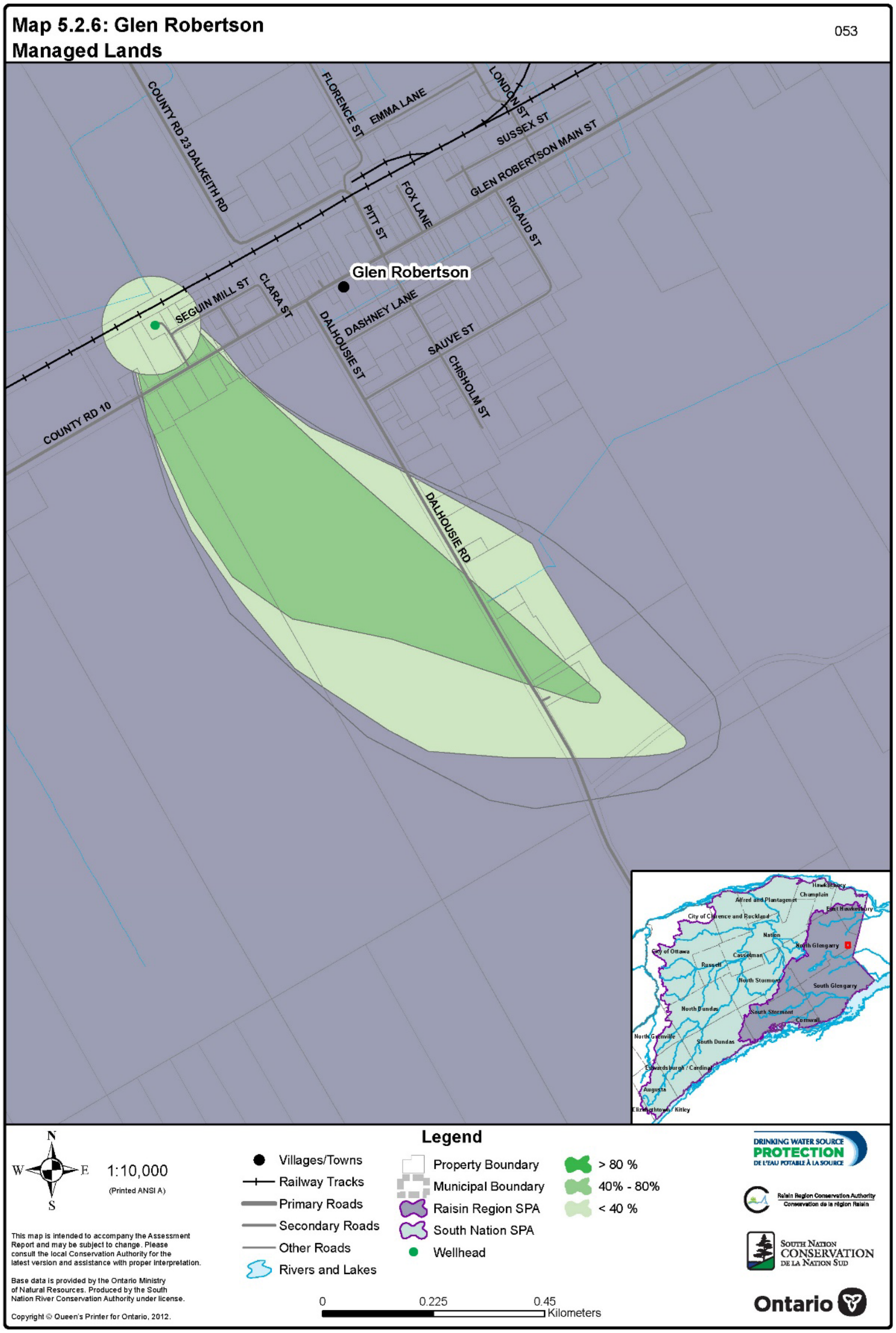
Potential Risk of Pathogen Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	10	Yes	Yes	*None*
WHPA-B	10	Yes	Yes	*None*

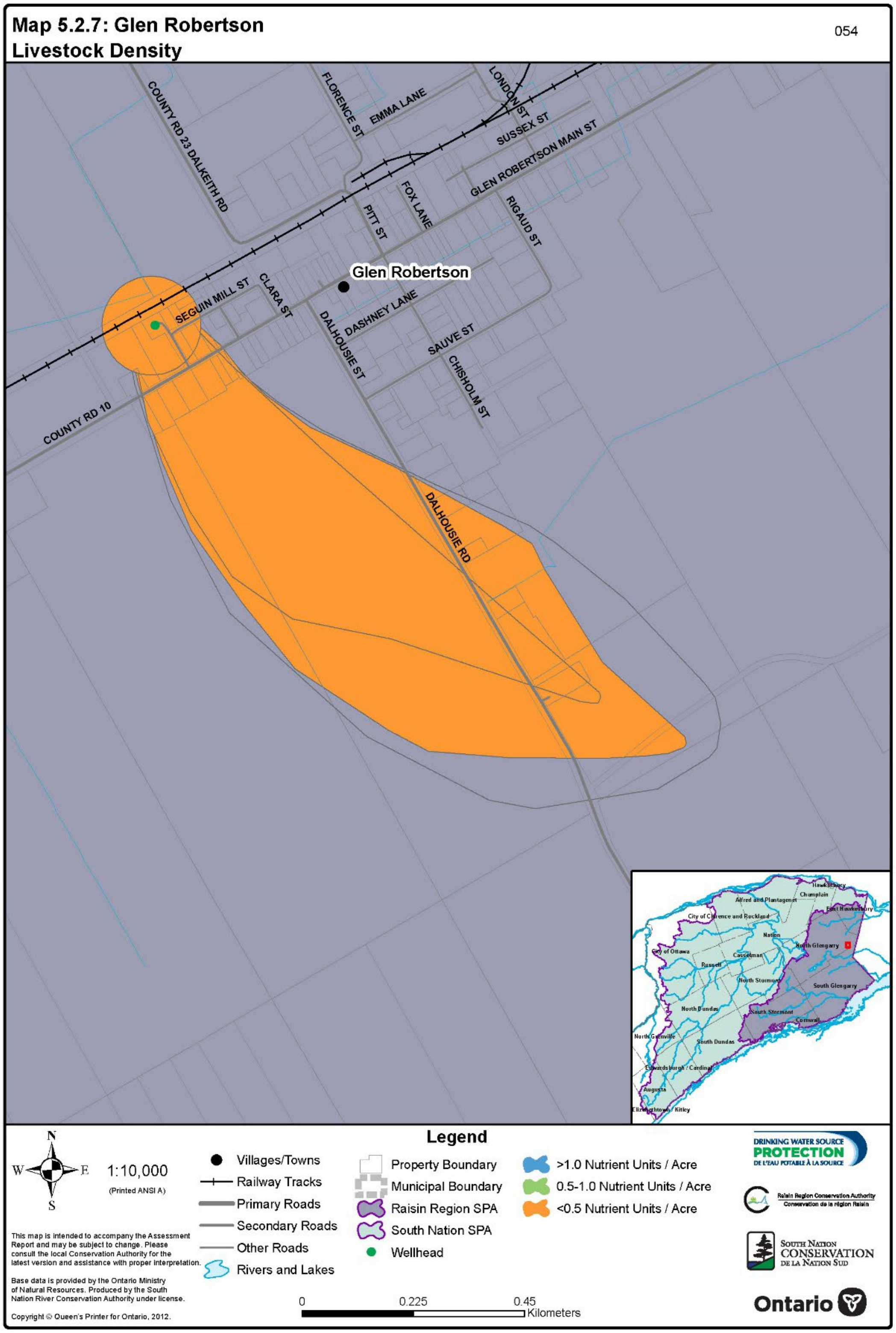
Potential Risk of DNAPL Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
WHPA-A	All Scores	Yes	*None*	*None*
WHPA-B	All Scores	Yes	*None*	*None*
WHPA-C	All Scores	Yes	*None*	*None*

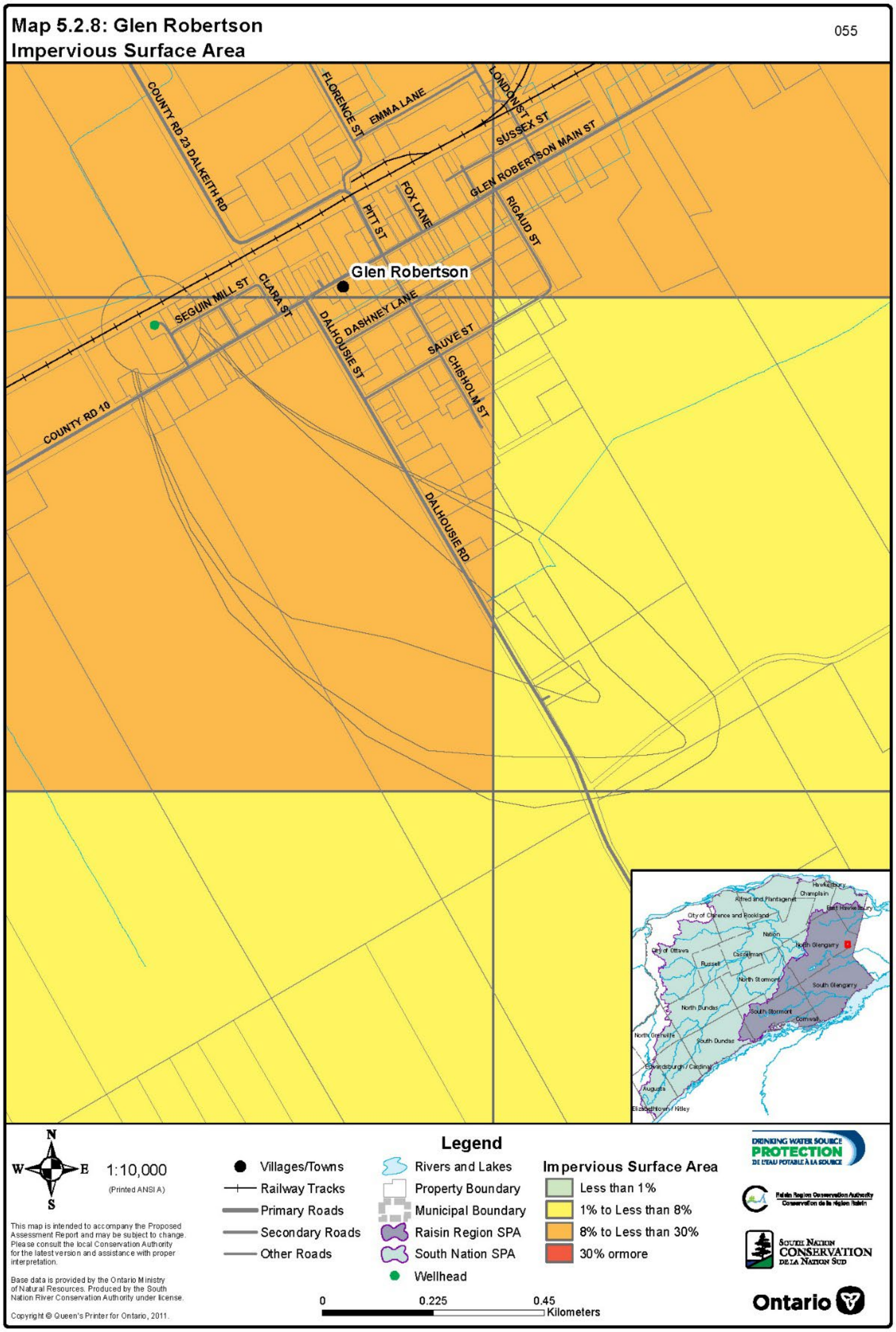
Map 5.2.6: Managed Lands, Glen Robertson



Map 511: Livestock Density, Glen Robertson



Map 5.2.8: Impervious Surface Area, Glen Robertson



5.3 Long Sault

The Village of Long Sault municipal water supply and treatment works are located on Moulinette Island, south of the village. The intake is in the St. Lawrence River, approximately 137m offshore. Water is drawn from approximately 1.5 m off the river bottom, at a depth of approximately 8 m. The Long Sault Water Treatment Plant is owned by the Township of South Stormont, and operated by CANEAU Water and Sewage Operations Inc. The water plant also supplies treated water to the Village of Ingleside, approximately 8 km to the east.

The site location is shown on *Map 5.3.1*. Drinking water system information is presented in *Table* 5.25.

Table 5.25: Drinking Water System Information, Long Sault

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	260066417
Drinking Water System Name	Long Sault/Ingleside Regional Water Treatment Plant
Owner	Township of South Stormont
Operating Authority	CANEAU Water and Sewage Operations Inc.
Source Water Type	Surface Water
Source Water	St. Lawrence River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	B
Coordinates of Intake	509623 Easting, 4984305 Northing (NAD 83, Zone-18)
Area served by System	Long Sault, Ingleside, Wales Village, Osnabruck Centre
Number of Users (approx. residents)	3,500
Average Daily Taking	5,459 m^3/day
Maximum Daily Taking	7,951 m^3/day
Permit to Take Water	4278-9XSHHK
Maximum Permitted Taking	9,500 m^3/day

5.3.1 Intake Classification

The intake is located in the St. Lawrence River, which is considered a connecting channel. For this reason, the intake is classified as type B.

5.3.2 Vulnerable Area Delineation

The vulnerable area for this system comprises two intake protection zones (IPZ): IPZ-1and IPZ-2 which have been delineated in accordance with the Technical Rules: Assessment Report (*the Rules*).

The vulnerable areas for this drinking water system are shown on *Map 5.3.2*. The respective area calculations are summarized in *Table 5.26*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.26: Total Area by Vulnerable Area, Long Sault

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	100.9	15%
IPZ-2	588.3	85%
Total	**689.2**	**100%**

5.3.2.1 Intake Protection Zone 1

An area known as IPZ-1 was delineated according to *the Rules*. It is composed of the following areas:

- A semi-circle that has a radius of 1,000 metres extending upstream from the center point of intake and a rectangle with a length of 2,000 metres and a width of 100 metres extending downstream from the centre point;
- a setback of not more than 120 m inland along the abutted land measured from the high water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River.

As there are no Regulation Limits along the St. Lawrence River, the 120 metre setback governs the IPZ-1 setback limits. The edge of surface water bodies has been used to represent the limits of high water.

The IPZ-1 was modified to reflect local hydrodynamic conditions. The IPZ-1 area was modified to exclude areas which cannot affect the intake.

5.3.2.2 Intake Protection Zone 2

Operator response time to adverse conditions in the quality of the surface water is less than two hours; therefore, the minimum travel time of two hours was used for delineation in accordance with *the Rules*.

The IPZ-2 is composed of the following areas:

- the area within each surface water body that may contribute water to the intake within 2 hours (hydraulic model, RMA-2 plus wind vector calculations);
- the area within the stormsewershed of each storm sewer that discharges into the surface water body where the time of travel to the intake is less than 2 hours;
- a setback of not more than 120 m inland along the abutted land measured from the high water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River;
- the area that contributes water to IPZ-2 through transport pathways (i.e., tile drainage, stormwater drainage system, etc.).

The 2-hour travel area has only an in-stream portion representing the St. Lawrence River (computed with RMA model). There are no tributaries or small watercourses within IPZ-2. There is one minor storm sewer outfall from the Water Treatment Plant nearby. The catchment area associated with this outfall was not included as discharges cannot reach the intake (based on the hydrodynamics, RMA model). No tile drains or other anthropogenic transport pathways are in IPZ-2.

Upstream of the intake, IPZ-2 extends to the American shores. The American land included in the zone is undeveloped.

5.3.3 Vulnerability Scoring

A vulnerability score was assigned to each vulnerable area in accordance with *the Rules*. The score is the product of the area vulnerability factor and the source vulnerability factor.

5.3.3.1 Area Vulnerability Factor

The Rules dictate the permissible range of scores for the area vulnerability factor based on the classification of intake. For this type of intake, the score for IPZ-1 is fixed at 10. For IPZ-2, the permissible values are 7, 8 or 9.

The scoring for IPZ-2 is determined based on the following criteria:

- The percentage of the area that is composed of land;
- The land cover, soil type, permeability and slope;
- Hydrological and hydrogeological conditions that contribute water to the area through transport pathways; and,

The area vulnerability factor for IPZ-2 was set at 7 after considering:

- The ratio of land to water is low (11% land vs. 89% water);
- Land cover is mostly covered by Long Sault Park and residential development;
- Slopes are mild;

- There are limited transport pathways present (no storm sewers or tile drainage).

5.3.3.2 Source Vulnerability Factor

A source vulnerability factor was assigned to the surface water intake as prescribed in *the Rules*. For this intake, the source vulnerability factor can be 0.7, 0.8 or 0.9 based on the following criteria:

- Depth of the intake from the top of the water surface;
- Distance of the intake from land;
- History of water quality concerns at the surface water intake.

The source vulnerability factor was taken as 0.8 after considering:

- The intake is not deep (3.5 m below the low river level);
- The intake is a long distance offshore (approximately 137 m);
- There is no history of water quality concerns.

5.3.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.27* and shown on *Map 5.3.3*.

Table 5.27: Vulnerability Scores, Long Sault

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.8	8
IPZ-2	7	0.8	5.6

5.3.4 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.3.4.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.3.4.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is significant, moderate or low drinking water threat. *Table 5.28* and *Table 5.29* can be used to determine which areas are vulnerable to chemical and pathogen threats. These are also referenced visually on *Map 5.3.4.*

Table 5.28: Risk of Chemical Threats, Long Sault

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	8	Yes	Yes	Yes
IPZ-2	5.6	Below threshold	Below threshold	Yes

Table 5.29: Risk of Pathogen Threats, Long Sault

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	8	Yes	Yes	Yes
IPZ-2	5.6	Below threshold	Below threshold	Yes

5.3.4.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.3.5* and is tabulated in *Table 5.30*.

Table 5.30: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Long Sault

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	100.9	0	9	9	9%
IPZ-2	588.3	0	0	9	0%

5.3.4.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 5.3.6* and is tabulated in *Table 5.31*.

Table 5.31: Livestock Density Assessment, Long Sault

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0
IPZ-2	0

5.3.4.5 Impervious Surface Area

The impervious area within each IPZ where the application of road salt could pose a low risk at minimum is shown on *Map 5.3.7* and tabulated in *Table 5.32.*

Table 5.32: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Long Sault

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
IPZ-1	19.6	8.2	73	0
IPZ-2	374.9	173.7	39.7	0

5.3.4.6 Issues Evaluation

There is no evidence that a parameter is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water. There are no issues therefore requiring further assessment or the delineation of an issues contributing area.

5.3.4.7 Conditions from Past Activities

Various data sets acquired through Ecolog ERIS were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition meeting the definition as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.3.4.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official's 2020 report, there are 0 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 0 unique locations (one location could possibly account for multiple threat activities). The vulnerability score for this system's intake protection zones is lower than the threshold to produce a significant drinking water threat as per the technical rules. Specific activities and location counts are listed in *Table 5.33*.

Table 5.33: Significant Drinking Water Threat Activities, Long Sault

Activity	Sub Threat, if Applicable	Count
None	n.a.	0
Total – All Activities		**0**

5.3.4.9 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards established for municipal drinking water systems throughout the Source Protection Authority and Source Protection Region, as outlined in *Section 4*. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.3.4.10 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.34*. The information sources quoted below may contain additional expanded references.

Table 5.34: Key Information Sources, Long Sault

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2018. *Long Sault/Ingleside Regional Water System 2018-2019 Inspection Report*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.

Section	Source(s)	Type	Analysis Method(s)
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Stormont, Long Sault Intake, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Stormont, Long Sault Intake, Assessment Report Input.*	Technical Study	Engineering Assessment
	Raisin Region Conservation Authority. 2021. *Update of Source Vulnerability Factor at Long Sault Water Intake.*	Technical Study	Literature Review
Managed Lands	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Technical Study	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, Township of South Stormont, Long Sault Intake, Assessment Report Input.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, Township of South Stormont, Long Sault Intake, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

Section	Source(s)	Type	Analysis Method(s)
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.3.4.11 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The degree of uncertainty related to the delineation of IPZ-1 is low as the geometry of the zone is prescribed by *the Rules*. The hydraulic model used for IPZ-2 delineation was created for the purpose of assessing Lake Ontario and St. Lawrence River flow regulation. The model contains sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The uncertainty related to the delineation of IPZ-2 is low.

The scoring of IPZ-1 and IPZ-2 are fairly prescriptive based on *the Rules*. The uncertainty is directly related to the data quality of physical setting and characteristics of the surrounding land. Good quality data was available in both cases, and therefore the uncertainty is considered to be low.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

The enumeration of significant threats has low uncertainty as there are only a few specific prescribed activities that would be considered significant drinking water threats in the IPZ-1 area based on the technical rules. The activities are either known not to be happening, or are not associated with the residential land use of the vulnerable area.

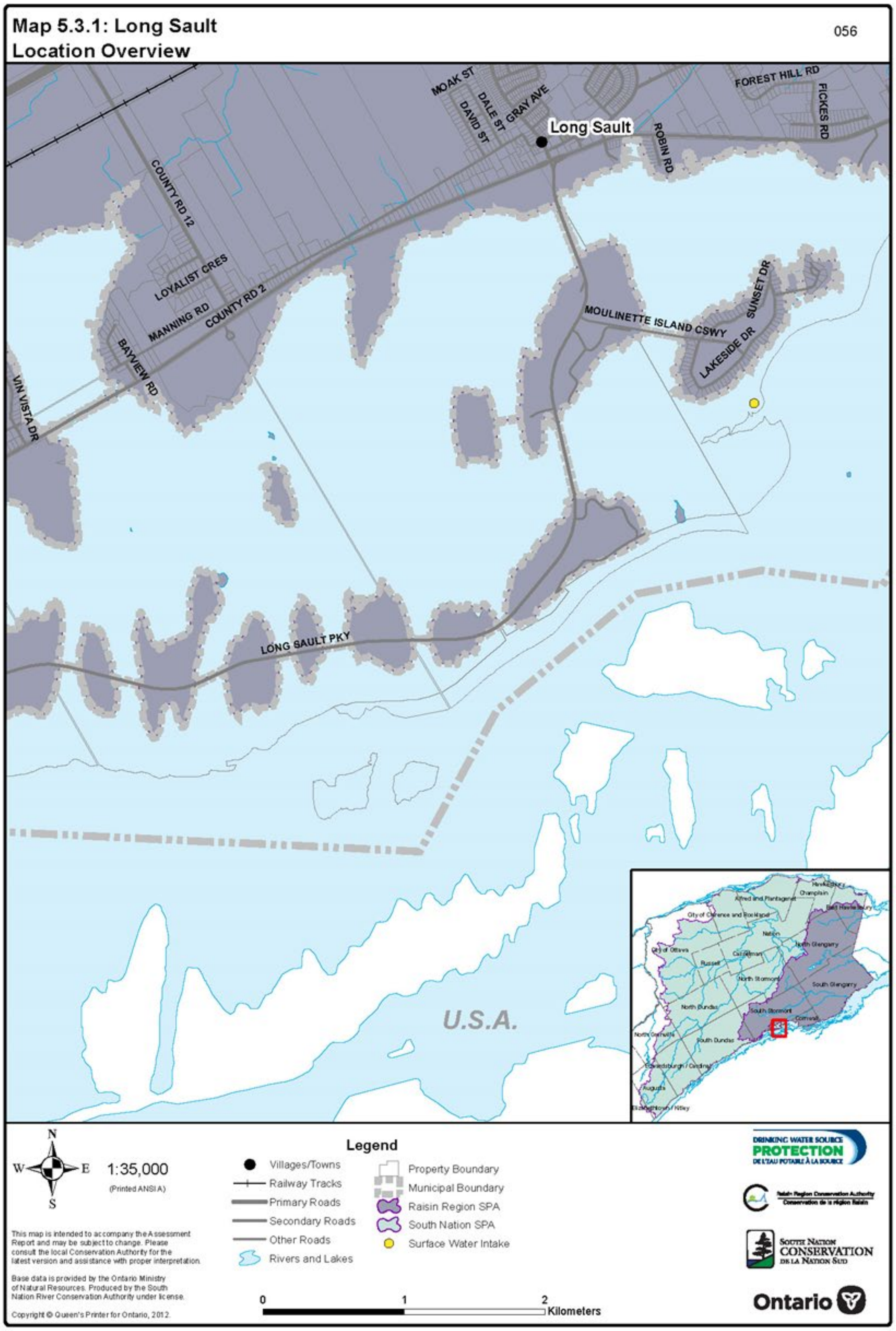
A summary of uncertainty is listed in *Table 5.35*.

Table 5.35: Summary of Uncertainty Analyses, Long Sault

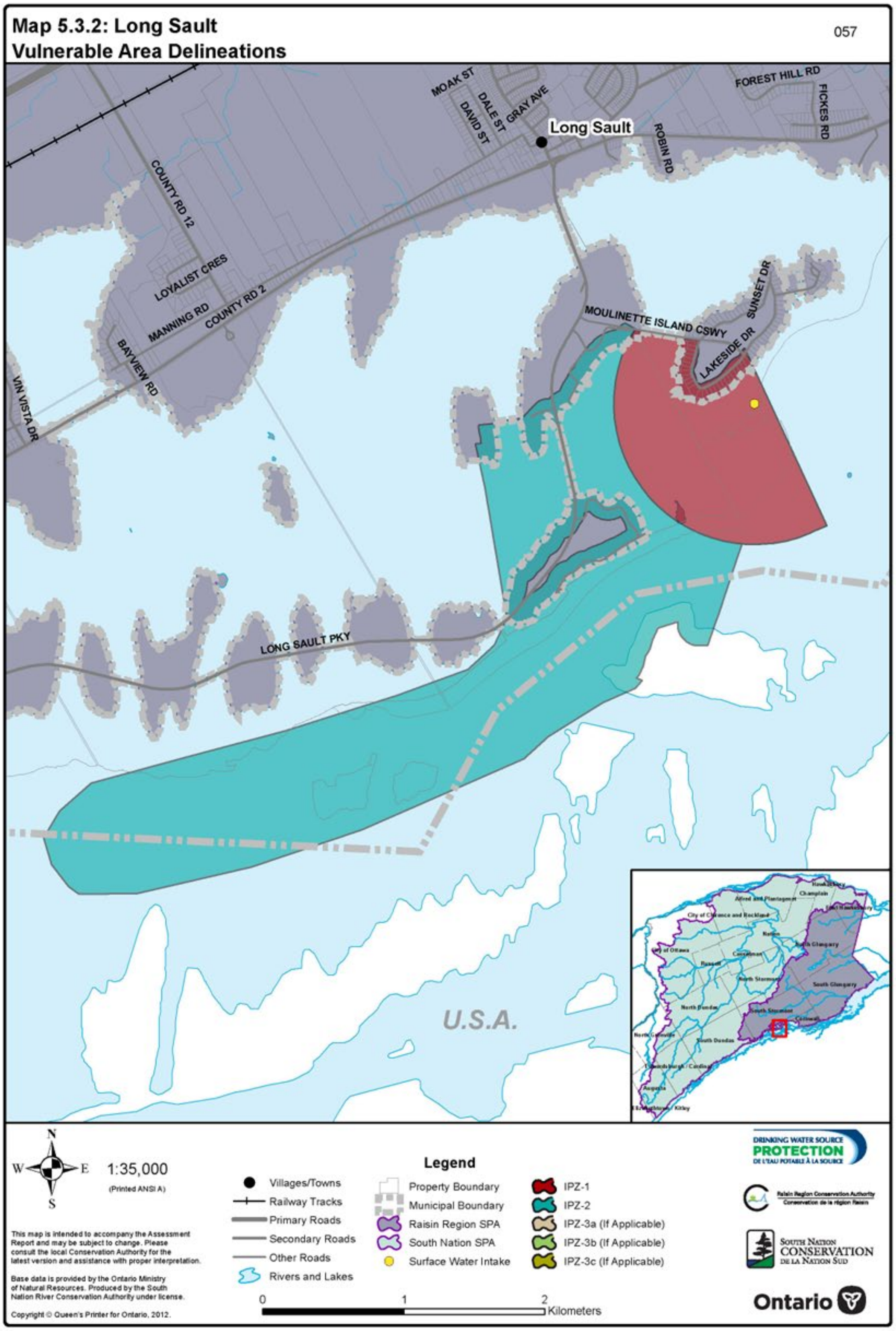
Component	Uncertainty Assessment
IPZ-1 Delineation	Low
IPZ-2 Delineation	Low
IPZ-1 Vulnerability Scoring	Low
IPZ-2 Vulnerability Scoring	Low
Issues Evaluation	Low

Component	Uncertainty Assessment
Managed Lands Evaluation	Low
Livestock Density Evaluation	Low
Impervious Surface Evaluation	Low
Threats Assessment	Low

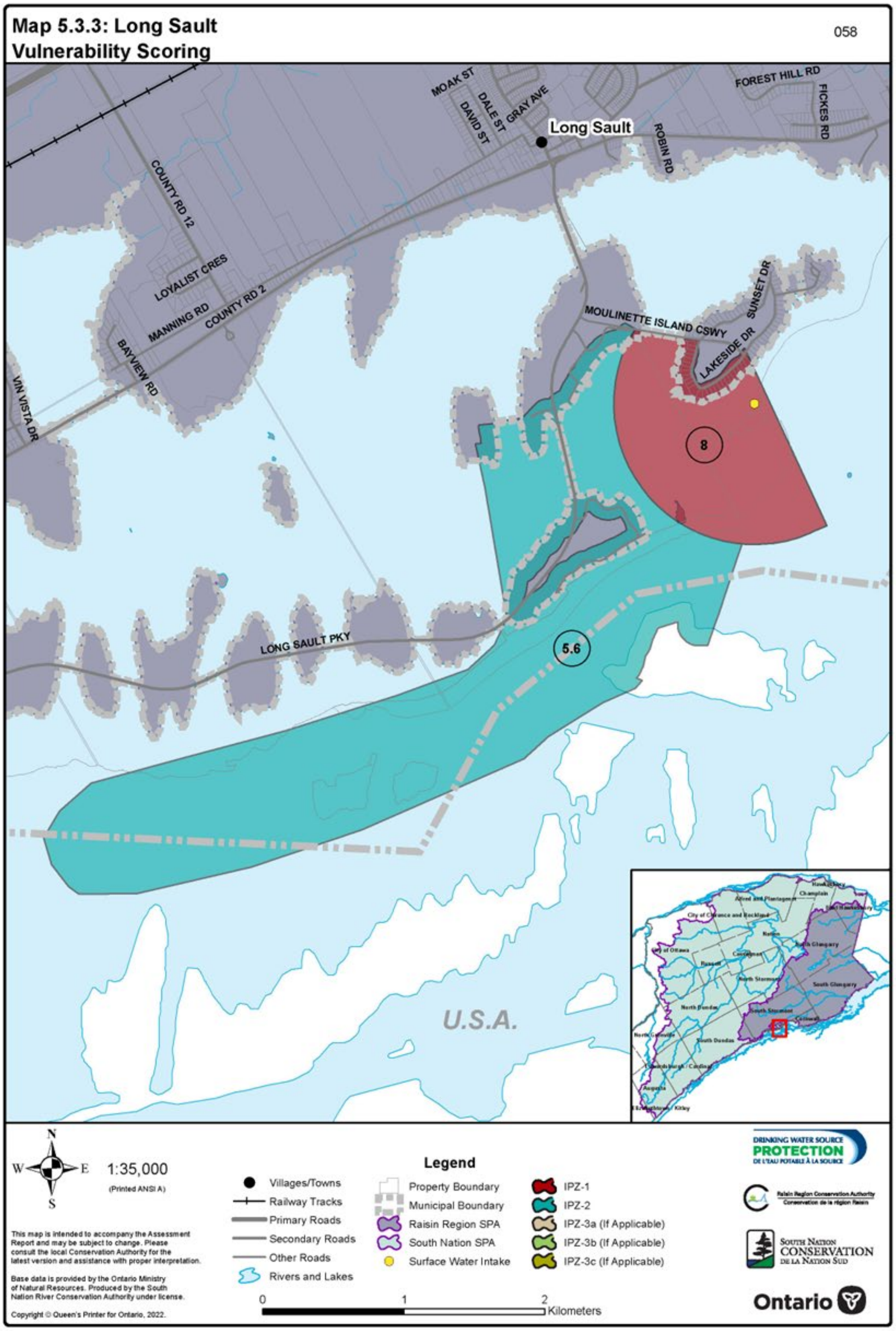
Map 5.3.1: Location Overview, Long Sault



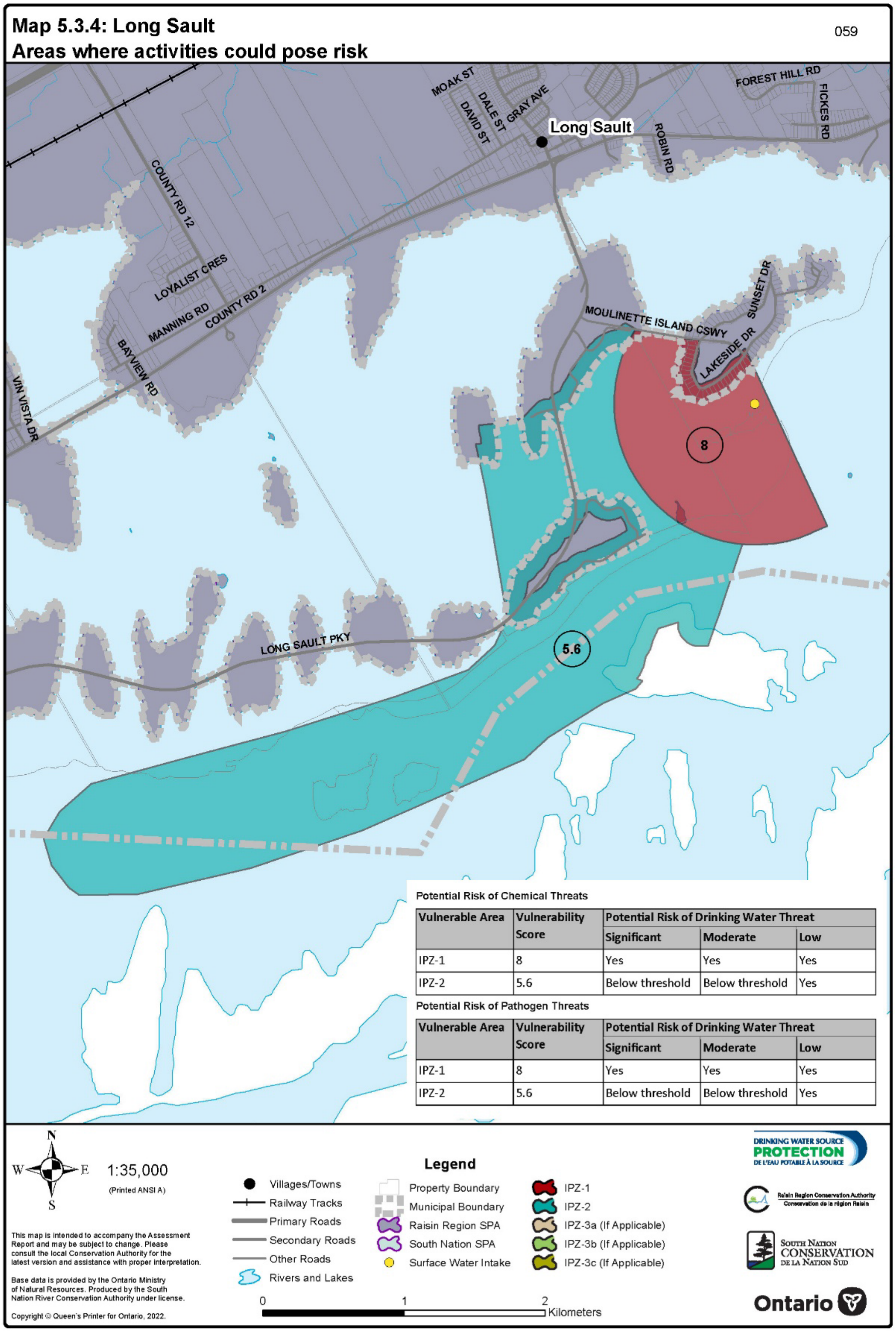
Map 5.3.2: Vulnerable Area Delineations, Long Sault



Map 5.3.3: Vulnerability Scoring, Long Sault



Map 5.3.4: Potential Threat Areas, Long Sault



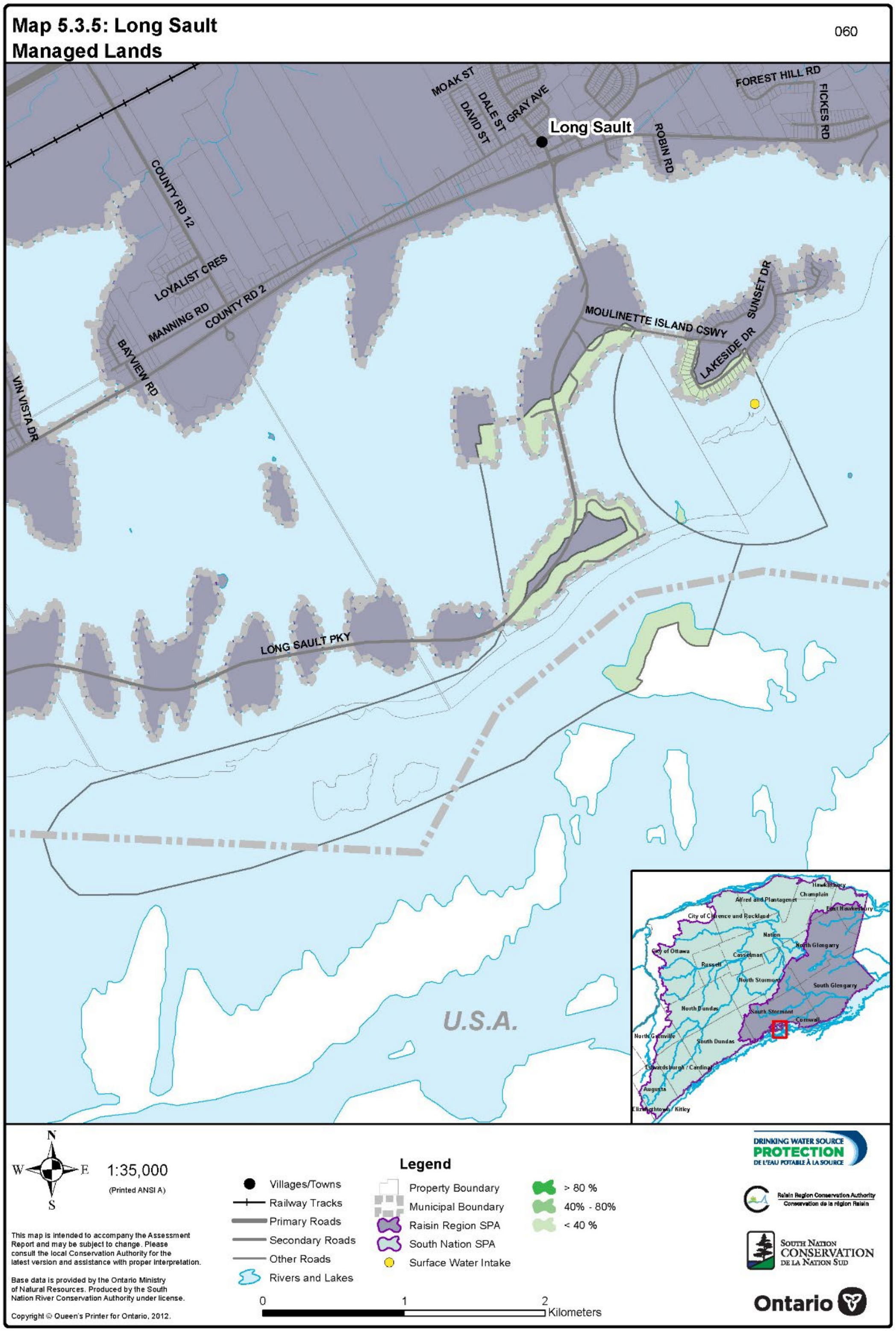
Potential Risk of Chemical Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	8	Yes	Yes	Yes
IPZ-2	5.6	Below threshold	Below threshold	Yes

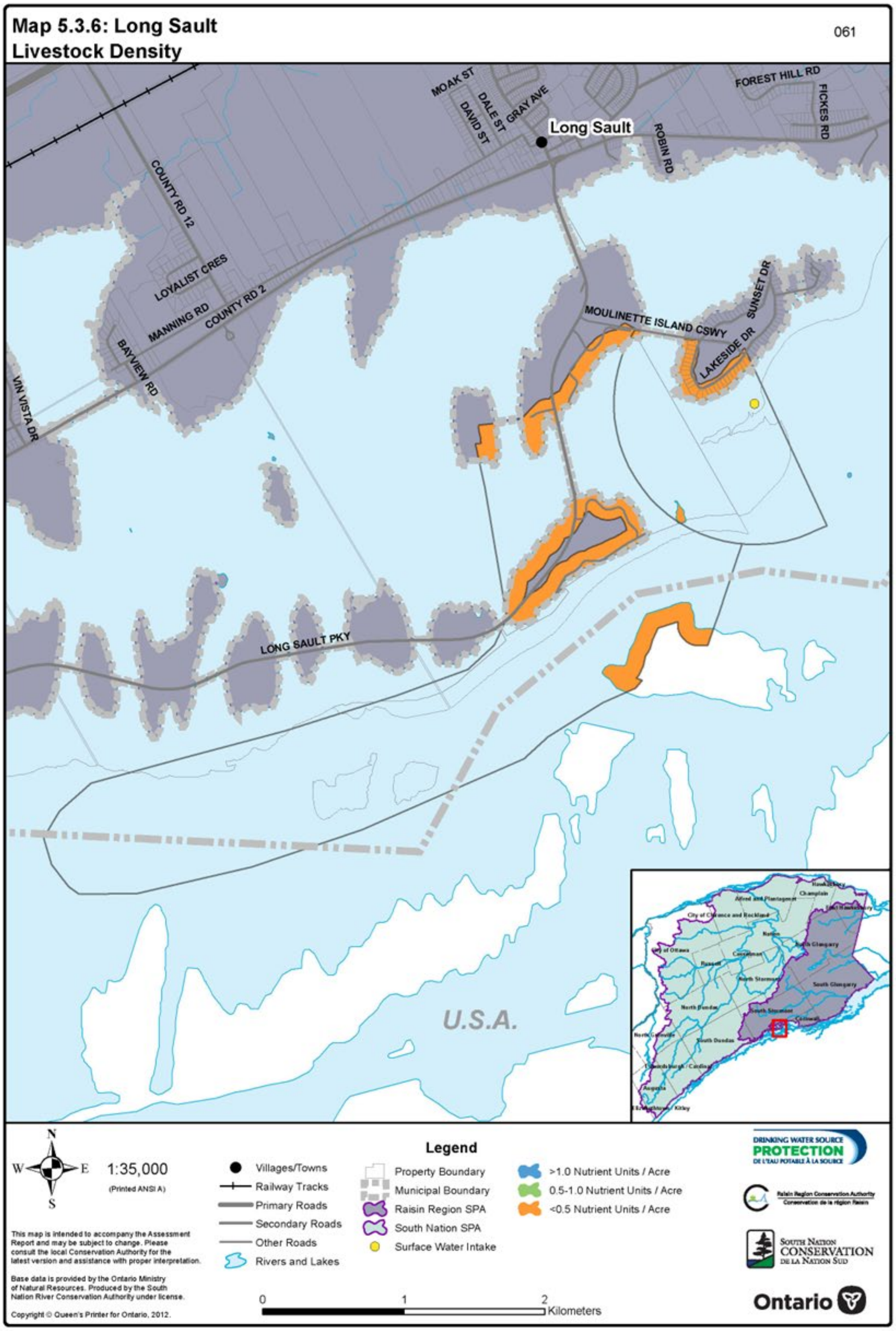
Potential Risk of Pathogen Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	8	Yes	Yes	Yes
IPZ-2	5.6	Below threshold	Below threshold	Yes

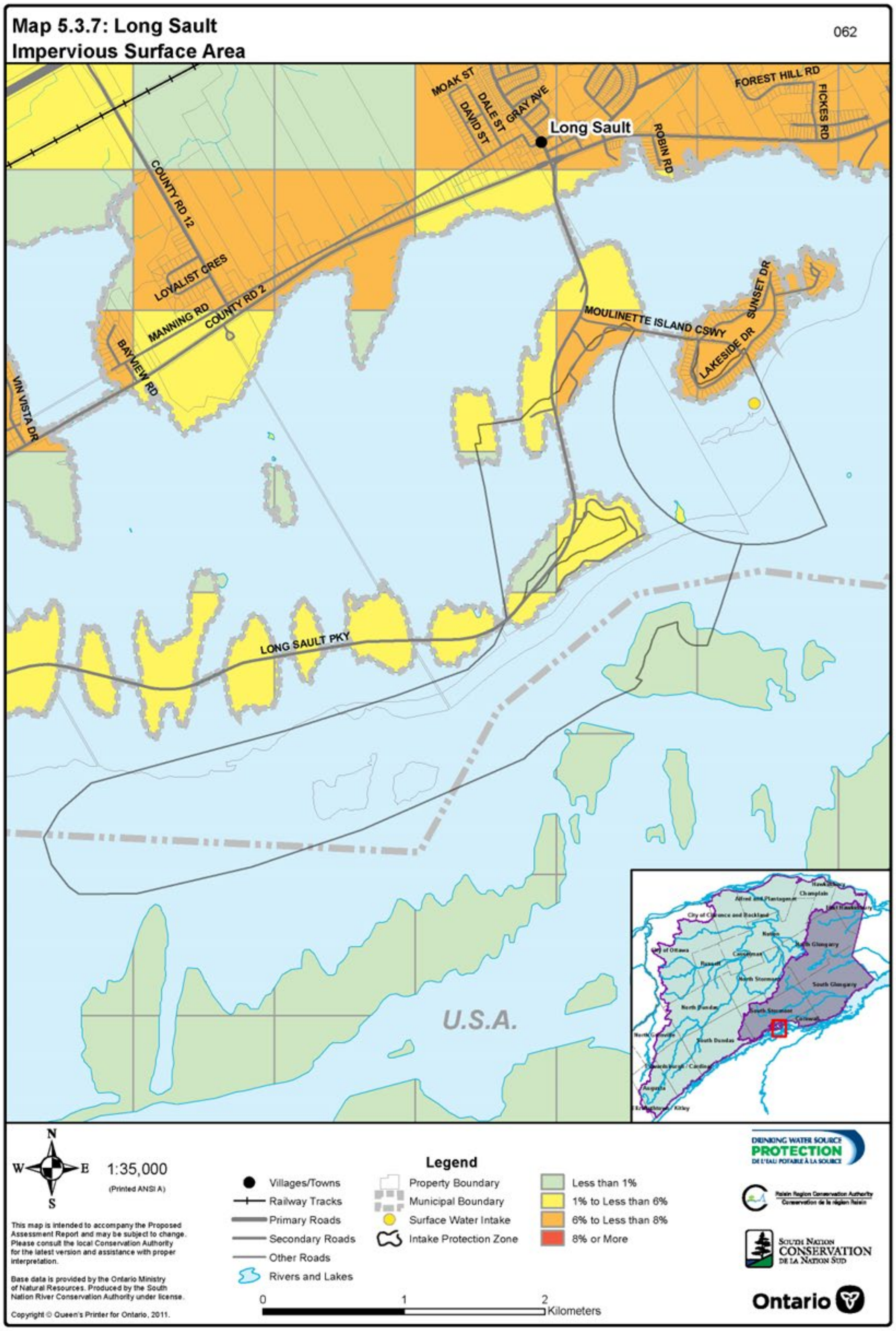
Map 5.3.5: Managed Lands, Long Sault



Map 5.3.6: Livestock Density, Long Sault



Map 5.3.7: Impervious Surface Area, Long Sault



5.4 Cornwall

The City of Cornwall's municipal water supply is taken from a small lake feature, within the St. Lawrence River (Lake St. Lawrence). The intake is located in the west face of the RH Saunders Dam, within the Cornwall Dyke Closure structure north of the dam. The depth of water over the intake is 15 m. Raw water is piped from the intake by a gravity fed main to the water purification plant, located approximately 3km east of the intake. Treated water from the Cornwall plant also supplies Rosedale Terrace and St. Andrews West.

The site location is shown on *Map 5.4.1*. Drinking water system information is presented in *Table* 5.36*.*

Table 5.36: Drinking Water System Information, Cornwall

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	220001049
Drinking Water System Name	Cornwall Water Treatment Plant
Owner	City of Cornwall
Operating Authority	City of Cornwall
Source Water Type	Surface Water
Source Water	St. Lawrence River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	B
Coordinates of Intake	516415 Easting, 4984501 Northing (NAD 83, Zone-18)
Area served by System	Cornwall, Rosedale Terrace, St. Andrews West
Number of Users (approx. residents)	47,000
Average Daily Taking	37,616 m^3/day
Maximum Daily Taking	56,893 m^3/day
Permit to Take Water	6352-98FRC9
Maximum Permitted Taking	100,000 m^3/day

5.4.1 Intake Classification

The intake is located in the St. Lawrence River, which is considered a connecting channel. For this reason, the intake is classified as type B.

5.4.2 Vulnerable Area Delineation

The vulnerable area for this system comprises two intake protection zones (IPZ): IPZ-1and IPZ-2 which have been delineated in accordance with the Technical Rules: Assessment Report (*the Rules*).

The vulnerable areas for this drinking water system are shown on *Map 5.4.2*. The respective area calculations are summarized in *Table 5.37*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.37: Total Area by Vulnerable Area, Cornwall

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	100.2	12%
IPZ-2	752.7	88%
Total	**852.9**	**100%**

5.4.2.1 Intake Protection Zone 1

An area known as IPZ-1 was delineated according to *the Rules*. It is composed of the following areas:

- A semi-circle that has a radius of 1,000 metres extending upstream from the center point of intake and a rectangle with a length of 2,000 metres and a width of 100 metres extending downstream from the centre point;
- a setback of not more than 120 m inland along the abutted land measured from the high water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River.

As there are no Regulation Limits along the St. Lawrence River, the 120 metre setback governs the IPZ-1 setback limits. The edge of surface water bodies has been used to represent the limits of high water. The IPZ-1 area does not include an in-land portion, as the surrounding dike structure effectively prevents on-shore releases from entering the source water. The dyke directs surface runoff away from the intake protection zone towards a subwatershed which discharges downstream of the intake.

5.4.2.2 Intake Protection Zone 2

Operator response time to adverse conditions in the quality of the surface water is less than two hours; therefore, the minimum travel time of two hours was used for delineation in accordance with *the Rules*.

The IPZ-2 is composed of the following areas:

- the area within each surface water body that may contribute water to the intake within 2 hours (hydraulic model, RMA-2 plus wind vector calculations);
- the area within the stormsewershed of each storm sewer that discharges into the surface water body where the time of travel to the intake is less than 2 hours;

- a setback of not more than 120 m inland along the abutted land measured from the high water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River;
- the area that contributes water to IPZ-2 through transport pathways (i.e., tile drainage, stormwater drainage system, etc.).

The 2-hour travel area has only an in-stream portion representing the St. Lawrence River. The IPZ-2 area for this intake does not include an in-land portion, as the surrounding dike structure effectively prevents on-shore releases from entering the source water. The dyke directs surface runoff away from the intake protection zone towards a subwatershed which discharges downstream of the intake. There are no tributaries or small watercourses, tile-drainage or stormsewersheds in IPZ-2.

5.4.3 Vulnerability Scoring

A vulnerability score was assigned to each vulnerable area in accordance with *the Rules*. The score is the product of the area vulnerability factor and the source vulnerability factor.

5.4.3.1 Area Vulnerability Factor

The Rules dictate the permissible range of scores for the area vulnerability factor based on the classification of intake. For this type of intake, the score for IPZ-1 is fixed at 10. For IPZ-2, the permissible values are 7, 8 or 9.

The scoring for IPZ-2 is determined based on the following criteria:

- The percentage of the area that is composed of land;
- The land cover, soil type, permeability and slope;
- Hydrological and hydrogeological conditions that contribute water to the area through transport pathways; and,

The area vulnerability factor for IPZ-2 was set at 7 after considering:

- The ratio of land to water is low (8% land vs. 92% water);
- Land cover is predominantly forest and slopes away from the intake;
- There are no transport pathways present (no storm sewers or tile drainage).

5.4.3.2 Source Vulnerability Factor

A source vulnerability factor was assigned to the surface water intake as prescribed in *the Rules*. For this intake, the source vulnerability factor can be 0.7, 0.8 or 0.9 based on the following criteria:

- Depth of the intake from the top of the water surface;

- Distance of the intake from land;
- History of water quality concerns at the surface water intake.

The source vulnerability factor was taken as 0.8 after considering:

- The intake is relatively deep (15 m below the low river level);
- The intake is located close to land (an offshore distance of 0 m, the intake is flush with the dam structure);
- There is no history of water quality concerns.

5.4.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.38* and shown on *Map 5.4.3*.

Table 5.38: Vulnerability Scores, Cornwall

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.8	8
IPZ-2	7	0.8	5.6

5.4.4 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.4.4.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.4.4.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is a significant, moderate or low drinking water threat. *Table 5.39* and

Table 5.40 can be used to determine which areas a vulnerable to chemical and pathogen threats. These are also referenced visually on *Map 5.4.4.*

Table 5.39: Risk of Chemical Threats, Cornwall

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	8	Yes	Yes	Yes
IPZ-2	5.6	Below threshold	Below threshold	Yes

Table 5.40: Risk of Pathogen Threats, Cornwall

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	**Moderate**	**Low**
IPZ-1	8	Yes	Yes	Yes
IPZ-2	5.6	Below threshold	Below threshold	Yes

5.4.4.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.4.5* and is tabulated in *Table 5.41*.

Table 5.41: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Cornwall

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	100.2	0	0	0	0%
IPZ-2	752.7	0	0	0	0%

5.4.4.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 5.4.6* and is tabulated in *Table 5.42*.

Table 5.42: Livestock Density Assessment, Cornwall

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0
IPZ-2	0

5.4.4.5 Impervious Surface Area

The impervious area within each IPZ where the application of road salt could pose a low risk at minimum is shown on *Map 5.4.7* and tabulated in *Table* 5.43*.*

Table 5.43: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Cornwall

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
IPZ-1	72.9	27.3	0	0
IPZ-2	749.9	2.7	0	0

5.4.4.6 Issues Evaluation

There is no evidence that a parameter is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water. There are no issues therefore requiring further assessment or the delineation of an issues contributing area.

5.4.4.7 Conditions from Past Activities

Various data sets acquired through Ecolog ERIS were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition meeting the definition as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.4.4.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official's 2020 report, there are 0 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 0 unique locations (one location could possibly account for multiple threat activities). The vulnerability scores for this system's intake protection zones are lower than the threshold to produce a significant drinking water threat as per the technical rules. Specific activities and location counts are listed in Table 5.44.

Table 5.44: Significant Drinking Water Threat Activities, Cornwall

Activity	Sub Threat, if Applicable	Count
None	n.a	0
Total – All Activities		**0**

5.4.4.9 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards established for municipal drinking water systems throughout the Source Protection Authority and Source Protection Region, as outlined in *Section 4*. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.4.4.10 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.45*. The information sources quoted below may contain additional expanded references.

Table 5.45: Key Information Sources, Cornwall

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2020. *Cornwall Drinking Water Inspection Report 2019-20*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, City of Cornwall, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, City of Cornwall, Assessment Report Input.*	Technical Study	Engineering Assessment

Section	Source(s)	Type	Analysis Method(s)
Managed Lands	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, City of Cornwall, Assessment Report Input.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, City of Cornwall, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.4.4.11 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The degree of uncertainty related to the delineation of IPZ-1 is low as the geometry of the zone is prescribed by *the Rules*. The hydraulic model used for IPZ-2 delineation was created for the purpose of assessing Lake Ontario and St. Lawrence River flow regulation. The model contains sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The uncertainty related to the delineation of IPZ-2 is low.

The scoring of IPZ-1 and IPZ-2 are fairly prescriptive based on *the Rules*. The uncertainty is directly related to the data quality of physical setting and characteristics of the surrounding land. Good quality data was available in both cases, and therefore the uncertainty is considered to be low.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

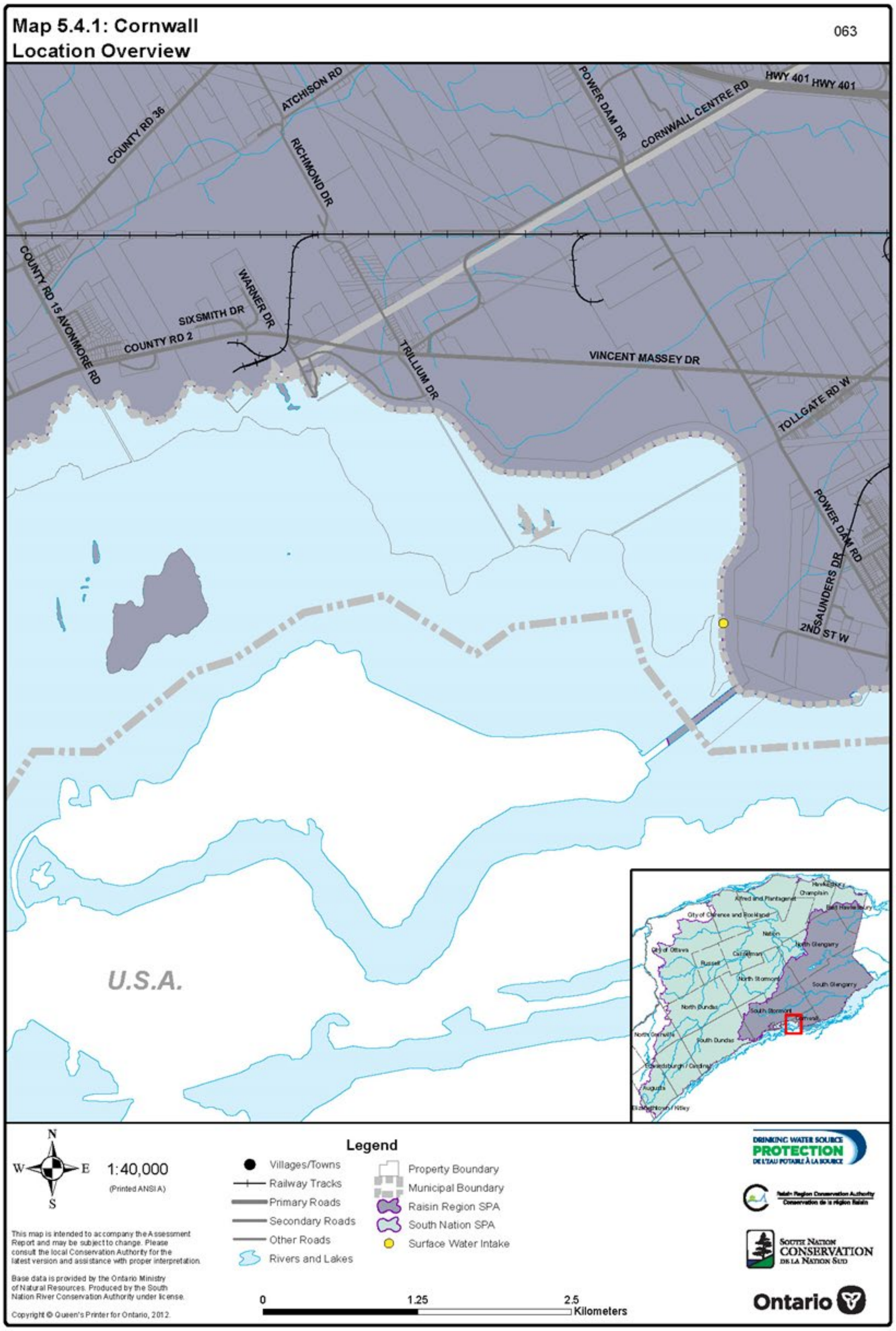
The enumeration of significant threats has low uncertainty as there are no prescribed threats or locally added threats that can score significant for the maximum IPZ score of 7.

A summary of uncertainty is listed in *Table 5.46*.

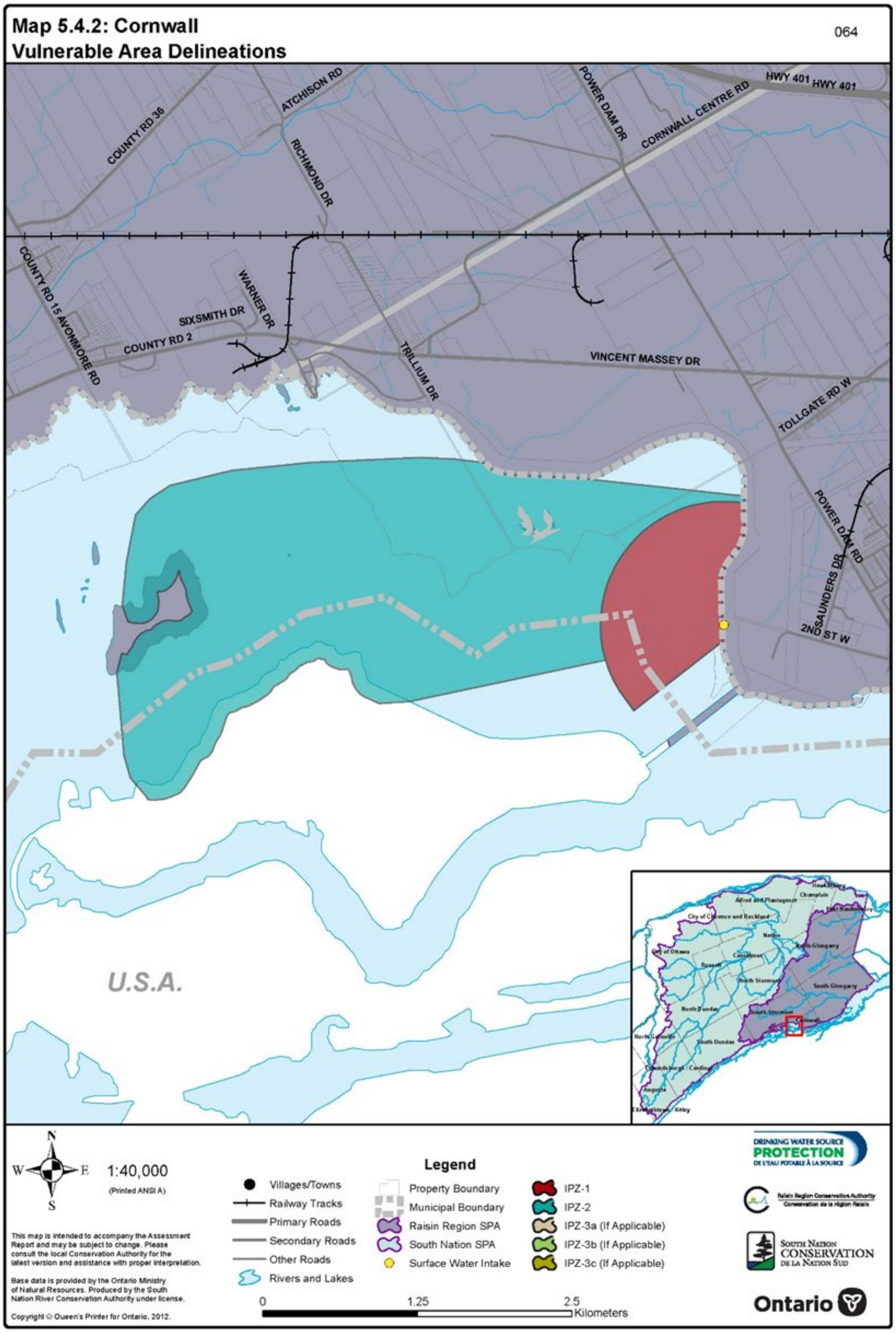
Table 5.46: Summary of Uncertainty Analyses, Cornwall

Component	Uncertainty Assessment
IPZ-1 Delineation	Low
IPZ-2 Delineation	Low
IPZ-1 Vulnerability Scoring	Low
IPZ-2 Vulnerability Scoring	Low
Issues Evaluation	Low
Managed Lands Evaluation	Low
Livestock Density Evaluation	Low
Impervious Surface Evaluation	Low
Threats Assessment	Low

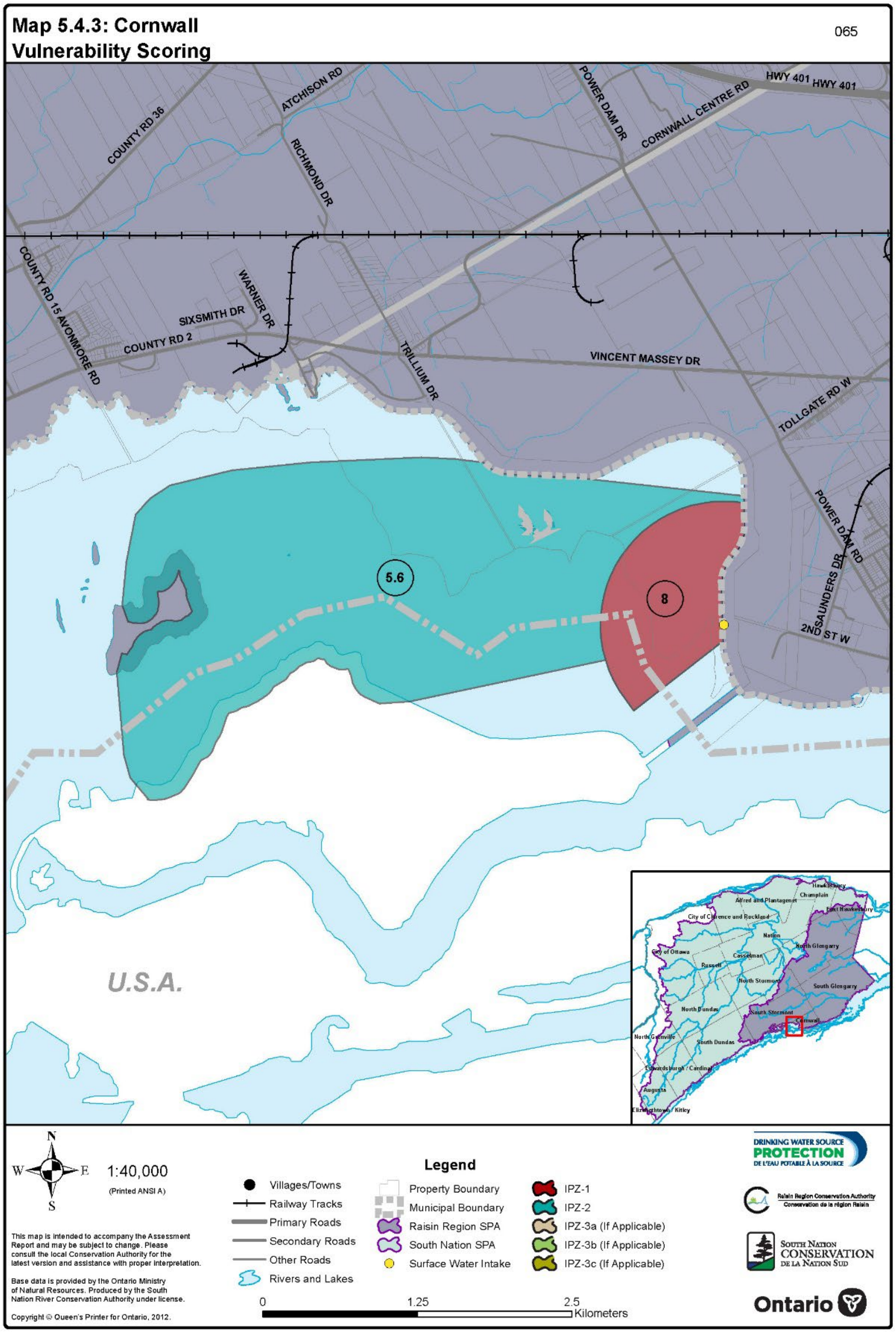
Map 5.4.1: Location Overview, Cornwall



Map 5.4.2: Vulnerable Area Delineations, Cornwall



Map 5.4.3: Vulnerability Scoring, Cornwall


Map 5.4.3: Cornwall
Vulnerability Scoring
065
HWY 401
ATCHISON RD
COUNTY RD 36
RICHMOND DR
POWER DAM DR
CORNWALL CENTRE RD
COUNTY RD 15 AVONMORE RD
WARNER DR
SIXSMITH DR
COUNTY RD 2
TRILLIUM DR
VINCENT MASSEY DR
TOLLGATE RD W
POWER DAM RD
SAUNDERS DR
2ND ST W
5.6
8
U.S.A.
1:40,000
(Printed ANSI A)
Legend
Villages/Towns
Railway Tracks
Primary Roads
Secondary Roads
Other Roads
Rivers and Lakes
Property Boundary
Municipal Boundary
Raisin Region SPA
South Nation SPA
Surface Water Intake
IPZ-1
IPZ-2
IPZ-3a (If Applicable)
IPZ-3b (If Applicable)
IPZ-3c (If Applicable)
This map is intended to accompany the Assessment Report and may be subject to change. Please consult the local Conservation Authority for the latest version and assistance with proper interpretation.
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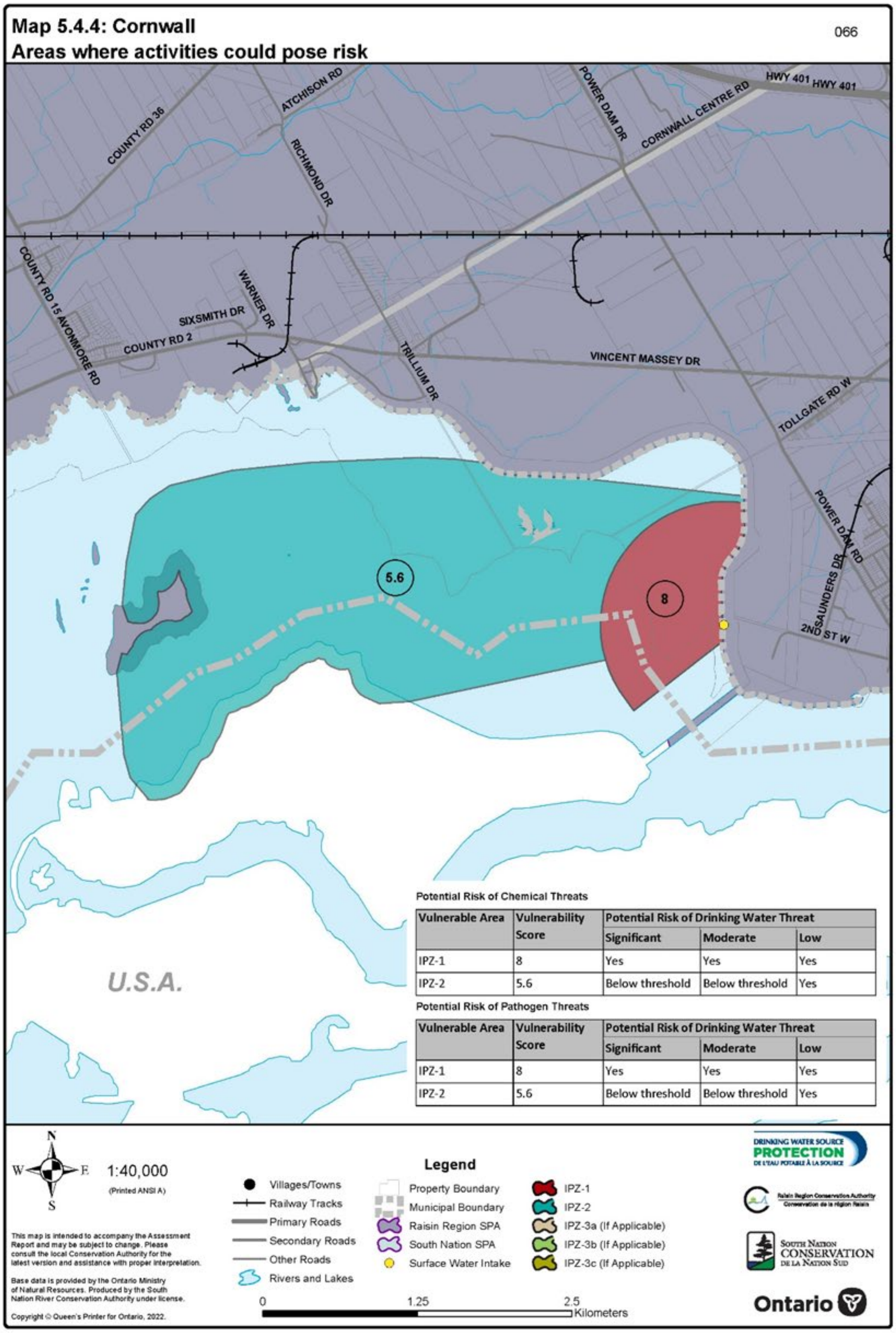
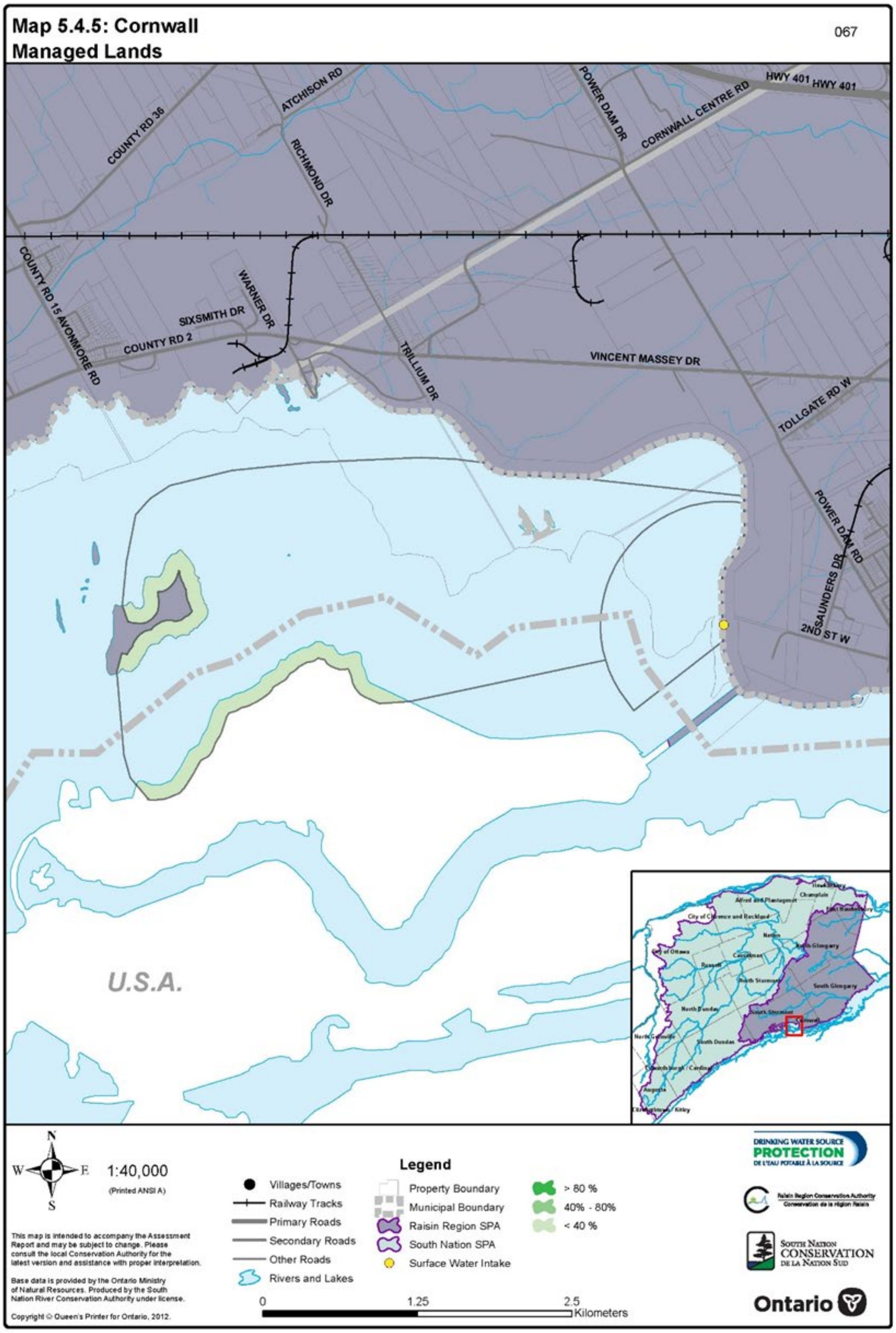
0
1.25
2.5
Kilometers
DRINKING WATER SOURCE PROTECTION
DE L'EAU POTABLE À LA SOURCE
Raisin Region Conservation Authority
South Nation Conservation
Ontario

Map 5.4.4: Potential Threat Areas, Cornwall



Map 5.4.5: Managed Lands, Cornwall


Map 5.4.5: Cornwall
Managed Lands
067
HWY 401
COUNTY RD 36
ATCHISON RD
RICHMOND DR
POWER DAM DR
CORNWALL CENTRE RD
COUNTY RD 15 AVONMORE RD
WARNER DR
SIXSMITH DR
COUNTY RD 2
TRILLIUM DR
VINCENT MASSEY DR
TOLLGATE RD W
POWER DAM RD
SAUNDERS DR
2ND ST W
U.S.A.
1:40,000
(Printed ANSI A)
This map is intended to accompany the Assessment Report and may be subject to change. Please consult the local Conservation Authority for the latest version and assistance with proper interpretation.
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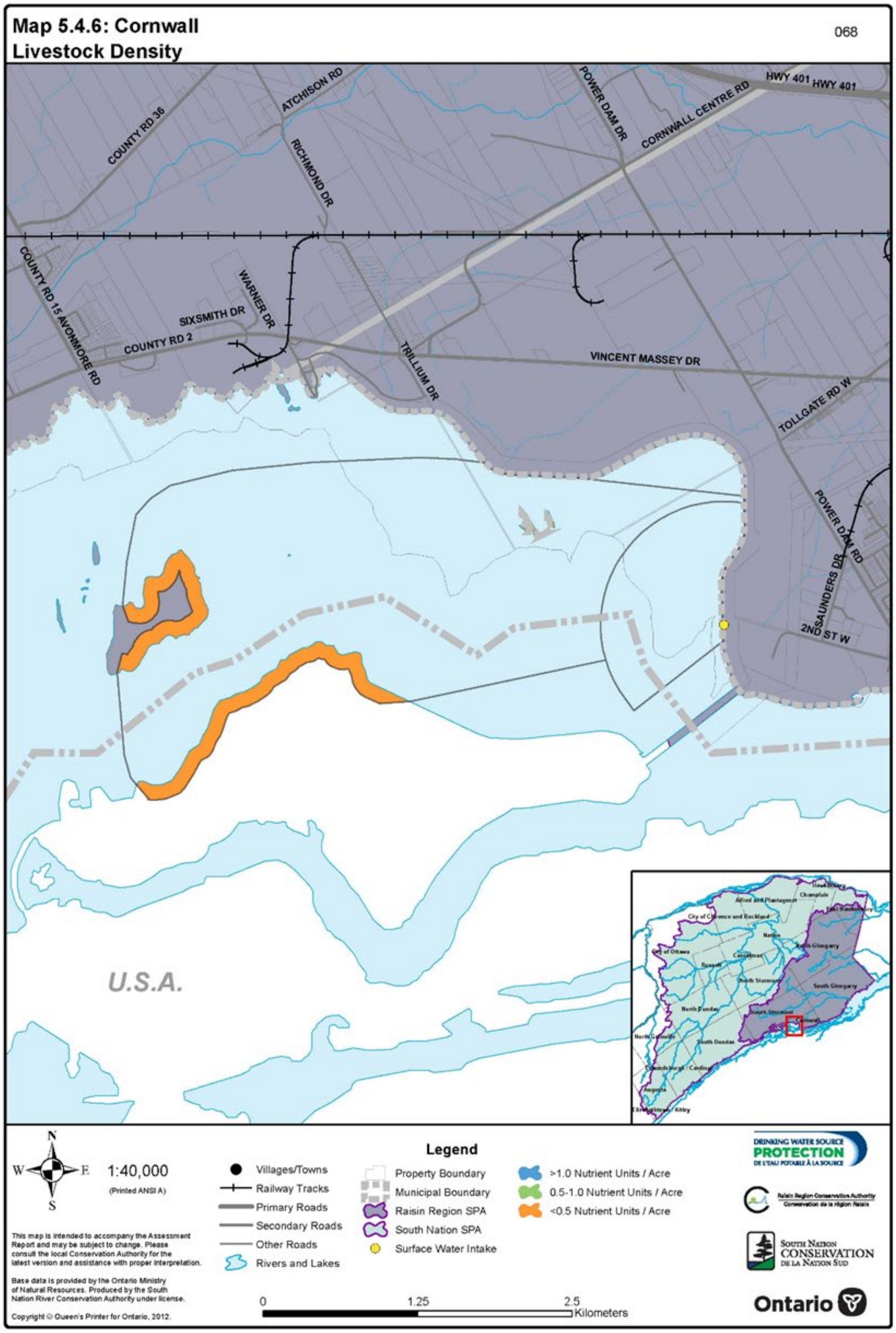
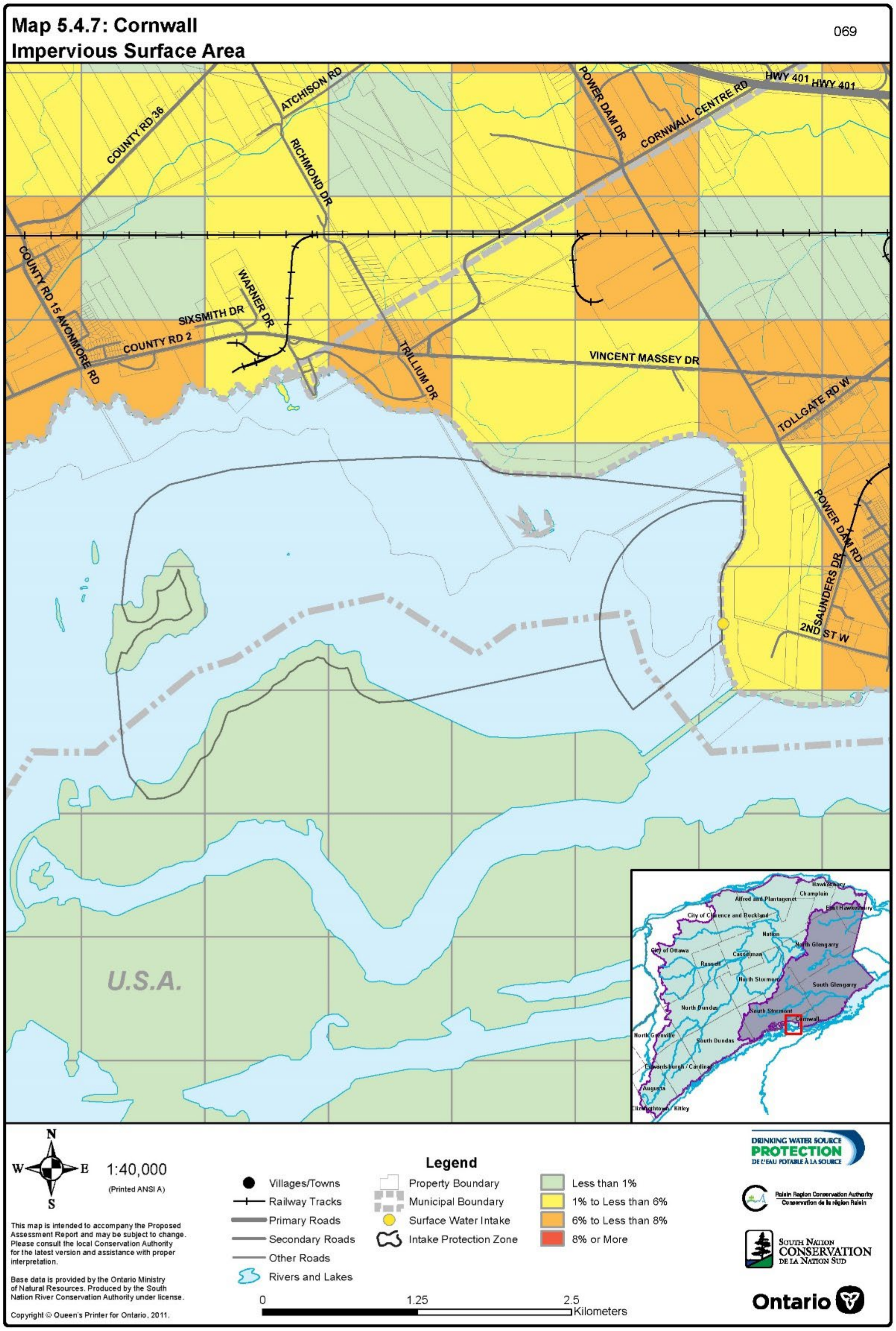
Legend
Villages/Towns
Railway Tracks
Primary Roads
Secondary Roads
Other Roads
Rivers and Lakes
Property Boundary
Municipal Boundary
Raisin Region SPA
South Nation SPA
Surface Water Intake
> 80 %
40% - 80%
< 40 %
0
1.25
2.5
Kilometers
DRINKING WATER SOURCE PROTECTION
DE L'EAU POTABLE À LA SOURCE
Raisin Region Conservation Authority
Conservation de la région Raisin
South Nation Conservation
de la Nation Sud
Ontario

Map 5.4.6: Livestock Density, Cornwall



Map 5.4.7: Impervious Surface Area, Cornwall



5.5 Glen Walter

The Glen Walter Water Treatment Plant is located at 18352 County Road 2 in the Village of Glen Walter, approximately 2km east of Cornwall. Municipal water is drawn from the St. Lawrence River. The intake is located approximately 390m offshore, at a depth of approximately 8m. The treatment plant is owned and operated by the Township of South Glengarry. The system has a design population of 1,080 people.

The site location is shown on *Map 5.5.1*. Drinking water system information is presented in *Table* 5.47*.*

Table 5.47: Drinking Water System Information, Glen Walter

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	210001861
Drinking Water System Name	Glen Walter Water Treatment Plant
Owner	Township of South Glengarry
Operating Authority	Township of South Glengarry
Source Water Type	Surface Water
Source Water	St. Lawrence River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	B
Coordinates of Intake	528881 Easting, 4986350 Northing (NAD 83, Zone-18)
Area served by System	Glen Walter
Number of Users (approx. residents)	1,080
Average Daily Taking	572 m^3/day
Maximum Daily Taking	896 m^3/day
Permit to Take Water	3285-9TMQM2
Maximum Permitted Taking	1,728 m^3/day

5.5.1 Intake Classification

The intake is located in the St. Lawrence River, which is considered a connecting channel. For this reason, the intake is classified as type B.

5.5.2 Vulnerable Area Delineation

The vulnerable area for this system comprises two intake protection zones (IPZ): IPZ-1and IPZ-2 which have been delineated in accordance with the Technical Rules: Assessment Report (*the Rules*).

The vulnerable areas for this drinking water system are shown on *Map 5.5.2*. The respective area calculations are summarized in *Table 5.48*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.48: Total Area by Vulnerable Area, Glen Walter

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	123.4	9%
IPZ-2	1,305.3	81%
Total	**1,428.7**	**100%**

5.5.2.1 Intake Protection Zone 1

An area known as IPZ-1 was delineated according to *the Rules*. It is composed of the following areas:

- A semi-circle that has a radius of 1,000 metres extending upstream from the center point of intake and a rectangle with a length of 2,000 metres and a width of 100 metres extending downstream from the centre point;
- A setback of not more than 120 m inland along the abutted land measured from the high water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River.

As there are no Regulation Limits along the St. Lawrence River, the 120 metre setback governs the IPZ-1 setback limits. The edge of surface water bodies has been used to represent the limits of high water.

5.5.2.2 Intake Protection Zone 2

Operator response time to adverse conditions in the quality of the surface water is less than two hours; therefore, the minimum travel time of two hours was used for delineation in accordance with *the Rules*.

The IPZ-2 is composed of the following areas:

- The area within each surface water body that may contribute water to the intake within 2 hours (hydraulic model, HYDROSIM plus wind vector calculations);
- The area within the stormsewershed of each storm sewer that discharges into the surface water body where the time of travel to the intake is less than 2 hours;
- A setback of not more than 120 m inland along the abutted land measured from the high water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River;
- The area that contributes water to IPZ-2 through transport pathways (i.e., tile drainage, stormwater drainage system, etc.).

The 2-hour travel area has an in-stream portion representing the St. Lawrence River (computed with HYDROSIM model) and up-tributary portions for small tributaries (i.e., Gray's Creek, Cornwall Island Creek) were estimated (Manning Equation). Instream calculations for smaller features in the subwatershed were considered using a 2-year flow in a hydraulic model (BASINS). There are storm sewer outfalls nearby; however, the IPZ-2 was not extended to include the stormsewersheds as discharges were found not to reach the intake (based on hydrodynamic modelling). There is no agricultural tile drainage within 2 hours travel time to the intake.

5.5.3 Vulnerability Scoring

A vulnerability score was assigned to each vulnerable area in accordance with *the Rules*. The score is the product of the area vulnerability factor and the source vulnerability factor.

5.5.3.1 Area Vulnerability Factor

The Rules dictate the permissible range of scores for the area vulnerability factor based on the classification of intake. For this type of intake, the score for IPZ-1 is fixed at 10. For IPZ-2, the permissible values are 7, 8 or 9.

The scoring for IPZ-2 is determined based on the following criteria:

- The percentage of the area that is composed of land;
- The land cover, soil type, permeability and slope;
- Hydrological and hydrogeological conditions that contribute water to the area through transport pathways; and,

The area vulnerability factor for IPZ-2 was set at 9 after considering:

- The ratio of land to water is moderate (27% land vs. 73% water);
- Land component has a high percentage of urban, pasture and forest areas;
- There is a high runoff potential from urban areas.

5.5.3.2 Source Vulnerability Factor

A source vulnerability factor was assigned to the surface water intake as prescribed in *the Rules*. For this intake, the source vulnerability factor can be 0.7, 0.8 or 0.9 based on the following criteria:

- Depth of the intake from the top of the water surface;
- Distance of the intake from land;
- History of water quality concerns at the surface water intake.

The source vulnerability factor was taken as 0.7 after considering:

- The intake is relatively deep (7 m below mean river level);
- The intake is located far from land (an offshore distance of approximately 390 m);
- There is no history of water quality concerns.

5.5.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.49* and shown on *Map 5.5.3*.

Table 5.49: Vulnerability Scores, Glen Walter

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.7	7
IPZ-2	9	0.7	6.3

5.5.4 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.5.4.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.5.4.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is a significant, moderate or low drinking water treat. *Table 5.50* and *Table* 5.51 can be used to determine which areas are vulnerable to chemical and pathogen threats. These are also referenced visually on *Map 5.5.4.*

Table 5.50: Risk of Chemical Threats, Glen Walter

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	7	Below threshold	Yes	Yes
IPZ-2	6.3	Below threshold	Yes	Yes

Table 5.51: Risk of Pathogen Threats, Glen Walter

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	7	Below threshold	Yes	Yes
IPZ-2	6.3	Below threshold	Yes	Yes

5.5.4.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.5.5* and is tabulated in *Table 5.52*.

Table 5.52: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Glen Walter

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	123.4	0	12	12	10%
IPZ-2	1,305.3	39	160	199	15%

5.5.4.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 5.5.6* and is tabulated in *Table 5.53*.

Table 5.53: Livestock Density Assessment, Glen Walter

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0
IPZ-2	0.14

5.5.4.5 Impervious Surface Area

The impervious area within each IPZ where the application of road salt could pose a low risk at minimum is shown on *Map 5.5.7* and tabulated in *Table 5.54.*

Table 5.54: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Glen Walter

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
IPZ-1	25.0	0	98.4	0
IPZ-2	651.6	259.6	394.1	0

5.5.4.6 Issues Evaluation

There is no evidence that a parameter is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water. There are no issues therefore requiring further assessment or the delineation of an issues contributing area.

5.5.4.7 Conditions from Past Activities

Various data sets acquired through Ecolog ERIS were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition meeting the definition as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.5.4.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official's 2020 report, there are 0 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 0 unique locations (one location could possibly account for multiple threat activities). The vulnerability score for this system's intake protection zones is lower than the threshold to produce a significant drinking water threat as per the technical rules. Specific activities and location counts are listed in *Table 5.55*.

Table 5.55: Significant Drinking Water Threat Activities, Glen Walter

Activity	Sub Threat, if Applicable	Count
None	n.a	0
Total – All Activities		**0**

5.5.4.9 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards established for municipal drinking water systems throughout the Source Protection Authority and Source Protection Region, as outlined in *Section 4*. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.5.4.10 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.56*. The information sources quoted below may contain additional expanded references.

Table 5.56: Key Information Sources, Glen Walter

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2019. *Glen Walter Drinking Water System Inspection Report 2019-2020*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Glengarry, Glen Walter Intake, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Glengarry, Glen Walter Intake, Assessment Report Input.*	Technical Study	Engineering Assessment

Section	Source(s)	Type	Analysis Method(s)
Managed Lands	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, Township of South Glengarry, Glen Walter Intake, Assessment Report Input.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, Township of South Glengarry, Glen Walter Intake, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.5.4.11 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The degree of uncertainty related to the delineation of IPZ-1 is low as the geometry of the zone is prescribed by *the Rules*. The hydraulic model used for IPZ-2 delineation was created for the purpose of assessing macrophyte growth in the shallow portion of the river system between

Cornwall and Ile-de-Salaberry. The model contains sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The uncertainty related to the delineation of IPZ-2 is low.

The scoring of IPZ-1 and IPZ-2 are fairly prescriptive based on *the Rules*. The uncertainty is directly related to the data quality of physical setting and characteristics of the surrounding land. Good quality data was available in both cases, and therefore the uncertainty is considered to be low.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

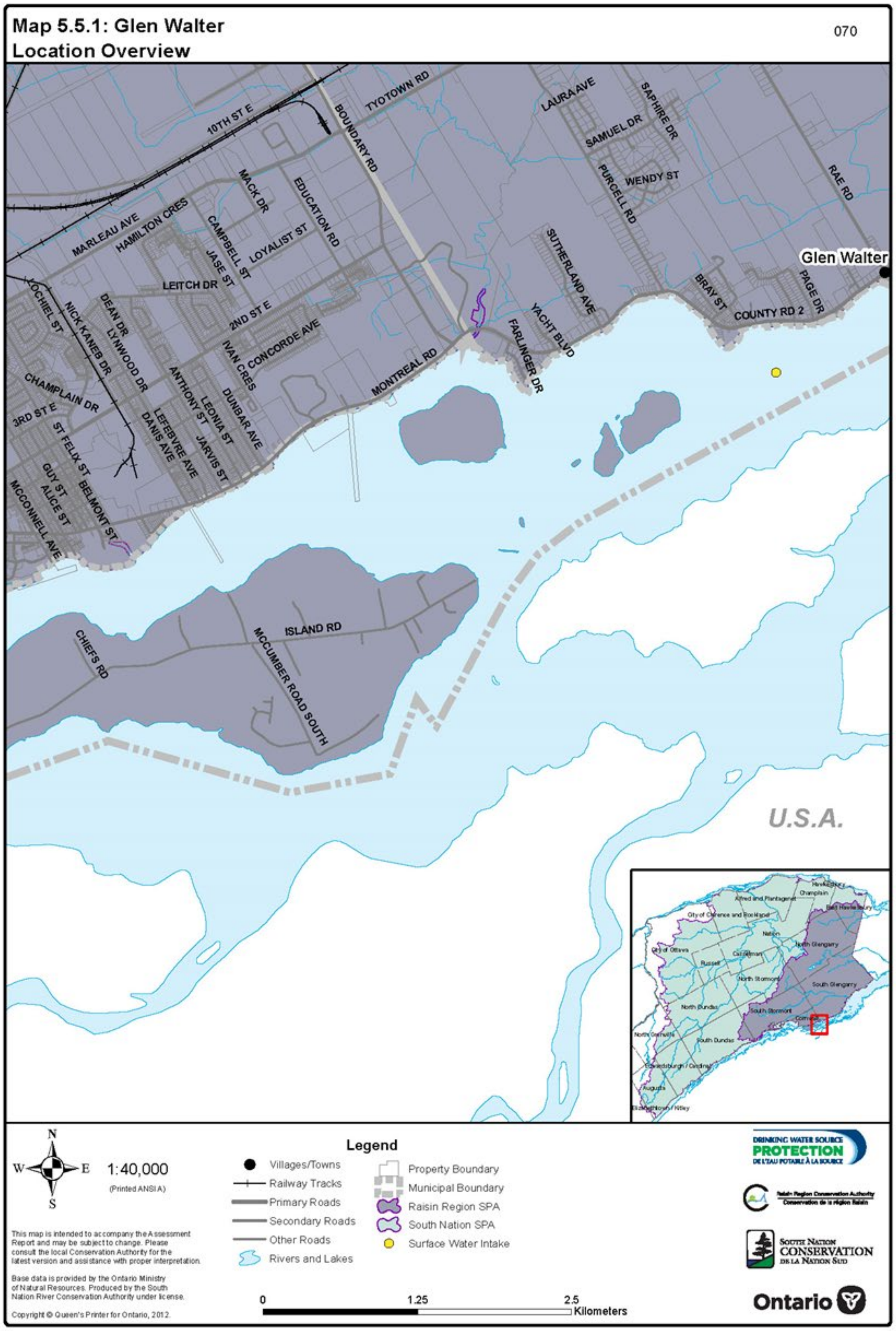
The enumeration of significant threats has low uncertainty as there are no prescribed threats or locally added threats that can score significant for the maximum IPZ score of 7.

A summary of uncertainty is listed in *Table 5.57*.

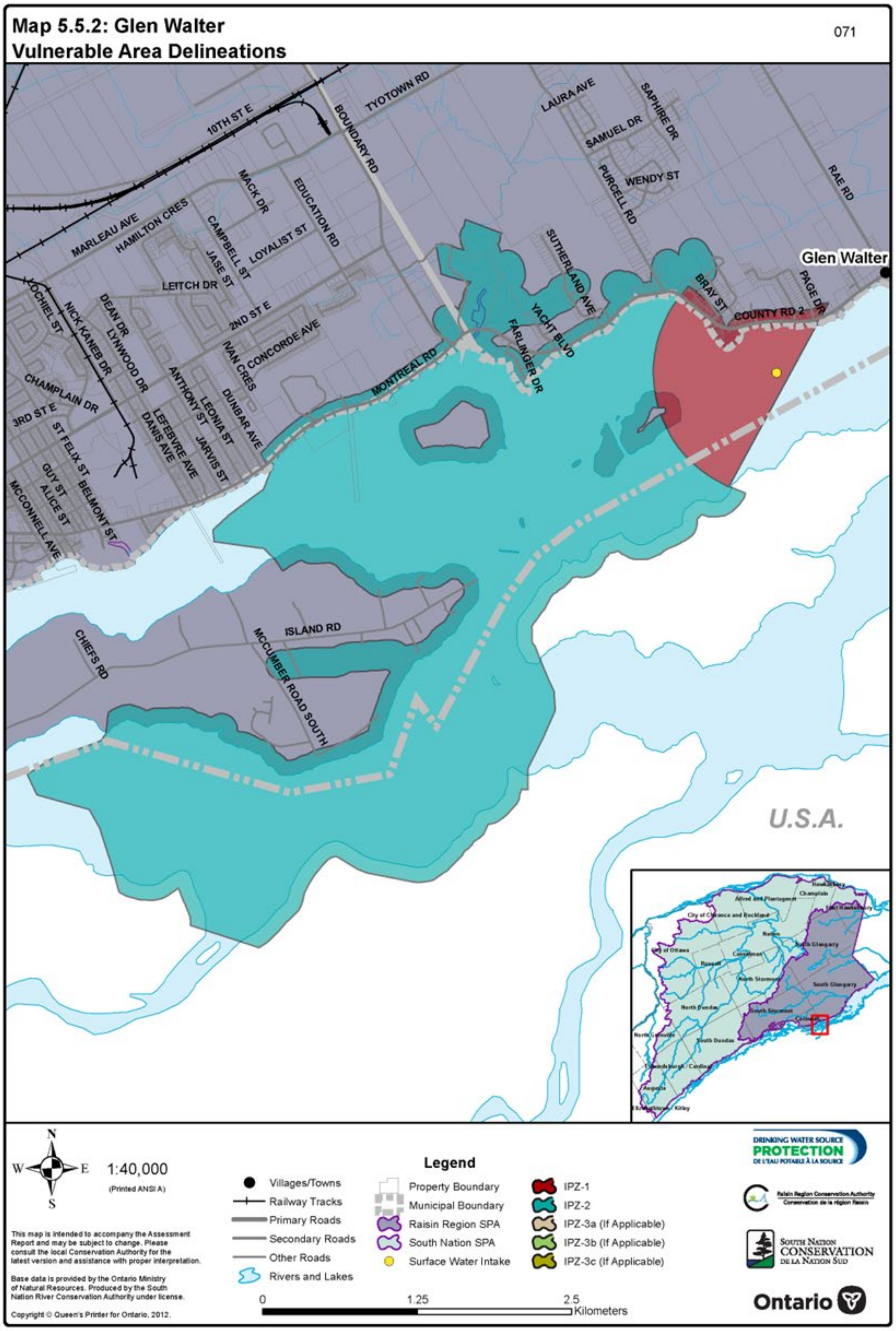
Table 5.57: Summary of Uncertainty Analyses, Glen Walter

Component	Uncertainty Assessment
IPZ-1 Delineation	Low
IPZ-2 Delineation	Low
IPZ-1 Vulnerability Scoring	Low
IPZ-2 Vulnerability Scoring	Low
Issues Evaluation	Low
Managed Lands Evaluation	Low
Livestock Density Evaluation	Low
Impervious Surface Evaluation	Low
Threats Assessment	Low

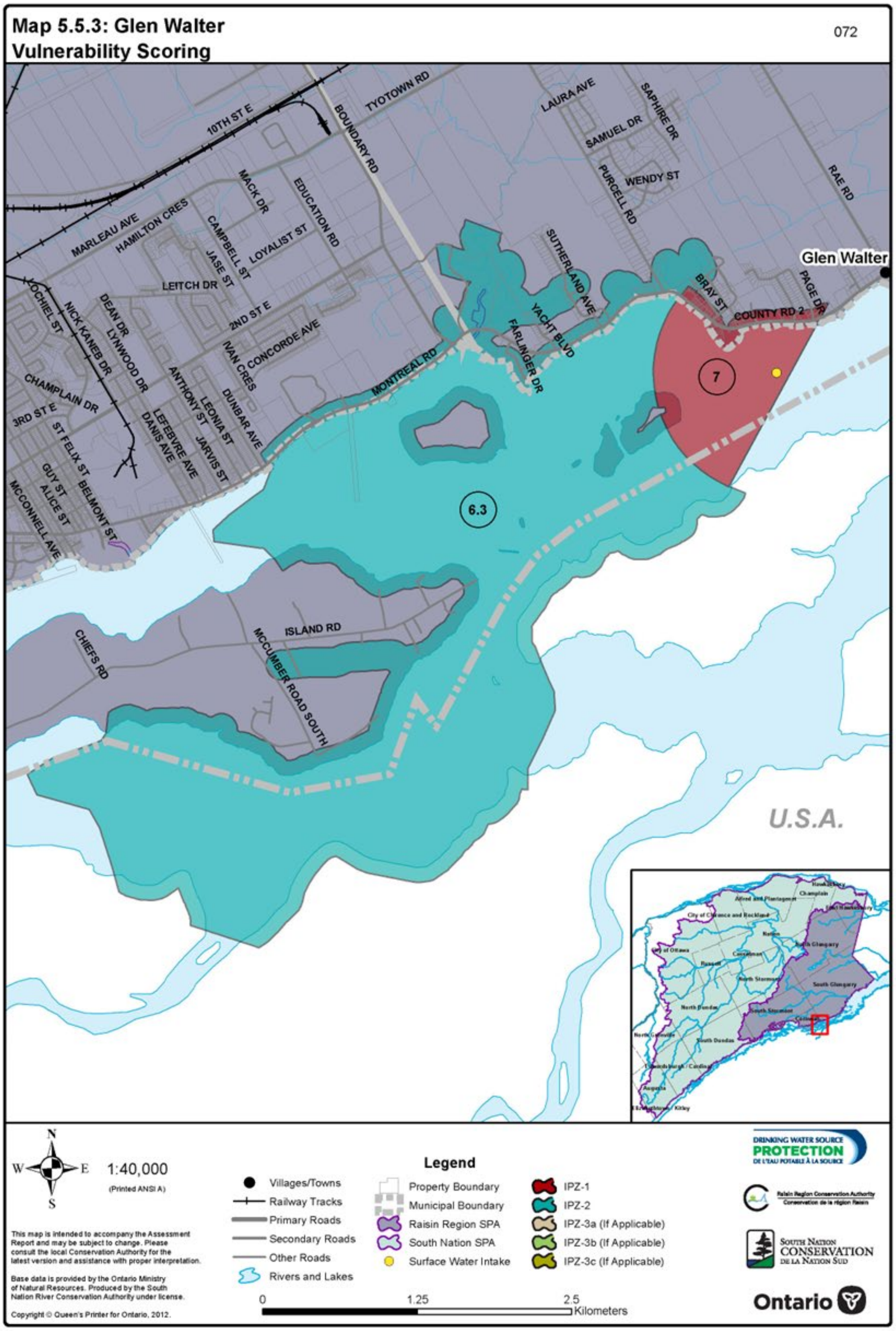
Map 5.5.1: Location Overview, Glen Walter



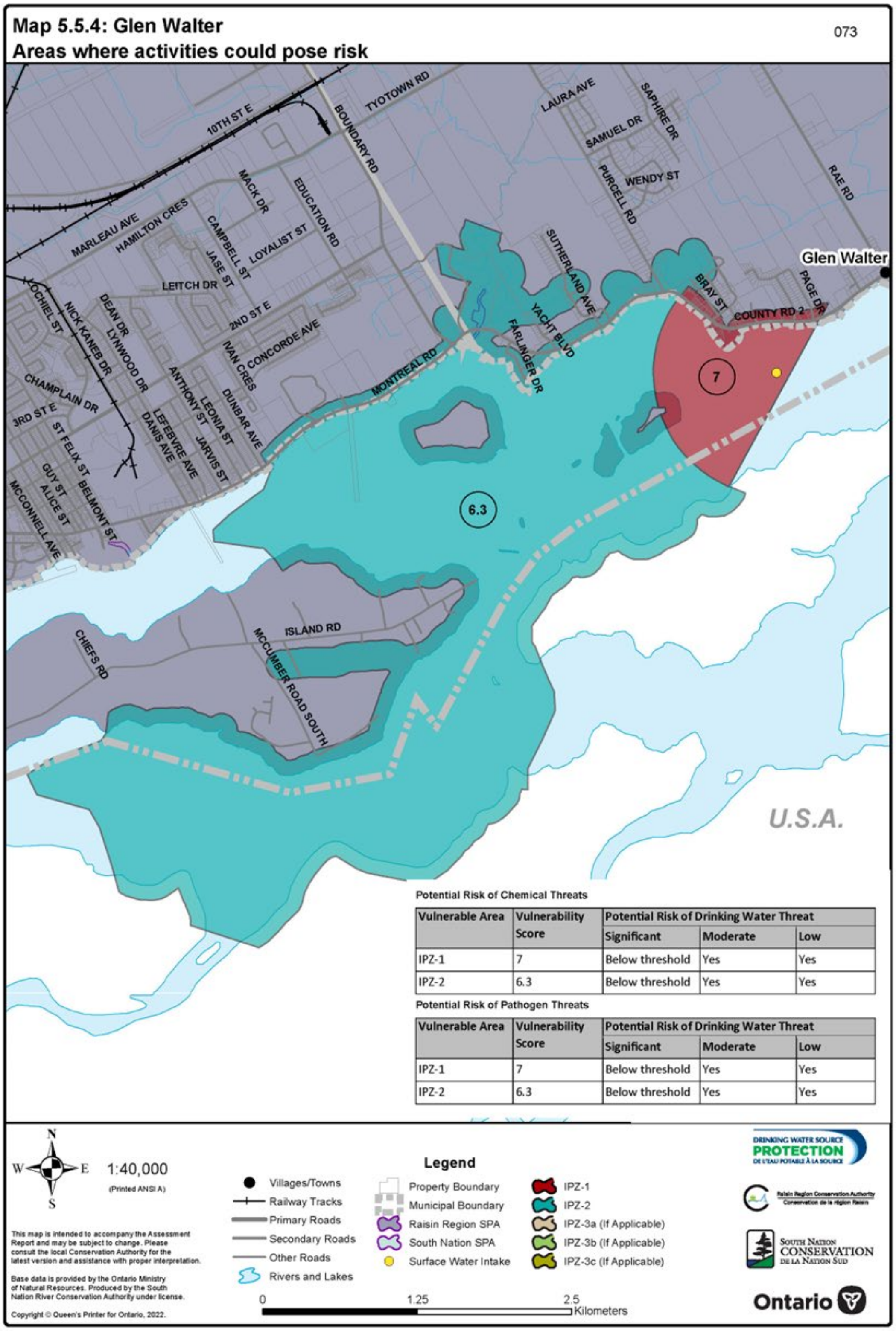
Map 5.5.2: Vulnerable Area Delineations, Glen Walter



Map 5.5.3: Vulnerability Scoring, Glen Walter



Map 5.5.4: Potential Threat Areas, Glen Walter



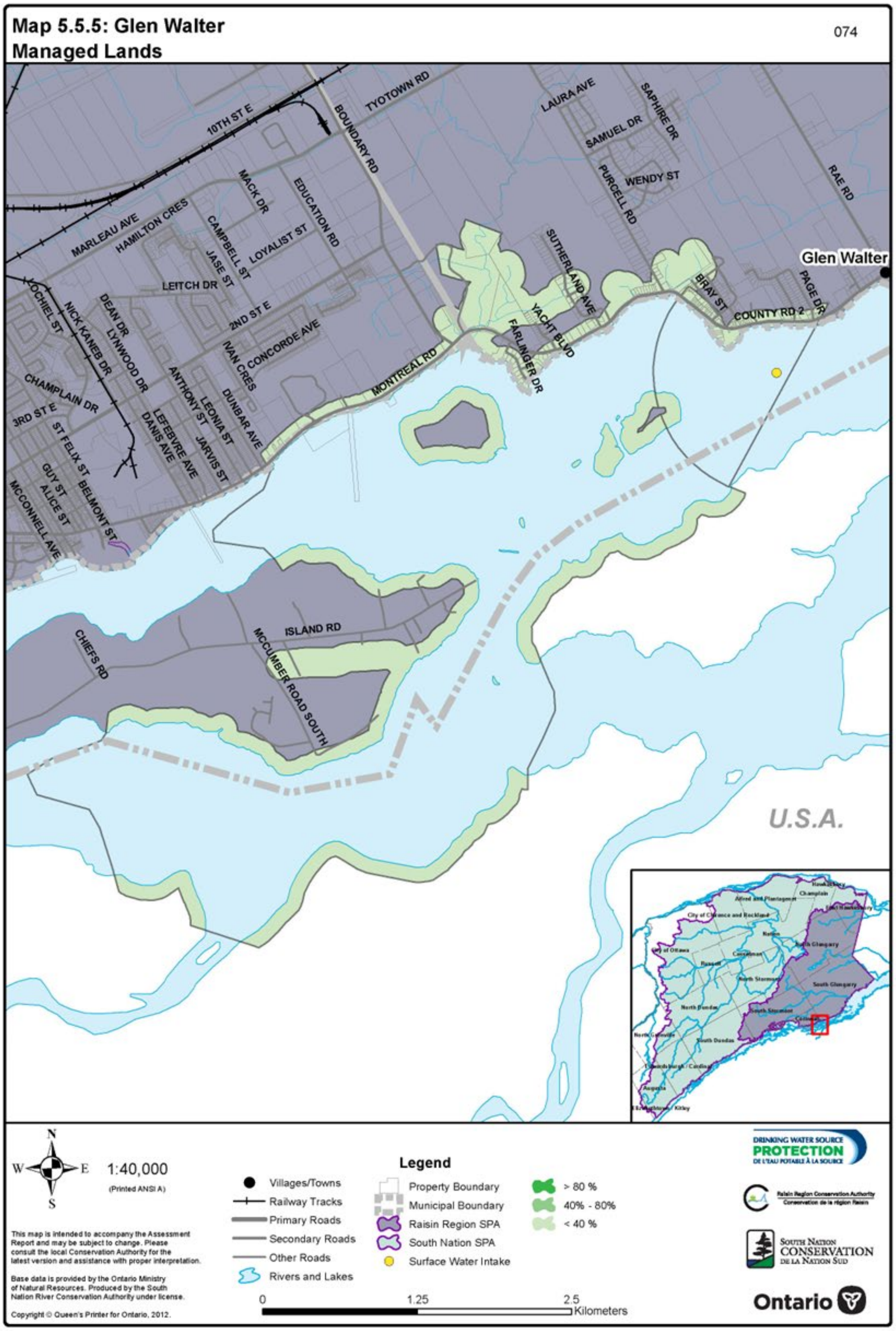
Potential Risk of Chemical Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	7	Below threshold	Yes	Yes
IPZ-2	6.3	Below threshold	Yes	Yes

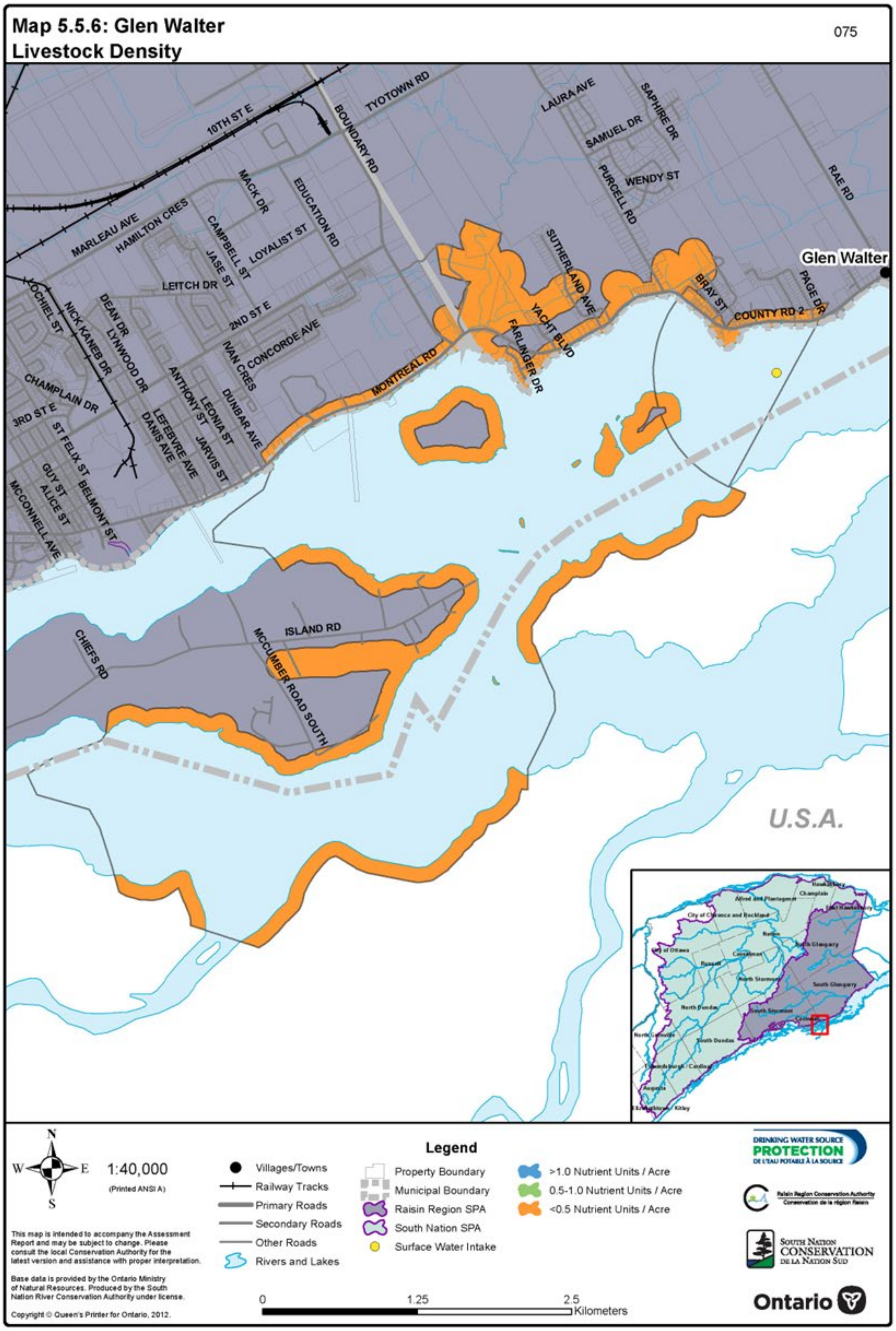
Potential Risk of Pathogen Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	7	Below threshold	Yes	Yes
IPZ-2	6.3	Below threshold	Yes	Yes

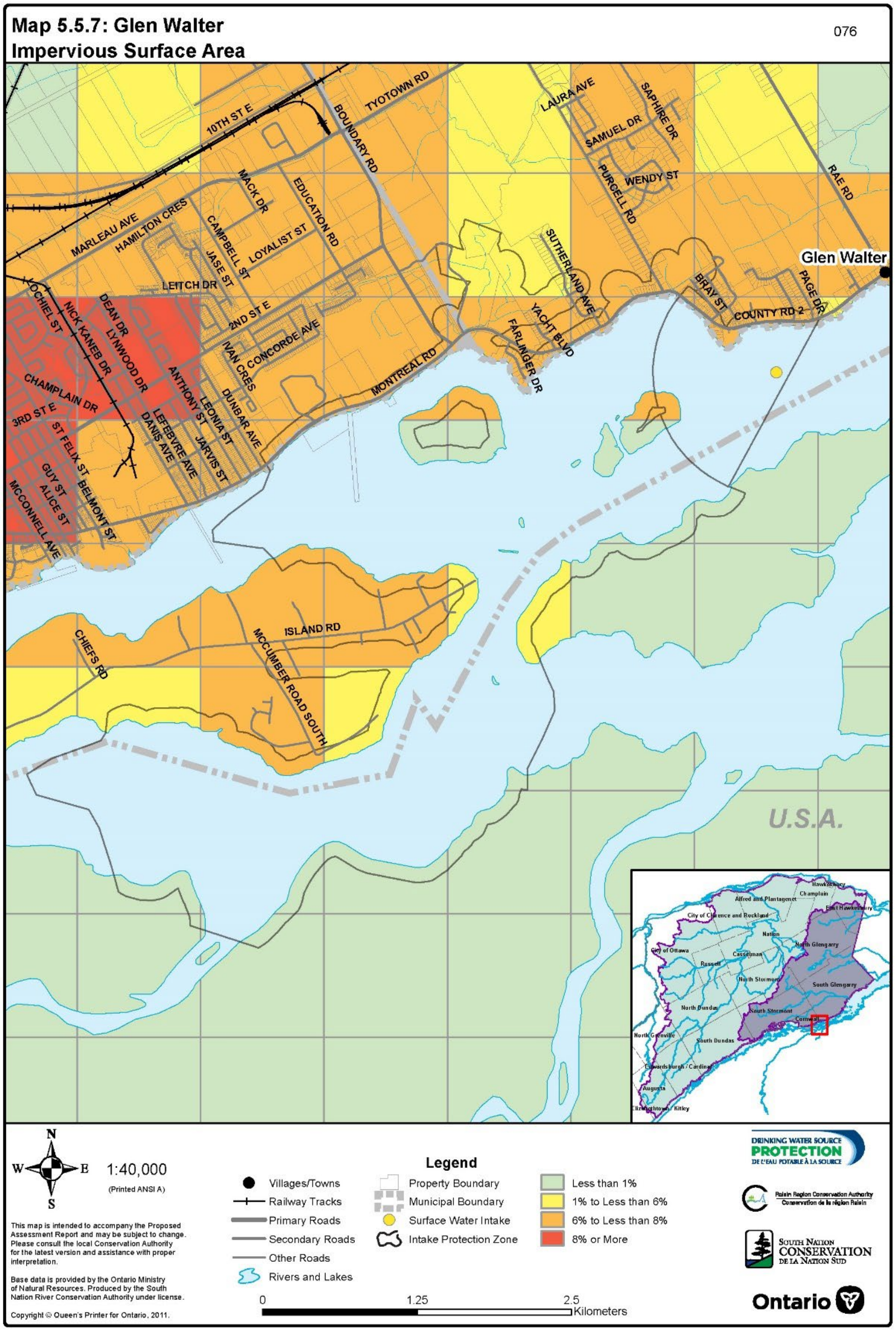
Map 5.5.5: Managed Lands, Glen Walter



Map 5.5.6: Livestock Density, Glen Walter



Map 5.5.7: Impervious Surface Area, Glen Walter



5.6 Lancaster

The Lancaster Water Treatment Plant is located approximately 1km downstream from the Village of Lancaster on Old Montreal. It serves a population of about 1,218 with 406 service connections. Municipal water is taken from Lake St. Francis, part of the St. Lawrence River. The intake is located southeast of Faulkner's Point, approximately 1,300 m offshore, at a depth of approximately 8 m, nearly 2 m off the bottom of the lake.

The site location is shown on *Map 5.6.1*. Drinking water system information is presented in Table 5.58.

Table 5.58: Drinking Water System Information, Lancaster

Drinking Water System Type (MOE)	Existing Large Municipal Residential System
Drinking Water System Number (MOE)	260006867
Drinking Water System Name	Lancaster Water Treatment Plant
Owner	Township of South Glengarry
Operating Authority	Township of South Glengarry
Source Water Type	Surface Water
Source Water	St. Lawrence River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	B
Coordinates of Intake	542520 Easting, 4997972 Northing (NAD 83, Zone-18)
Area served by System	Lancaster
Number of Users (229approx. residents)	1,218
Average Daily Taking	452 m^3/day
Maximum Daily Taking	796 m^3/day
Permit to Take Water	6653-AP9H6L
Maximum Permitted Taking	1,440 m^3/day

5.6.1 Intake Classification

The intake is located in the St. Lawrence River, which is considered a connecting channel. For this reason, the intake is classified as type B.

5.6.2 Vulnerable Area Delineation

The vulnerable area for this system comprises two intake protection zones (IPZ): IPZ-1and IPZ-2 which have been delineated in accordance with the Technical Rules: Assessment Report (*the Rules*).

The vulnerable areas for this drinking water system are shown on *Map 5.6.2*. The respective area calculations are summarized in *Table 5.59*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.59: Total Area by Vulnerable Area, Lancaster

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	52.2	8%
IPZ-2	572.2	92%
Total	**624.4**	**100%**

5.6.2.1 Intake Protection Zone 1

An area known as IPZ-1 was delineated according to *the Rules*. It is composed of the following areas:

- A semi-circle that has a radius of 1,000 metres extending upstream from the center point of intake and a rectangle with a length of 2,000 metres and a width of 100 metres extending downstream from the centre point;
- a setback of not more than 120 m inland along the abutted land measured from the high-water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River.

As there are no Regulation Limits along the St. Lawrence River, the 120-metre setback governs the IPZ-1 setback limits. The edge of surface water bodies has been used to represent the limits of high water. IPZ-1 however, does not touch land in the case of the Lancaster intake.

5.6.2.2 Intake Protection Zone 2

Operator response time to adverse conditions in the quality of the surface water is less than two hours; therefore, the minimum travel time of two hours was used for delineation in accordance with *the Rules*.

The IPZ-2 is composed of the following areas:

- the area within each surface water body that may contribute water to the intake within 2 hours (hydraulic model, HYDROSIM plus wind vector calculations);
- the area within the stormsewershed of each storm sewer that discharges into the surface water body where the time of travel to the intake is less than 2 hours;
- a setback of not more than 120 m inland along the abutted land measured from the high-water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the St. Lawrence River;
- the area that contributes water to IPZ-2 through transport pathways (i.e., tile drainage, stormwater drainage system, etc.).

The 2-hour travel area does not touch land and accordingly has only an in-stream portion representing the St. Lawrence River. There are no tributaries, small watercourses or anthropogenic transport pathways in IPZ-2.

5.6.3 Vulnerability Scoring

A vulnerability score was assigned to each vulnerable area in accordance with *the Rules*. The score is the product of the area vulnerability factor and the source vulnerability factor.

5.6.3.1 Area Vulnerability Factor

The Rules dictate the permissible range of scores for the area vulnerability factor based on the classification of intake. For this type of intake, the score for IPZ-1 is fixed at 10. For IPZ-2, the permissible values are 7, 8 or 9.

The scoring for IPZ-2 is determined based on the following criteria:

- The percentage of the area that is composed of land;
- The land cover, soil type, permeability and slope;
- Hydrological and hydrogeological conditions that contribute water to the area through transport pathways; and,

The area vulnerability factor for IPZ-2 was set at 7 after considering:

- The zone does not extend to land, it is 100%;
- There are no transport pathways present (no storm sewers or tile drainage).

5.6.3.2 Source Vulnerability Factor

A source vulnerability factor was assigned to the surface water intake as prescribed in *the Rules*. For this intake, the source vulnerability factor can be 0.7, 0.8 or 0.9 based on the following criteria:

- Depth of the intake from the top of the water surface;
- Distance of the intake from land;
- History of water quality concerns at the surface water intake.

The source vulnerability factor was taken as 0.7 after considering:

- The intake is relatively deep (8 m below low river level);
- The intake is very far from the mainland (an offshore distance of approximately 1,300 m);
- There is no history of water quality concerns.

5.6.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in Table 5.60 and shown on *Map 5.6.3*.

Table 5.60: Vulnerability Scores, Lancaster

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.7	7
IPZ-2	7	0.7	4.9

5.6.4 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.6.4.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.6.4.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is a significant, moderate or low drinking water threat. *Table 5.61* and *Table 5.62* can be used to determine which areas are vulnerable to chemical and pathogen threats. These are also referenced visually on *Map 5.6.4.*

Table 5.61: Risk of Chemical Threats, Lancaster

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	7	Below threshold	Yes	Yes
IPZ-2	4.9	Below threshold	Below threshold	Yes

Table 5.62: Risk of Pathogen Threats, Lancaster

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	7	Below threshold	Yes	Yes
IPZ-2	4.9	Below threshold	Below threshold	Yes

5.6.4.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.6.5* and is tabulated in *Table 5.63*.

Table 5.63: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Lancaster

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Percent Managed Land
IPZ-1	52.2	0	0	0%
IPZ-2	572.2	0	0	0%

5.6.4.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 5.6.6* and is tabulated in *Table 5.64*.

Table 5.64: Livestock Density Assessment, Lancaster

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0
IPZ-2	0

5.6.4.5 Impervious Surface Area

The impervious area within each IPZ where the application of road salt could pose a low risk at minimum is shown on *Map 5.6.7* and tabulated in *Table 5.65.*

Table 5.65: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Lancaster

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
IPZ-1	0	0	0	0
IPZ-2	0	0	0	0

5.6.4.6 Issues Evaluation

There is no evidence that a parameter is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water. There are no issues therefore requiring further assessment or the delineation of an issues contributing area.

5.6.4.7 Conditions from Past Activities

Various data sets acquired through Ecolog ERIS were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition meeting the definition as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.6.4.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official’s 2020 report, there are 0 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 0 unique locations (one location could possibly account for multiple threat activities). The vulnerability score for this system’s intake protection zones is lower than the threshold to produce a significant drinking water threat as per the technical rules. Specific activities and location counts are listed in Table 5.66.

Table 5.66: Significant Drinking Water Threat Activities, Lancaster

Activity	Sub Threat, if Applicable	Count
None	n.a.	0
Total – All Activities		**0**

5.6.4.9 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards established for municipal drinking water systems throughout the Source Protection Authority and Source Protection Region, as outlined in *Section 4*. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.6.4.10 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.67*. The information sources quoted below may contain additional expanded references.

Table 5.67: Key Information Sources, Lancaster

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2019. *Lancaster Drinking Water System 2019-20 Inspection Report*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Glengarry, Lancaster Intake, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Glengarry, Lancaster Intake, Assessment Report Input.*	Technical Study	Engineering Assessment

Section	Source(s)	Type	Analysis Method(s)
Managed Lands	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, Township of South Glengarry, Lancaster Intake, Assessment Report Input.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems along the St. Lawrence River, Township of South Glengarry, Lancaster Intake, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.6.4.11 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The degree of uncertainty related to the delineation of IPZ-1 is low as the geometry of the zone is prescribed by *the Rules*. The hydraulic model used for IPZ-2 delineation was created for the purpose of assessing macrophyte growth in the shallow portion of the river system between

Cornwall and Ile-de-Salaberry. The model contains sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The uncertainty related to the delineation of IPZ-2 is low.

The scoring of IPZ-1 and IPZ-2 are fairly prescriptive based on *the Rules*. The uncertainty is directly related to the data quality of physical setting and characteristics of the surrounding land. Good quality data was available in both cases, and therefore the uncertainty is considered to be low.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

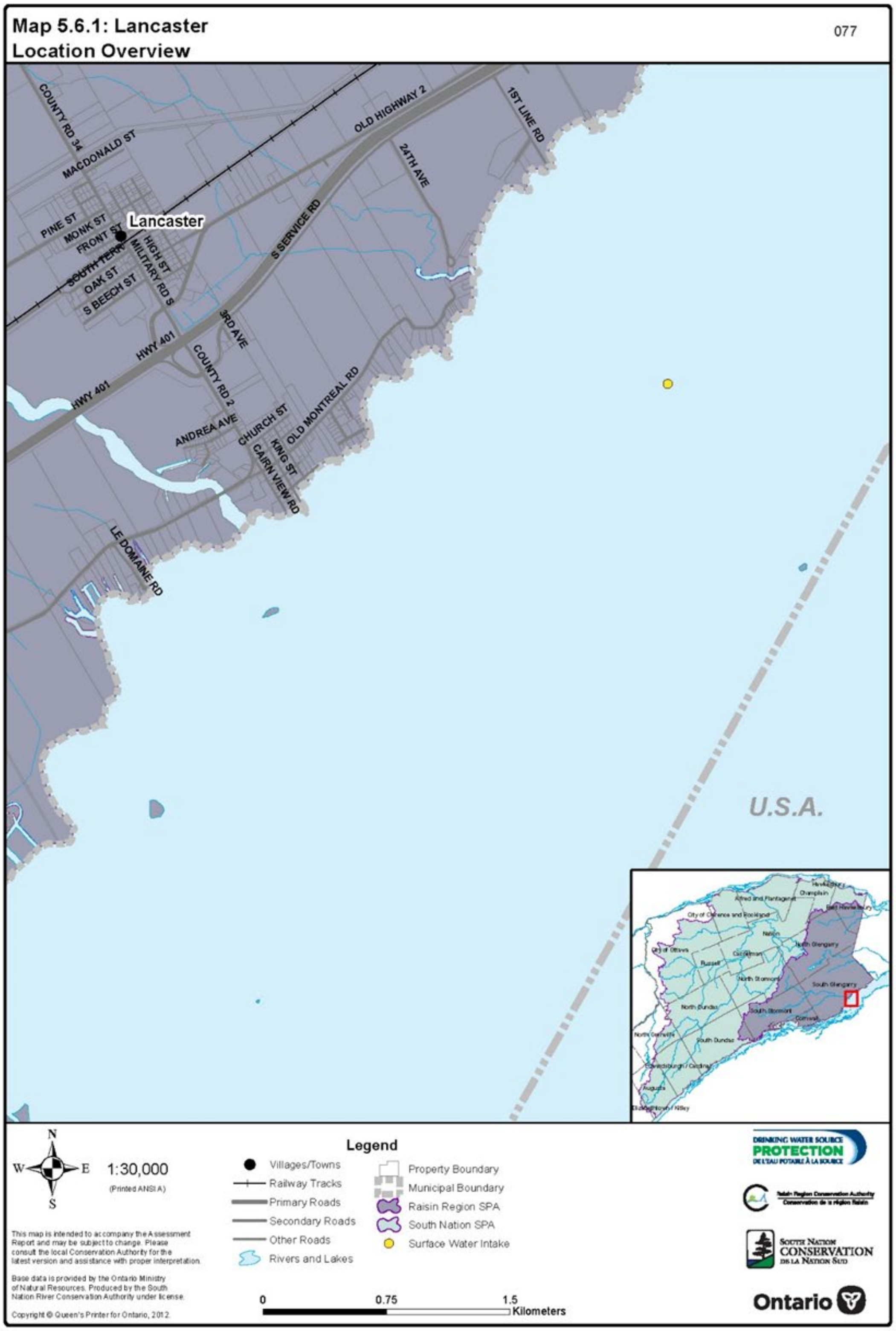
The enumeration of significant threats has low uncertainty as there are no prescribed threats or locally added threats that can score significant for the maximum IPZ score of 7.

A summary of uncertainty is listed in *Table* 5.68.

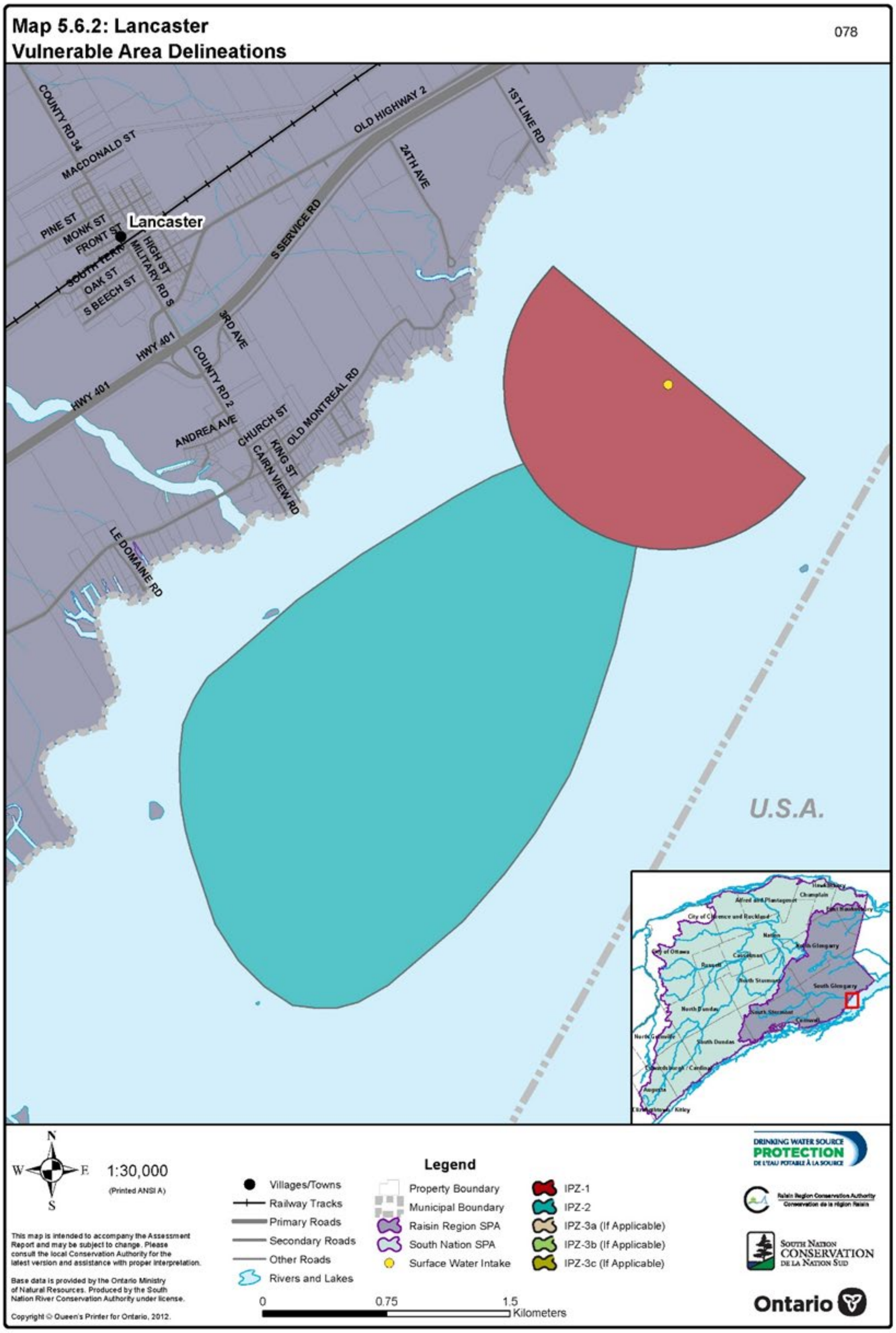
Table 5.68: Summary of Uncertainty Analyses, Lancaster

Component	Uncertainty Assessment
IPZ-1 Delineation	Low
IPZ-2 Delineation	Low
IPZ-1 Vulnerability Scoring	Low
IPZ-2 Vulnerability Scoring	Low
Issues Evaluation	Low
Managed Lands Evaluation	Low
Livestock Density Evaluation	Low
Impervious Surface Evaluation	Low
Threats Assessment	Low

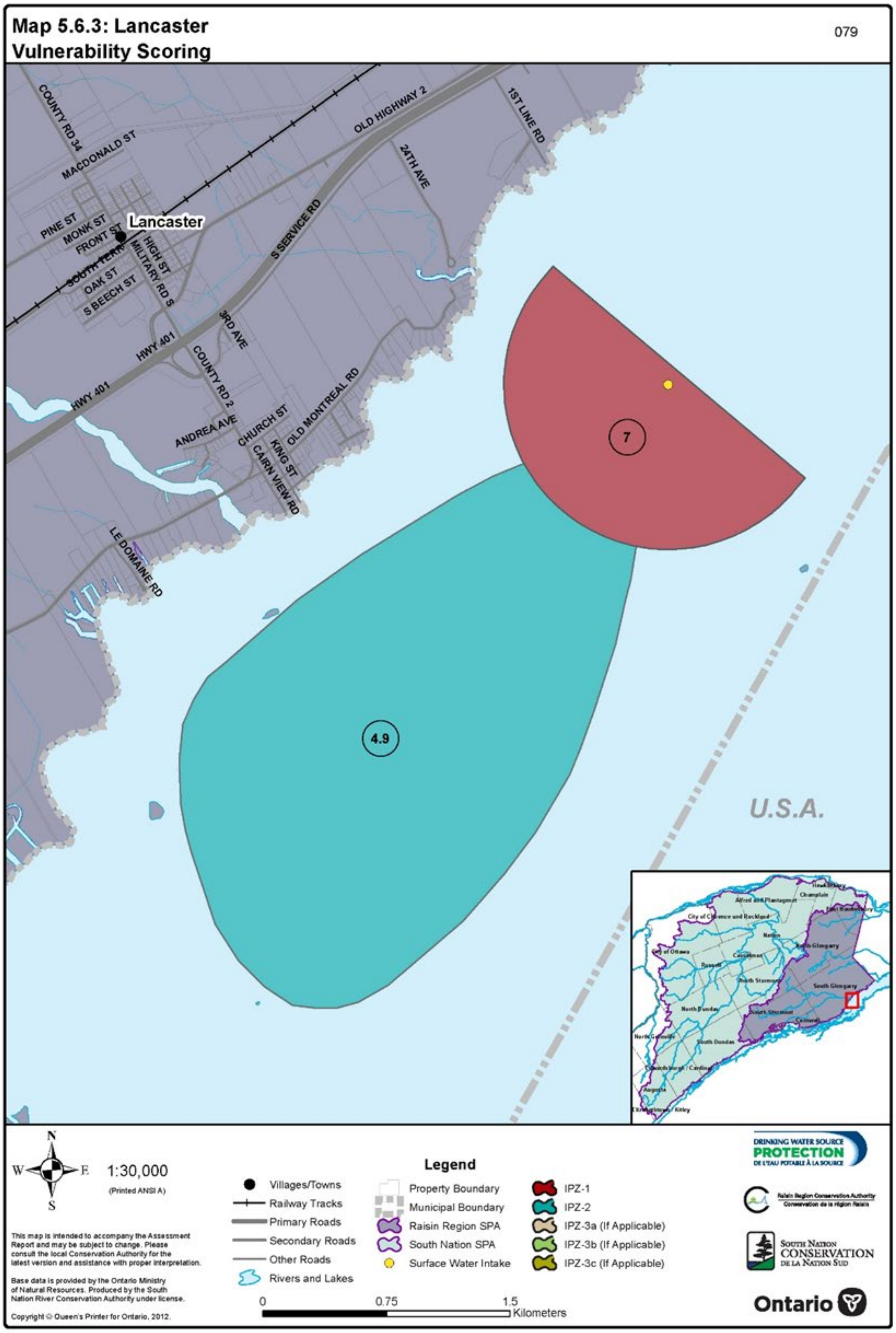
Map 5.6.1: Location Overview, Lancaster



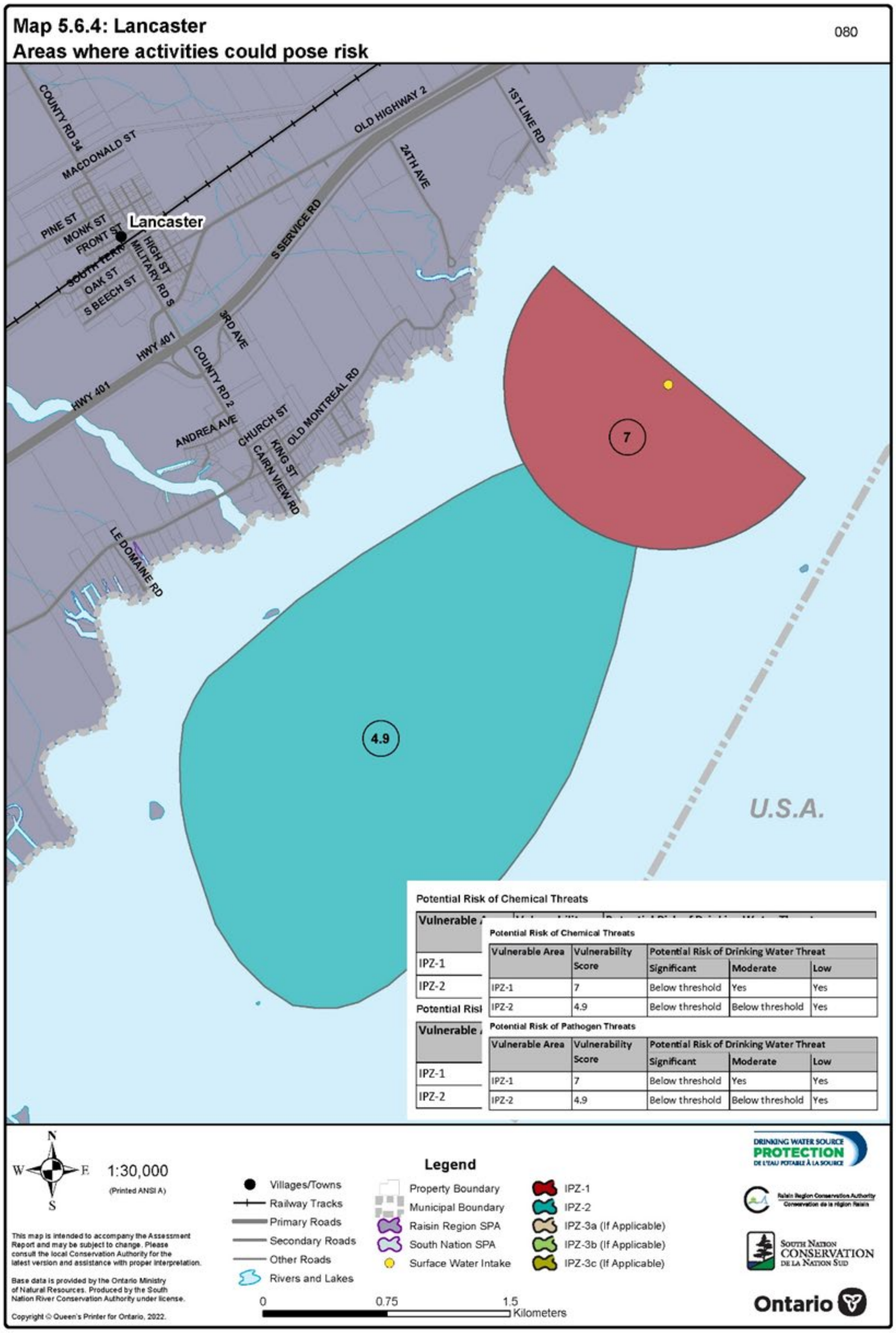
Map 5.6.2: Vulnerable Area Delineations, Lancaster



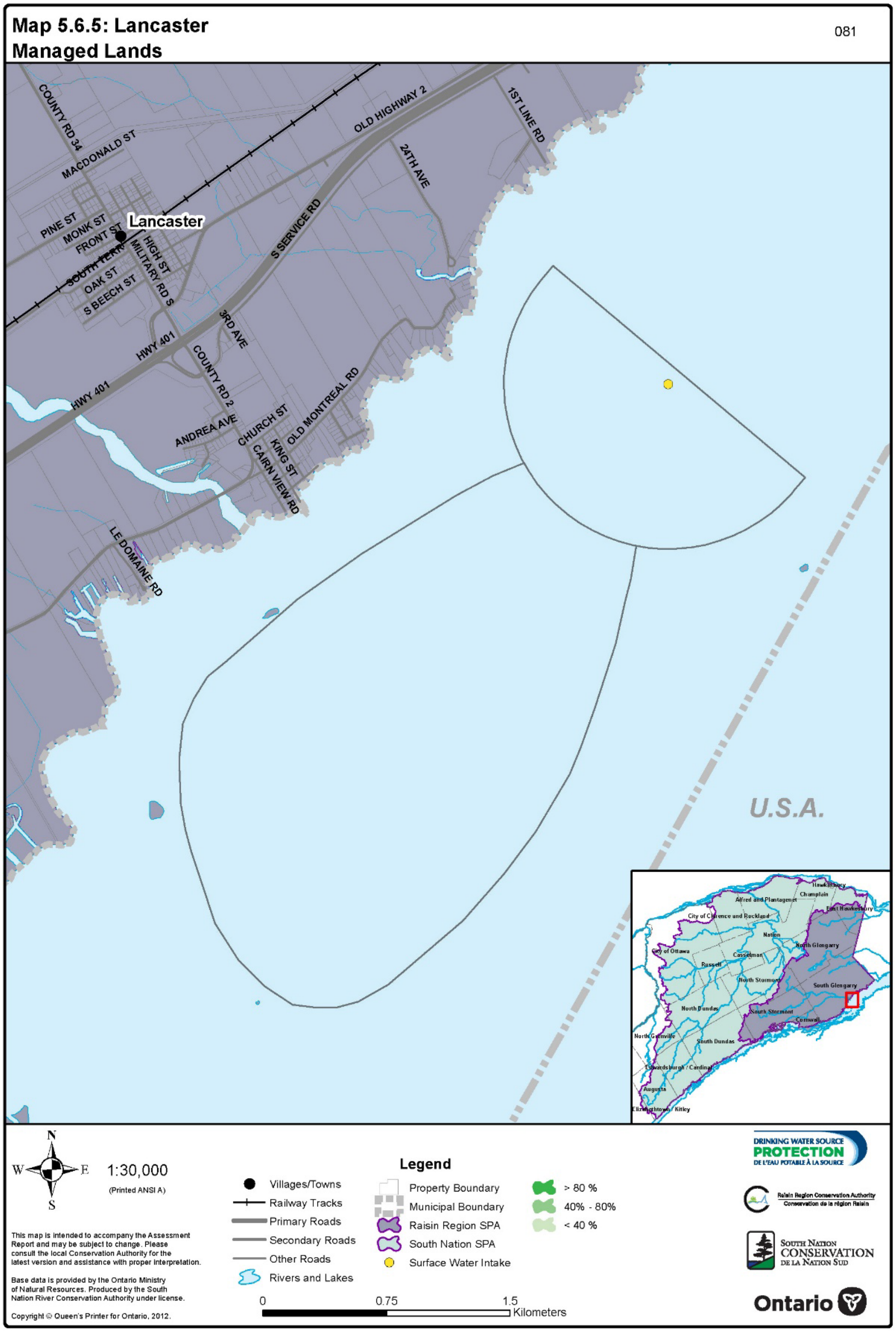
Map 5.6.3: Vulnerability Scoring, Lancaster



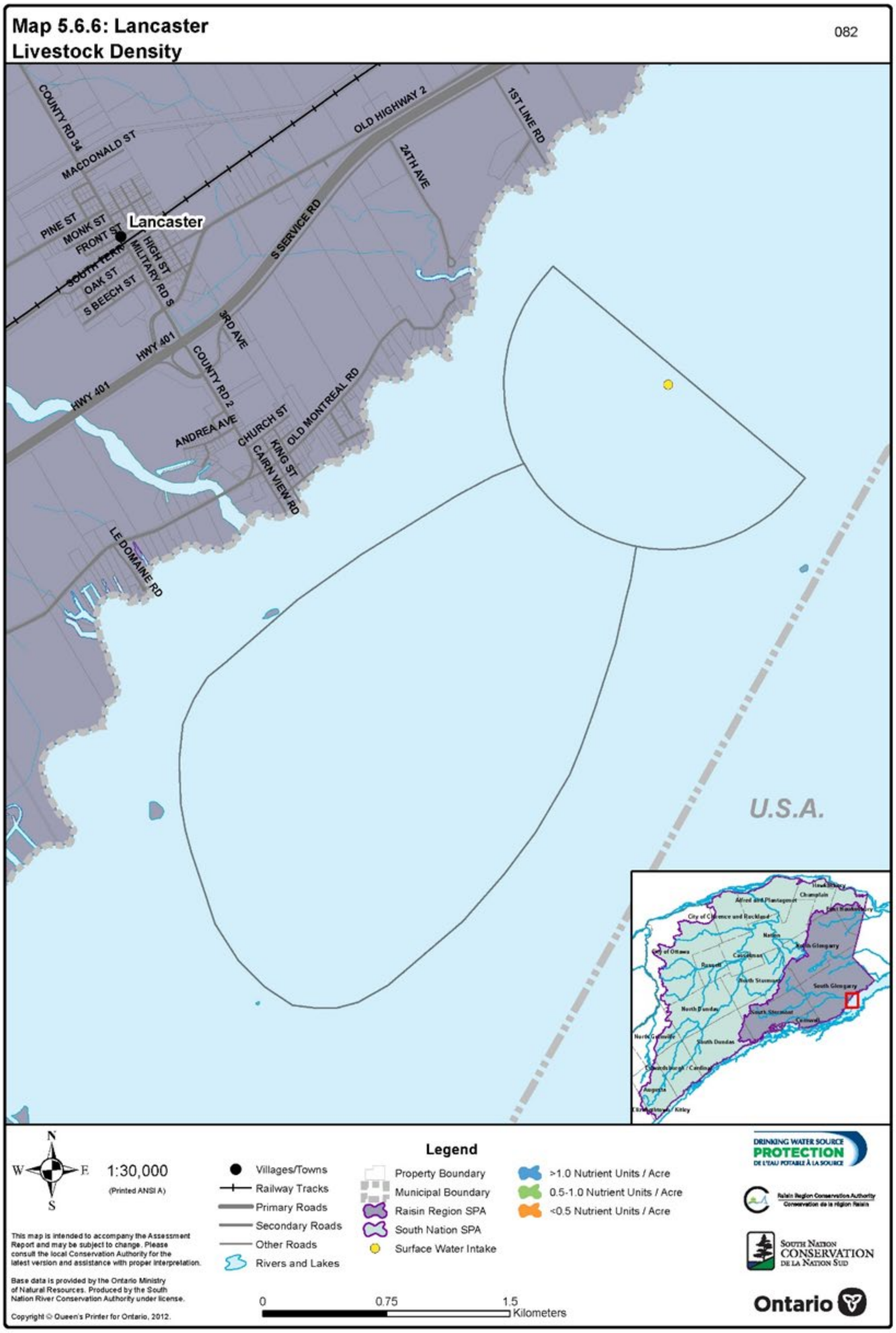
Map 5.6.4: Potential Threat Areas, Lancaster



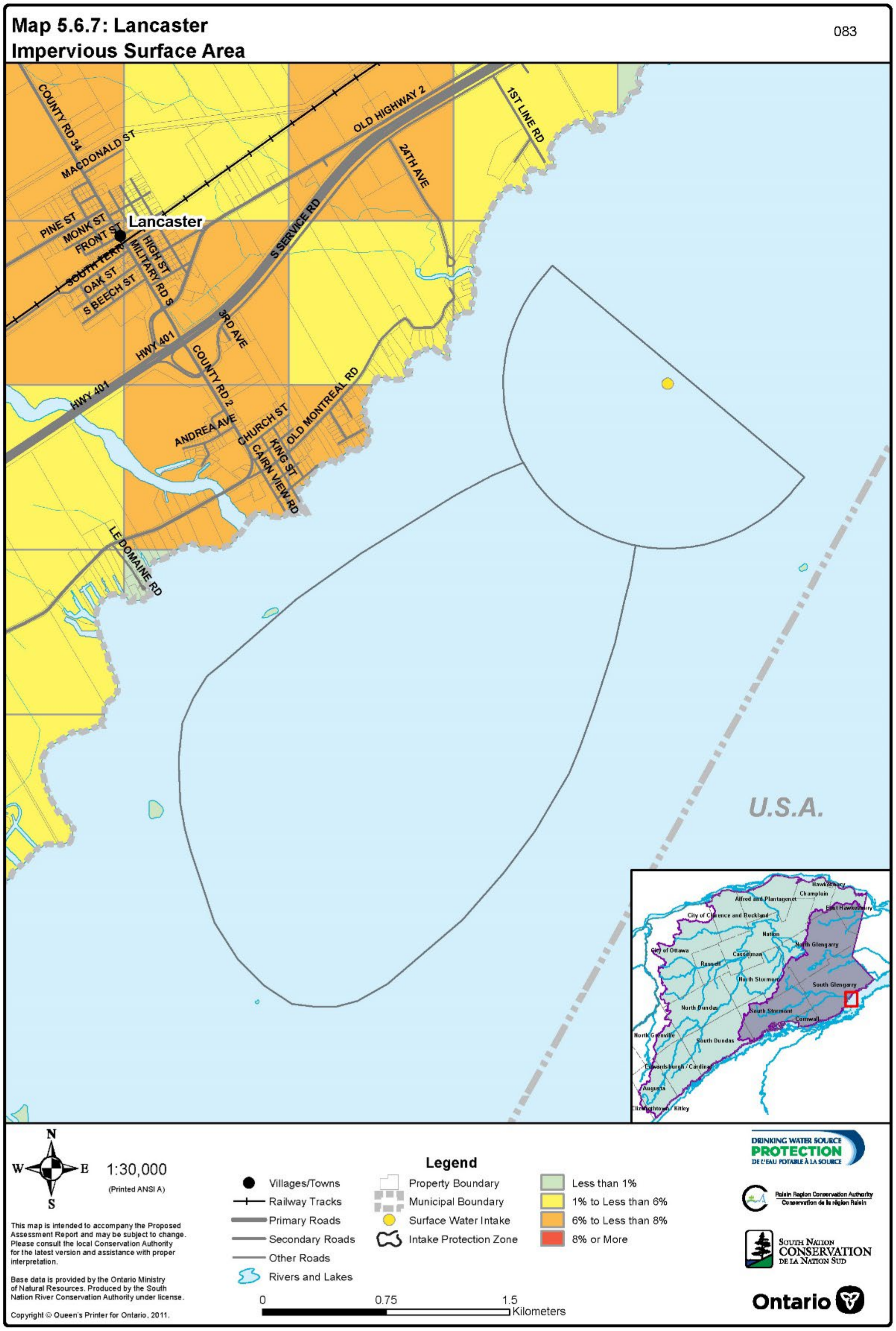
Map 5.6.5: Managed Lands, Lancaster



Map 5.6.6: Livestock Density, Lancaster



Map 5.6.7: Impervious Surface Area, Lancaster



5.7 Alexandria

The Town of Alexandria municipal water intake is located within Mill Pond, which is fed by the Garry River system. Mill pond is the last of three regulated in-land lakes linked by the Garry River. Water levels in Loch Garry, Middle Lake and Mill Pond are controlled by individual dams which are operated by the Raisin Region Conservation Authority. The drinking water system is owned and operated by the Township of North Glengarry. The intake is approximately 32 m from the shore at a maximum depth of 2.4 m. The treatment plant serves a population of approximately 3,600.

The site location is shown on *Map 5.7.1*. Drinking water system information is presented in *Table 5.69.*

Table 5.69: Drinking Water System Information, Alexandria

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	220001030
Drinking Water System Name	Alexandria Water Treatment Plant
Owner	Township of North Glengarry
Operating Authority	Township of North Glengarry
Source Water Type	Surface Water
Source Water	Mill Pond / Garry River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	D
Coordinates of Intake	528350 Easting, 5016890 Northing (NAD 83, Zone-18)
Area served by System	Alexandria, Maxville
Number of Users (approx. residents)	3,600 (plus up to 850 additional users in 2020 and beyond when Maxville comes online).
Average Daily Taking	2,139 m^3/day
Maximum Daily Taking	3,399 m^3/day
Permit to Take Water	0512-8VVPRD
Maximum Permitted Taking	5,616 m^3/day

5.7.1 Intake Classification

The intake is located in Mill Pond, close to the mouth of the Garry River where flow rates are relatively low. The flow conditions at the intake are affected by a downstream water impoundment structure (Mill Pond Dam). For this reason, the intake is classified as type D.

5.7.2 Vulnerable Area Delineation

The vulnerable area for this system comprises three intake protection zones (IPZ): IPZ-1, IPZ-2 and IPZ-3 which have been delineated in accordance with the Technical Rules: Assessment Report (*the Rules*).

The vulnerable areas for this drinking water system are shown on *Map 5.7.2* and *Map 5.7.3*. The respective area calculations are summarized in *Table 5.70*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1, Intake Protection Zone 2* and *Intake Protection Zone 3* below.

Table 5.70: Total Area by Vulnerable Area, Alexandria

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	62.0	3%
IPZ-2	38.0	2%
IPZ-3a	233.7	12%
IPZ-3b	635.5	32%
IPZ-3c	998.2	51%
Total	**1,967.4**	**100%**

5.7.2.1 Intake Protection Zone 1

An area known as IPZ-1 was delineated according to *the Rules*. It is composed of the following areas:

- A circle that has a radius of 1,000 metres from the center point of intake;
- a setback of not more than 120 m inland along the abutted land measured from the high-water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the river.

The IPZ-1 was modified to reflect local hydrodynamic conditions. The rationale for modifying the shape is the presence of the dam which prevents reverse flow into the pond.

IPZ-1 has been modified to the east side of the Mill Pond, as the overland flow is intercepted by a stormsewershed which discharges into the Delisle River, below the Mill Pond dam.

5.7.2.2 Intake Protection Zone 2

Operator response time to adverse conditions in the quality of the surface water is less than two hours; therefore, the minimum travel time of two hours was used for delineation in accordance with *the Rules*.

The IPZ-2 is composed of the following areas:

- the area within each surface water body that may contribute water to the intake within 2 hours (hydraulic model, OTTHYMO and HEC-RAS plus wind vector calculations);
- the area within the stormsewershed of each storm sewer that discharges into the surface water body where the time of travel to the intake is less than 2 hours;
- a setback of not more than 120 m inland along the abutted land measured from the high-water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the river;
- the area that contributes water to IPZ-2 through transport pathways (i.e., tile drainage, stormwater drainage system, etc.).

The 2-hour travel area has been divided into two components: the instream portion representing Garry River, and the up-tributary portions representing small watercourse and drainage features that discharge into Mill Pond. Instream delineation was achieved through hydrologic modelling (OTTHYMO) and hydraulic modelling (HEC-RAS). Up-tributary delineation analyses showed that 2-year flow conditions were very low, and the 2-hour travel distance did not extend beyond the limits of IPZ-1.

There are storm sewers which discharged into Mill Pond. MOE storm sewer design guidelines specify a minimum velocity of 0.7m/s to prevent sedimentation. Using this conservative velocity, a 2-hour travel time would result in a travel distance of just over 5km. The largest reach within the town was found to be approximately 870m. The entire contributing storm sewer network was therefore considered to drain to Mill Pond and was incorporated with IPZ-2. There were no agricultural tile drains within the IPZ-2 limits.

A 120m setback was applied to abutted land where overland flow drained into the river. The high-water mark was assumed to be the edge of shore as delineated by the Conservation Authority.

5.7.2.3 Intake Protection Zone 3

An area known as IPZ-3 was delineated according to *the Rules*. It is composed of the following areas:

- the area within each surface water body that may contribute water to the intake;
- a setback of not more than 120 m inland along the abutted land measured from the high-water mark of the surface water body. The 120 m setback encompasses the area where overland flow drains into the river;
- the area that contributes water to IPZ-3 through transport pathways (i.e., tile drainage, stormwater drainage system, etc.)

The IPZ-3 area includes Garry River, contributing tributaries and mapped drainage features, online and contiguous lakes and wetland features upstream of the intake (including Middle Lake, Loch Garry and Lost Lake/Little Lake), and a 120 m inland setback. The 120m setback was applied to abutted land where overland flow drained into the river. There were no tile drainage features within the limits of IPZ-3.

The IPZ-3 area was divided into IPZ-3a, IPZ-3b, IPZ-3c due to the different potential impacts of these zones on water quality at the intake. IPZ-3a includes lands abutting the portion of Garry River that is downstream of Kenyon Dam, as well as land abutting the western tributary. IPZ-3b includes lands along the river between Loch Garry Dam and Kenyon Dam (including Middle Lake). IPZ-3c includes lands along the river upstream of Loch Garry Dam (including Loch Garry).

5.7.3 Vulnerability Scoring

A vulnerability score was assigned to each vulnerable area in accordance with *the Rules*. The score is the product of the area vulnerability factor and the source vulnerability factor.

5.7.3.1 Area Vulnerability Factor

The Rules dictate the permissible range of scores for the area vulnerability factor based on the classification of intake. For this type of intake, the score for IPZ-1 is fixed at 10. For IPZ-2, the permissible values are 7, 8 or 9.

The scoring for IPZ-2 is determined based on the following criteria:

- The percentage of the area that is composed of land;
- The land cover, soil type, permeability and slope;
- Hydrological and hydrogeological conditions that contribute water to the area through transport pathways; and,

The area vulnerability factor for IPZ-2 was set at 8 after considering:

- The ratio of land to water is high (99% land vs. 1% water);
- Despite a high percentage of land area in the zone, the total area is relatively small (38 hectares);
- Land cover is predominantly urban; however, there is a low number of impervious surfaces, and the soils are moderately permeable;
- The slope is moderate;
- There are storm sewers in the area; however, most discharge downstream of the intake and as there is little flow in the Mill Pond, contaminants would have an opportunity to settle or dilute.

The Rules allow for one or more vulnerability factors to be assigned to discreet areas within an IPZ-3. The zone was divided into three sub-zones: IPZ-3a, IPZ-3b and IPZ-3c based on the presence of dams.

The area vulnerability factor for IPZ-3a was set at 7 after considering:

- Proximity to the intake;
- The ratio of land to water is high;
- There is moderate runoff potential.

The area vulnerability factor for IPZ-3b was set at 3 after considering:

- The Kenyon dam divides the area beyond the IPZ-3a boundary and provides flow attenuation and dilution potential due to storage behind the dam;
- The proximity to the intake is far, resulting in longer travel times to the intake.

The area vulnerability factor for IPZ-3c was set at 1 after considering:

- The Loch Garry dam divides the area beyond the IPZ-3-b boundary and provides flow attenuation and dilution potential due to storage behind the dam;
- The proximity to the intake is very far, resulting in longer travel times to the intake;
- The ratio of land to water is very low.

5.7.3.2 Source Vulnerability Factor

A source vulnerability factor was assigned to the surface water intake as prescribed in *the Rules*. For this intake, the source vulnerability factor can be 0.8, 0.9 or 1 based on the following criteria:

- Depth of the intake from the top of the water surface;
- Distance of the intake from land;
- History of water quality concerns at the surface water intake.

The source vulnerability factor was taken as 1.0 after considering:

- The intake is relatively shallow (maximum of 2.4 m below river level);
- The intake is located close to land (an offshore distance of approximately 32 m);
- There is a history of water quality concerns (high turbidity, elevated bacteria count);
- Low dilution potential in Mill pond, particularly in the winter and summer months when flushing rate is low.

5.7.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.71* and shown on *Map 5.7.4*.

Table 5.71: Vulnerability Scores, Alexandria

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	1.0	10
IPZ-2	8	1.0	8
IPZ-3a	7	1.0	7
IPZ-3b	3	1.0	3
IPZ-3c	1	1.0	1

5.7.4 Water Quality Threats Assessment

Drinking water threats are activities or conditions that adversely affect or have 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 regulations as a drinking water threat.

5.7.4.1 Activities and Conditions

The activities which are the prescribed drinking water threats for this type of municipal drinking water source are listed in *Section 4.2.1*. These are the activities prescribed to be drinking water threats as per O. Reg. 287/07 (General).

No local threats or activities have been added to the provincial list by the Source Protection Committee for this drinking water system.

5.7.4.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats circumstances by the Source Protection Committee for this drinking water system.

The Tables of drinking water threats circumstances and this drinking water system's vulnerability maps can be used to assess if a prescribed activity is a significant, moderate or low drinking water threat. *Table 5.72* and *Table 5.73* can be used to determine which areas are vulnerable to chemical and pathogen threats. These are also referenced visually on *Map 5.7.5.*

Table 5.72: Risk of Chemical Threats, Alexandria

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	10	Yes	Yes	Yes
IPZ-2	8	Yes	Yes	Yes
IPZ-3a	7	Below threshold	Yes	Yes
IPZ-3b	3	Below threshold	Below threshold	Below threshold
IPZ-3c	1	Below threshold	Below threshold	Below threshold

Table 5.73: Risk of Pathogen Threats, Alexandria

Vulnerable Area	Vulnerability Score	Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	10	Yes	Yes	Yes
IPZ-2	8	Yes	Yes	Yes
IPZ-3a	7	Below threshold	Below threshold	Below threshold
IPZ-3b	3	Below threshold	Below threshold	Below threshold
IPZ-3c	1	Below threshold	Below threshold	Below threshold

5.7.4.3 Managed Lands

The percentage of managed lands in the vulnerable area for the purpose of assessing nutrient application, where such an activity could pose a low, significant or moderate threat is shown in *Map 5.7.6* and is tabulated in *Table 5.74*. The area vulnerability scores for IPZ-3B and IPZ-3C are less than the vulnerability score necessary for the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land to be considered a low threat; therefore, those areas are not considered for this evaluation.

Table 5.74: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Alexandria

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	62.0	3	22	25	40%
IPZ-2	38.0	0	32	32	84%
IPZ-3a	233.7	89	126	215	92%

5.7.4.4 Livestock Density

Livestock density of agricultural managed lands within each vulnerable area, where such an activity could pose a low risk at minimum was computed and is shown in *Map 5.7.7* and is tabulated in *Table 5.75*. The area vulnerability scores for IPZ-3B and IPZ-3C are less than the vulnerability score necessary for the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land to be considered a low threat; therefore, those areas are not considered for this evaluation.

Table 5.75: Livestock Density Assessment, Alexandria

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.12
IPZ-2	0
IPZ-3a	0.12

5.7.4.5 Impervious Surface Area

The impervious area within each IPZ where the application of road salt could pose a low risk at minimum is shown on *Map 5.7.8* and tabulated in *Table 5.76.*The area vulnerability scores for IPZ-3B and IPZ-3C are less than the vulnerability score necessary for the application of road salt to be considered a significant, moderate or low threat and those areas are therefore not considered for this evaluation.

Table 5.76: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Alexandria

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km² grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
IPZ-1	0	19.7	155.7	0
IPZ-2	0	0	38.0	0
IPZ-3a	29.5	175.4	28.8	0

5.7.4.6 Issues Evaluation

There is evidence that a parameter (ESCHERICHIA COLI MF) is present at a concentration or trending towards a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water. The parameter is potentially anthropogenic as it can be linked to sewage and agricultural activities. The delineation of an issues contributing area may be considered in an updated *Assessment Report* (see *Section 6)*.

5.7.4.7 Conditions from Past Activities

Various data sets acquired through Ecolog ERIS were reviewed in order to identify potential conditions based on historical activities. There was insufficient information in these publicly available sources to confirm the presence of a condition meeting the definition as per *the Rules*. Therefore, no condition-related drinking water threats have been identified.

5.7.4.8 Enumeration of Significant Drinking Water Threats

Activities that are associated with drinking water threats have been enumerated within the vulnerable area for this drinking water system. Estimates of threats were made during the preparation of the initial version of the Assessment Report. Since then, Risk Management Inspectors and Risk Management Officials have been able to meet with the landowners, residents, and businesses within the vulnerable areas and verify more accurately the actual threat counts, as well as negotiate Risk Management Plans to mitigate the risk to the drinking water source.

As of the Risk Management Official's 2020 report, there are 12 activities that are or would be drinking water quality threats to this system, and they have been enumerated at 12 unique locations (one location could possibly account for multiple threat activities). Specific activities and location counts are listed in *Table 5.77*.

Table 5.77: Significant Drinking Water Threat Activities, Alexandria

Activity	Sub Threat, if Applicable	Count
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	Onsite sewage works	11
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	Sanitary sewers	1
Handling and storage of a dense non-aqueous phase liquid.		0
*The application of road salt. **		*11*
Total – All Activities		**23**

*This table has not been revised to reflect updated threat counts, threat counts remain unchanged and are those enumerated in 2020, instead it has been updated to account for the new threats and threat subcategories per the Technical Rules updates in 2021.

5.7.5 Methods of Analysis

The assessment of this drinking water system followed the same general protocols and standards established for municipal drinking water systems throughout the Source Protection Authority and Source Protection Region, as outlined in *Section 4*. Detailed analysis methodologies are outlined in the technical reports which were used as information sources, below.

5.7.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.78*. The information sources quoted below may contain additional expanded references.

Table 5.78: Key Information Sources, Alexandria

Section	Source(s)	Type	Analysis Method(s)
System Information	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Literature Review
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the Raisin Region Conservation Authority Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment, Conservation and Parks. 2020. *Alexandria Drinking Water System Inspection Report 2019-20*.	Report	Site Audit
	Raisin Region Conservation Authority. 2020. *Drinking Water Systems in the Raisin-South Nation Source Protection Region. Updated information for the Assessment Reports.*	Report	Literature Review, Interviews with Drinking Water Operators.
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the Garry River, Township of North Glengarry, Alexandria Intake, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the Garry River, Township of North Glengarry, Alexandria Intake, Assessment Report Input.*	Technical Study	Engineering Assessment
Managed Lands	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	Intera Engineering Limited. 2010. *Raisin-South Nation Source Protection Region, Managed Lands, Livestock Density and Impervious Surface Mapping*.	Technical Study	Engineering Assessment, Spatial Analyses

Section	Source(s)	Type	Analysis Method(s)
Issues Evaluation	Raisin Region Conservation Authority and South Nation Conservation. 2008. *Raisin-South Nation Source Protection, Watershed Characterization*.	Report	Data Analyses, Interviews with Operators, Interviews with Drinking Water Inspectors
	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems on the Garry River, Township of North Glengarry, Alexandria Intake, Assessment Report Input.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Issues Evaluation, Threats Inventory and Water Quality Risk Assessment for Surface Water Systems on the Garry River, Township of North Glengarry, Alexandria Intake, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment
	Raisin Region Conservation Authority. 2020. *Drinking Water Threat Counts, Updated information for the Assessment Reports.*	Report	Field Verification

5.7.5.2 Uncertainty Analysis

Uncertainty analyses have been conducted as part of the technical studies assessing vulnerability and threats for this drinking water system. For the purpose of this report, uncertainty is assessed as either being “High” or “Low”.

The degree of uncertainty related for the delineation of IPZ-1 is low as the geometry of the zone is prescribed by *the Rules*. The hydraulic model for IPZ-2 delineation was created for the purpose of analyzing water levels and flow velocities under flood conditions; measured inflows to Mill Pond were not available so the model could not be properly calibrated for a 2-year design flow. The degree of uncertainty is considered high for IPZ-2 delineation. The uncertainty for delineating IPZ-3 is considered low, as the prescribed by *the Rules* were implemented using accurate base mapping data.

The Rules for scoring of IPZ-1 and IPZ-2 are fairly prescriptive, and therefore have low uncertainty; however, more uncertainty is associated with the vulnerability scores for the IPZ-3 subzones given the nature of *the Rules* to set these values and wide range of potential values.

The evaluations of Managed Lands, Livestock Density and Impervious Surfaces were considered to have low uncertainty. In general, there was good mapping and statistical information available to adequately characterize these data sets. The prescribed thresholds which break the enumeration categories within these assessments were large enough to encompass any minor inaccuracies.

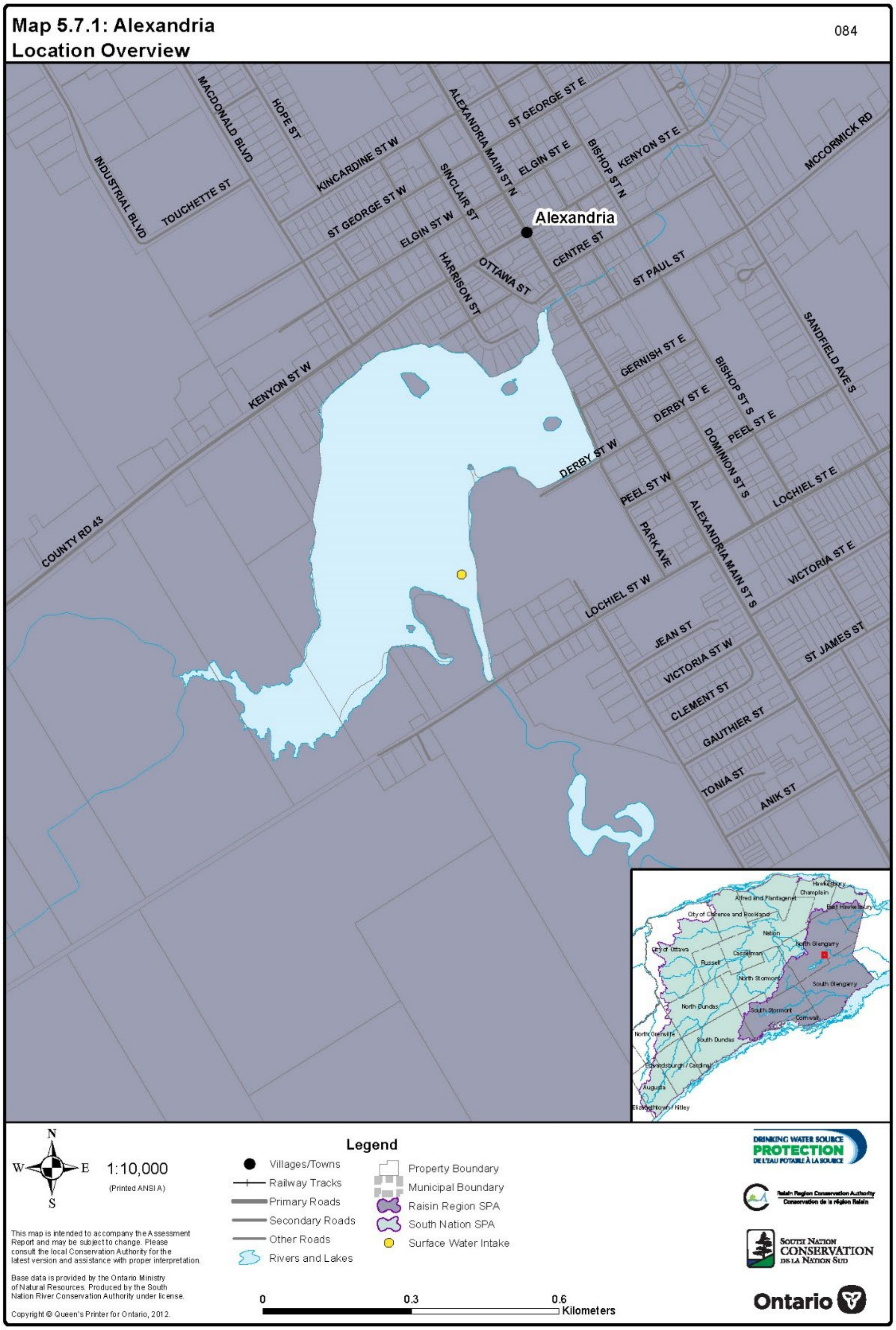
The enumeration of threats has been validated through site visits and/or communications with the landowner by either a Risk Management Official or Risk Management Inspector which included a review of the activity's location and circumstances, and is therefore considered to have low uncertainty.

A summary of uncertainty is listed in *Table 5.79*.

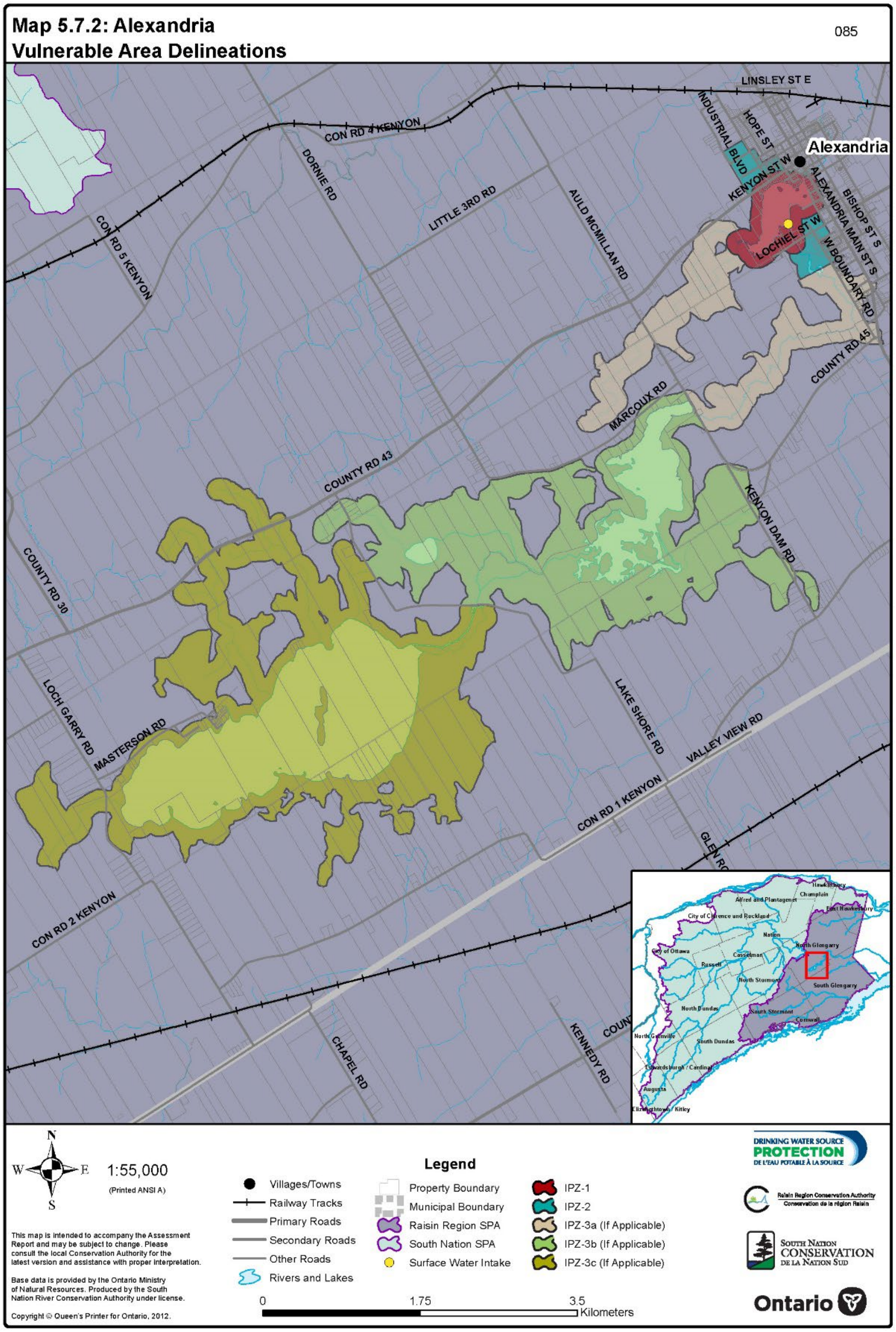
Table 5.79: Summary of Uncertainty Analyses, Alexandria

Component	Uncertainty Assessment
IPZ-1 Delineation	Low
IPZ-2 Delineation	High
IPZ-3 Delineation	Low
IPZ-1 Vulnerability Scoring	Low
IPZ-2 Vulnerability Scoring	Low
IPZ-3 Vulnerability Scoring	High
Issues Evaluation	Low
Managed Lands Evaluation	Low
Livestock Density Evaluation	Low
Impervious Surface Evaluation	Low
Threats Assessment	Low

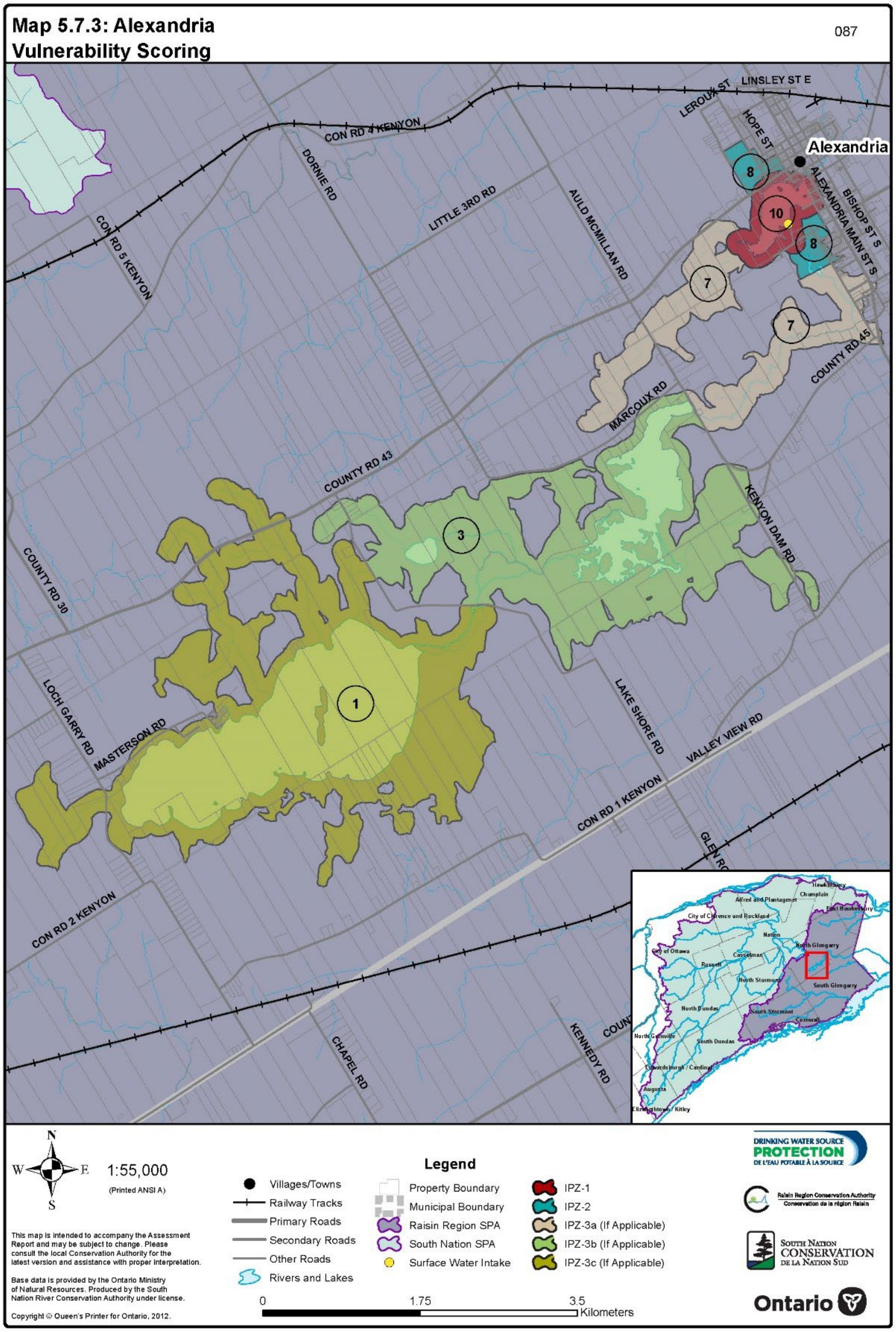
Map 5.7.1: Location Overview, Alexandria



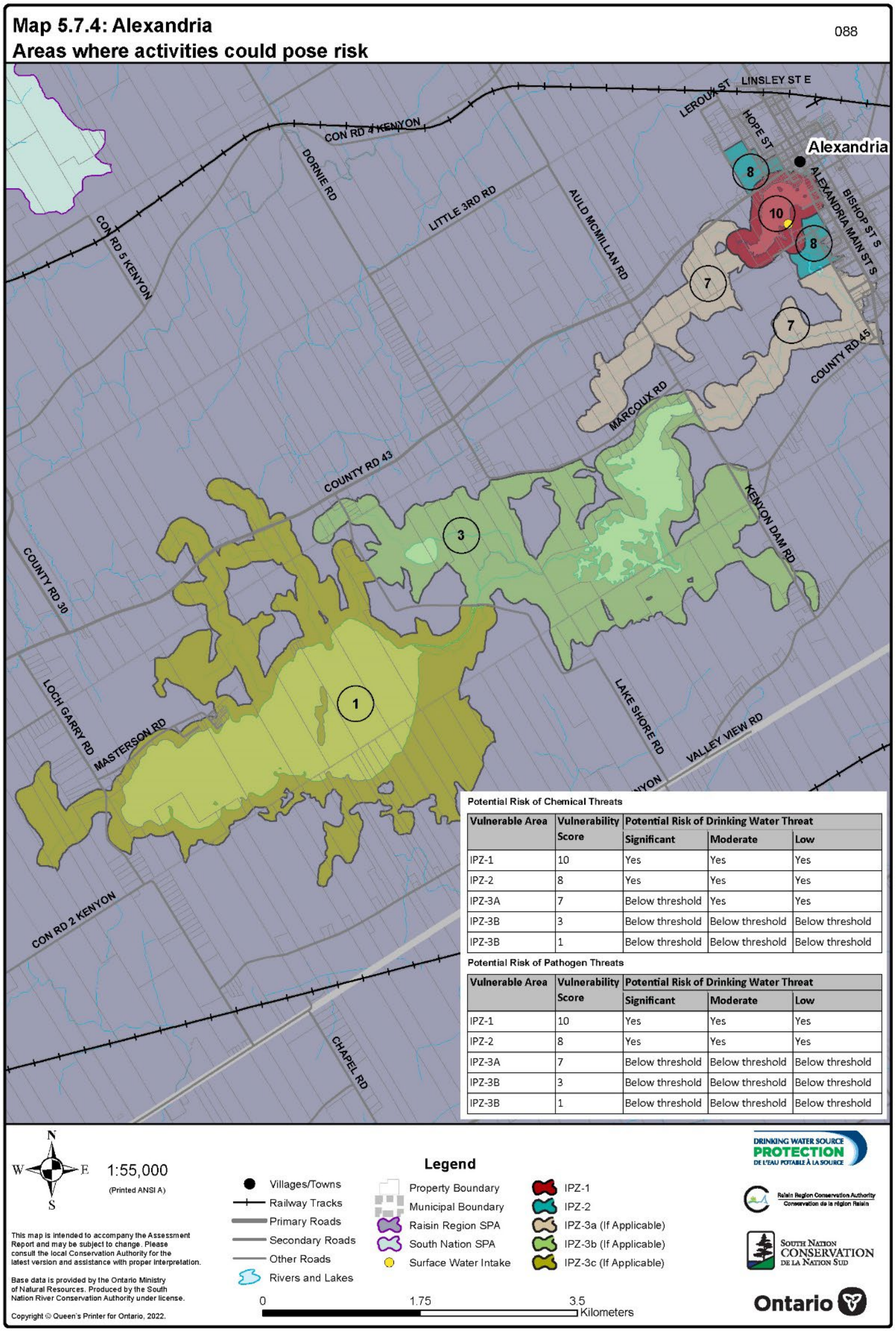
Map 5.7.2: Vulnerable Area Delineations, Alexandria



Map 5.7.3: Vulnerability Scoring, Alexandria



Map 5.7.4: Potential Threat Areas, Alexandria



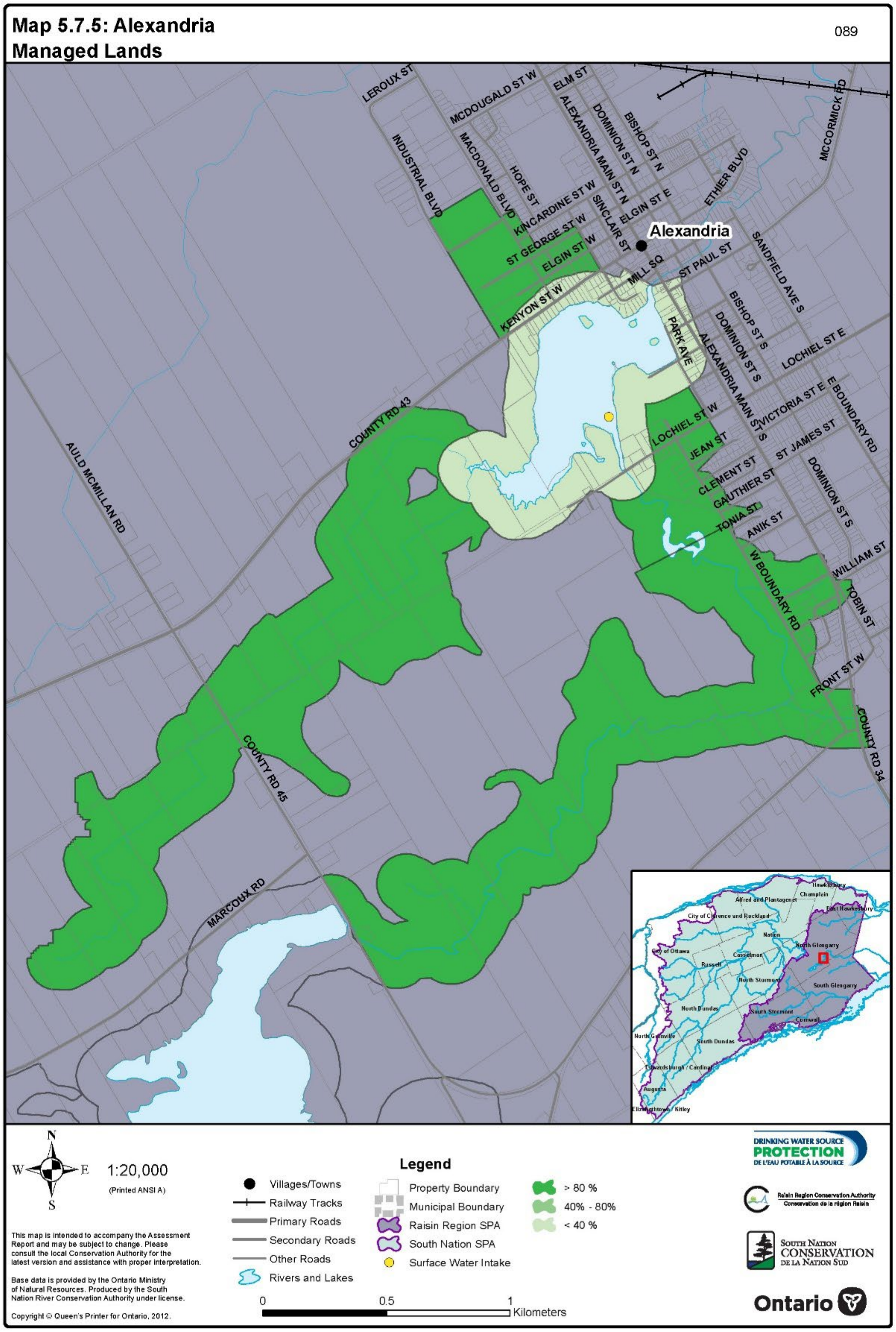
Potential Risk of Chemical Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	10	Yes	Yes	Yes
IPZ-2	8	Yes	Yes	Yes
IPZ-3A	7	Below threshold	Yes	Yes
IPZ-3B	3	Below threshold	Below threshold	Below threshold
IPZ-3B	1	Below threshold	Below threshold	Below threshold

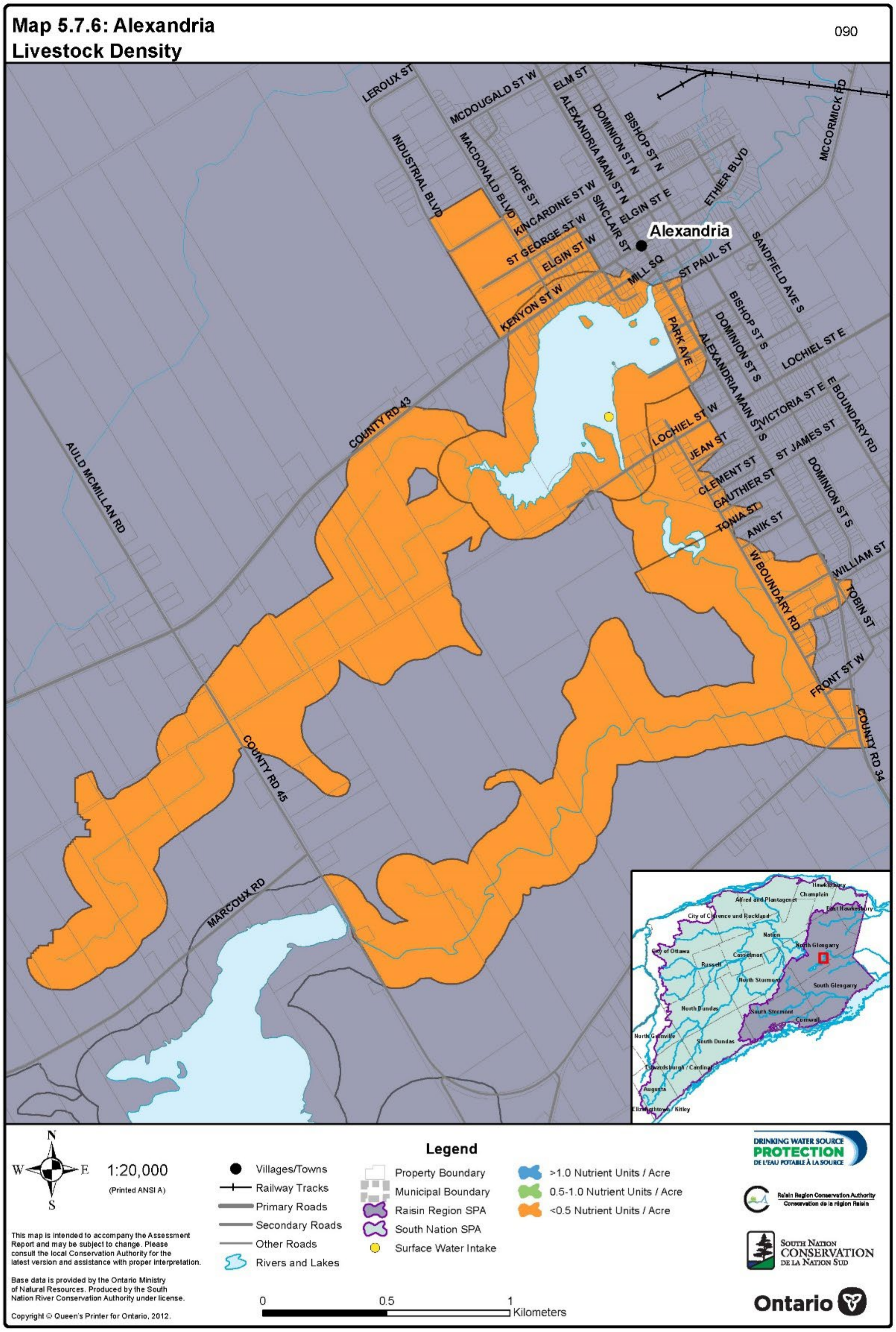
Potential Risk of Pathogen Threats

Vulnerable Area	Vulnerability Score	Potential Risk of Drinking Water Threat		
		Significant	Moderate	Low
IPZ-1	10	Yes	Yes	Yes
IPZ-2	8	Yes	Yes	Yes
IPZ-3A	7	Below threshold	Below threshold	Below threshold
IPZ-3B	3	Below threshold	Below threshold	Below threshold
IPZ-3B	1	Below threshold	Below threshold	Below threshold

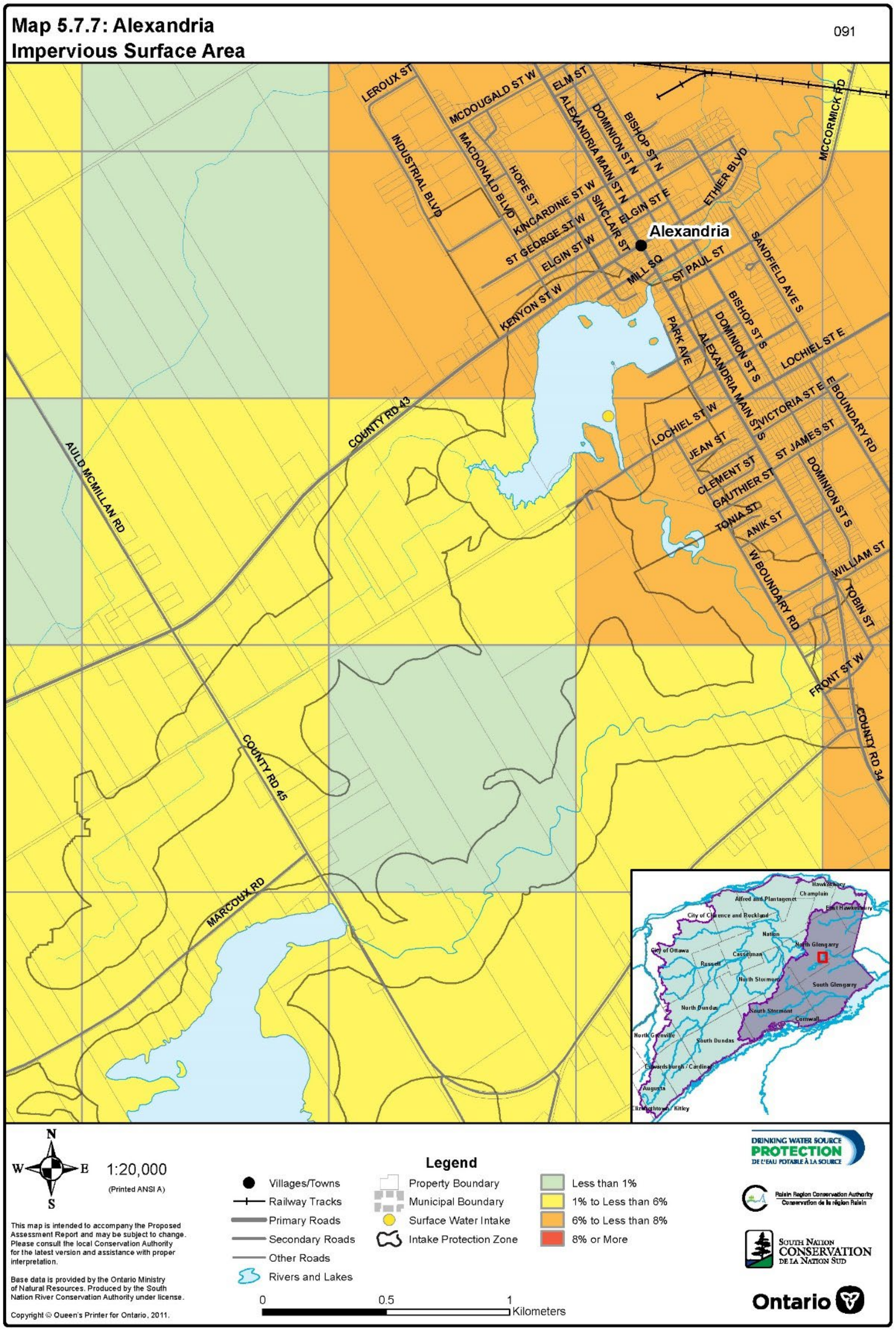
Map 5.7.5: Managed Lands, Alexandria



Map 5.7.6: Livestock Density, Alexandria



Map 5.7.7: Impervious Surface Area, Alexandria



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