Assessment Report

South Nation Source Protection Area

Draft ~~Version 1.1.0~~Version 1.1.3

~~September 1, 2016~~February 1, 2026

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Version Control

Version	Date	Editor	Note
Version 1.1.3	February 1, 2026	JS	Minor updates resulting from Early Engagement Comments from MECP related to WHPA change to support the municipal s.34 for Winchester
Version 1.1.2	Ocotber 1, 2025	JS	Mapping and Table updates resulting from WHPA change to support the municipal s.34
Version 1.1.0	September 1, 2016	PMB	Several typographic corrections were made. Removal of (decommissioned) Embrun-Marionville Wellhead, corrections to Chesterville WHPA and Winchester WHPA.
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 22, 2011	PMB	Updated IPZ Mapping, as per Director's review; Revised pumping rates for Limoges DWS; Corrected typographical errors; Added supporting text where appropriate; Updated style/template for map series for drinking water system maps.
		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.
Version 0.0.5	September 8, 2010	PMB	Updated References, missing tables, grammar edits. Presented to SPC for endorsement, September 8.

Version 0.0.4	August 26, 2010	PMB	Completed Map booklet; Added "Next Steps"; Updated individual system information, added Tier 2 water budget, updated Reg. 170 system info; Presented to Source Protection Committee, August 26.
Version 0.0.3	August 19, 2010	PMB/ KC	Incorporates Source Protection Committee edits; Surface Water Quality data updated; updated drinking water system information. Presented to South Nation Source Protection Authority, August 19.
Version 0.0.2	July 20, 2010	PMB	Updated Layout, added South Nation content. Presented to Source Protection Committee, July 22
Version 0.0.1	June 17, 2010	PMB	Raisin Region Source Protection Area report template. Presented to Raisin Region Source Protection Authority, June 17. Presented to Source Protection Committee, June 24

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Executive Summary

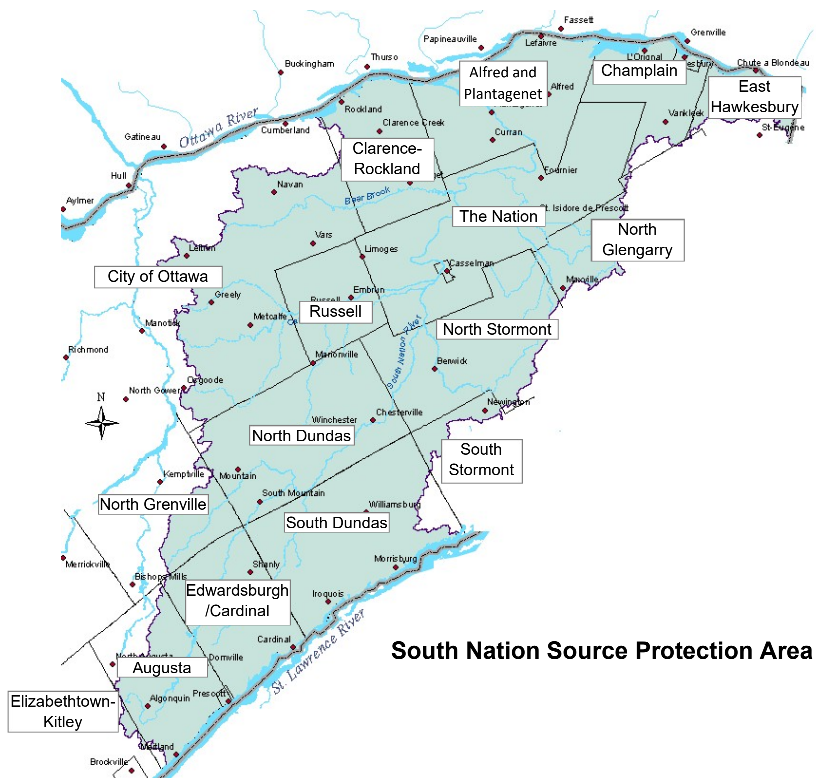
The **Clean Water Act** helps protect drinking water at the source, as part of an overall commitment from the Province of Ontario to safeguard human health and the environment. A key focus of this legislation is the preparation of **locally developed, science-based assessment reports and source protection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

The South Nation Source Protection Area accounts for nearly 4,900 km² and comprises the jurisdiction of the South Nation Conservation, plus the Town of Prescott, and additional watershed-based area to the North-East. The total population of the area is approximately 120,000 and includes all of or portions of the following municipalities:

- City of Ottawa
- Town of Prescott
- Township of Augusta
- Township of Edwardsburgh/Cardinal
- Municipality of North Grenville
- City of Clarence-Rockland
- The Nation Municipality
- Town of Hawkesbury
- Township of Alfred and Plantagenet
- Township of Champlain
- Township of East Hawkesbury
- Township of Russell
- Village of Casselman
- Township of North Dundas
- Township of North Glengarry
- Township of North Stormont
- Township of South Dundas
- Township of South Stormont



Eighteen (18) municipal drinking water sources were studied for water quantity and quality threats assessment:

- Vars (City of Ottawa), 2 groundwater wells
- Limoges (The Nation Municipality), 2 groundwater wells
- Shadow Ridge, Greely (City of Ottawa), 1 groundwater well
- Crysler (Township of North Stormont), 2 groundwater wells

- Moose Creek (Township of North Stormont), 3 groundwater wells
- Finch (Township of North Stormont), 2 groundwater wells
- Winchester (Township of North Dundas), 6 groundwater wells
- Chesterville (Township of North Dundas), 2 groundwater wells
- Newington (Township of South Stormont), 2 groundwater wells
- Bennett Street, Spencerville (Township of Edwardsburgh/Cardinal), 1 groundwater well
- Prescott (Town of Prescott), 1 surface water intake
- Cardinal (Township of Edwardsburgh/Cardinal), 1 surface water intake
- Morrisburg (Township of South Dundas), 1 surface water intake
- Rockland (City of Clarence-Rockland), 1 surface water intake
- Wendover (Township of Alfred-Plantagenet), 1 surface water intake
- Lefaivre (Township of Alfred-Plantagenet), 1 surface water intake
- Hawkesbury (Town of Hawkesbury), 1 surface water intake
- Casselman (Village of Casselman), 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.

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

The scientific studies revealed that no water **quantity** threats exist in the area. Some activities that are or would be significant drinking water **quality** threats were identified.

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
Vars	Groundwater	6	4
Limoges	Groundwater	1	1
Shadow Ridge (Greely)	Groundwater	287	145
Crysler	Groundwater	44	9
Moose Creek	Groundwater	30	18
Finch	Groundwater	67	34
Winchester	Groundwater	181	64
Chesterville	Groundwater	30	11
Newington	Groundwater	65	56
Bennett Street (Spencerville)	Groundwater	5	3
Prescott	Surface Water (St. Lawrence River)	0	0
Cardinal	Surface Water (St. Lawrence River)	0	0
Morrisburg	Surface Water (St. Lawrence River)	0	0
Rockland	Surface Water (Ottawa River)	0	0
Wendover	Surface Water (Ottawa River)	82	39
Lefaivre	Surface Water (Ottawa River)	0	0
Hawkesbury	Surface Water (Ottawa River)	23	12
Casselman	Surface Water (South Nation River)	384	128
Totals for 18 Drinking Water Systems		**1,205**	**524**

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 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 Nation Sud s'étend sur environ 4 900 km² et comprend le territoire de compétence de la Conservation de la Nation Sud, la Ville de Prescott, et une autre région du bassin hydrographique située au nord-est. Cette région a une population approximative de 120 000 et elle est composée des municipalités suivantes, en entier ou en partie:

- Ville d'Ottawa
- Village de Prescott
- Canton d'Augusta
- Canton d'Edwardsburgh/Cardinal
- Municipalité de Grenville Nord
- Cité de Clarence-Rockland
- Municipalité de la Nation
- Ville d'Hawkesbury
- Canton d'Alfred et Plantagenet
- Canton de Champlain
- Canton d'Hawkesbury Est
- Canton de Russell
- Village de Casselman
- Canton de Dundas Nord
- Canton de Glengarry Nord
- Canton de Stormont Nord
- Canton de Dundas Sud
- Canton de Stormont Sud

La zone de protection des sources de la Nation Sud

Dans la zone de protection des sources de la Nation Sud, dix-huit (18) sources d'eau potable municipales ont été étudiées dans le but d'évaluer les menaces visant la qualité et la quantité de l'eau. Incluses sont les sources suivantes:

- Vars (Ville d'Ottawa), 2 puits d'eaux souterraines
- Limoges (Municipalité de la Nation), 2 puits d'eaux souterraines
- Shadow Ridge, Greely (Ville d'Ottawa), 1 puits d'eaux souterraines
- Crysler (Canton de Stormont Nord), 2 puits d'eaux souterraines
- Moose Creek (Canton de Stormont Nord), 3 puits d'eaux souterraines
- Finch (Canton de Stormont Nord), 2 puits d'eaux souterraines
- Winchester (Canton de Dundas Nord), 6 puits d'eaux souterraines
- Chesterville (Canton Dundas Nord), 2 puits d'eaux souterraines
- Newington (Canton de Stormont Sud), 2 puits d'eaux souterraines
- Rue Bennett, Spencerville (Canton d'Edwardsburgh/Cardinal), 1 puits d'eaux souterraines
- Prescott (Village de Prescott), 1 prise d'eaux de surface
- Cardinal (Canton d'Edwardsburgh/Cardinal), 1 prise d'eaux de surface
- Morrisburg (Canton de Dundas Sud), 1 prise d'eaux de surface
- Rockland (Cité de Clarence-Rockland), 1 prise d'eaux de surface
- Wendover (Canton d'Alfred-Plantagenet), 1 prise d'eaux de surface
- Lefaivre (Canton d'Alfred-Plantagenet), 1 prise d'eaux de surface
- Hawkesbury (Ville d'Hawkesbury), 1 prise d'eaux de surface
- Casselman (Village de Casselman), 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

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 n'ont révélé aucune menace à la **quantité** de l'eau dans la région. Cependant, certaines activités qui sont ou qui pourraient devenir des menaces importantes à la **qualité** de l'eau ont été identifiées.

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
Vars	Eaux souterraines	6	4
Limoges	Eaux souterraines	1	1
Shadow Ridge (Greely)	Eaux souterraines	287	145
Crysler	Eaux souterraines	44	9
Moose Creek	Eaux souterraines	30	18
Finch	Eaux souterraines	67	34
Winchester	Eaux souterraines	181	64
Chesterville	Eaux souterraines	30	11
Newington	Eaux souterraines	65	56
Rue Bennett (Spencerville)	Eaux souterraines	5	3
Prescott	Eaux de surface (Fleuve St-Laurent)	0	0
Cardinal	Eaux de surface (Fleuve St-Laurent)	0	0
Morrisburg	Eaux de surface (Fleuve St-Laurent)	0	0
Rockland	Eaux de surface (Rivière Outaouais)	0	0
Wendover	Eaux de surface (Rivière Outaouais)	82	39
Lefaivre	Eaux de surface (Rivière Outaouais)	0	0
Hawkesbury	Eaux de surface (Rivière Outaouais)	23	12
Casselman	Eaux de surface (Rivière Nation Sud)	384	128
Total pour les 18 systèmes d'eau potable		**1,205**	**524**

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.

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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". The content of the Report is further defined in the Terms of Reference submitted to the MOE by the South Nation Source Protection Authority in May 2009. The focus is on the municipal drinking water systems within the South Nation 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 South Nation 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 South Nation Source Protection Area therefore comprises the jurisdiction of the South Nation Conservation (SNC). As Source Protection Areas are watershed based, the boundary is slightly expanded beyond the Conservation Authority's jurisdiction to encompass the Town of Prescott and an additional watershed-based area to the north-east.

The Source Protection Area is shown in *Map 1.1*. The total area of the South Nation Source Protection Area is approximately 4,900 km^2. Area types are tabulated in *Table 1.1*.

Table 1.1: Area types within the South Nation Source Protection Area

Area Type	Comment	Area (km^2)
Watershed	Main land area	4,752.7
Lake/River Jurisdiction	Area extending to International Boundary	56.8
Lake/River Jurisdiction	Area extending to International Boundary	48.9
Shoreline or Island	Miscellaneous Islands	< 0.1
Total Area		**4,858.4**

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 within the South Nation Source Protection Area:

- City of Ottawa
- Town of Prescott
- Township of Augusta
- Township of Edwardsburgh/Cardinal
- Municipality of North Grenville
- City of Clarence-Rockland
- The Nation Municipality
- Town of Hawkesbury
- Township of Alfred and Plantagenet
- Township of Champlain
- Township of East Hawkesbury
- Township of Russell
- Village of Casselman
- Township of North Dundas

- Township of North Glengarry
- Township of North Stormont
- Township of South Dundas
- Township of South Stormont.

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

The South Nation Source Protection Area combined with the Raisin Region 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 South Nation Source Protection Area is represented by the South Nation Source Protection Authority. The South Nation Source Protection Authority is comprised of the Board of Directors of the SNC. The Raisin Region Source Protection Authority has been designated the lead authority for the Raisin-South Nation Source Protection Region.

1.3.1 Neighbouring Source Protection Areas and Regions

The South Nation Source Protection Area is the second eastern-most source protection area in the province. The eastern boundary abuts the Raisin Region Source Protection Area and a small portion of Quebec. The southern boundary abuts the St. Lawrence River. The majority of the western boundary is shared with the Mississippi Valley Source Protection Area of the Mississippi-Rideau Source Protection Region. The southwestern most portion of the area is bordered with the Cataraqui Source Protection Area. The Ottawa River serves as the northern border.

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.

The Province of Ontario has 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 South Nation Source Protection Area drains to the *Lower Ottawa* secondary watershed (WRIP identifier, '02L'), with a portion to the south contributing to the *Upper St. Lawrence* secondary watershed (WRIP identifier, '02M'). Furthermore, the South Nation Source Protection Area includes the majority of the tertiary watershed, *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 South Nation Source Protection Area and the Raisin Region Source Protection Area to the east. This boundary represents for the most part a definitive and characteristic split between the two Source Protection Areas. The majority of the South Nation Source Protection Area drains north towards the Ottawa River. The majority of the Raisin Region Source Protection Area ultimately drains south towards the St. Lawrence River.

As they are based on topography, watershed boundaries do not necessarily align with political boundaries. Several townships in the region belong to more than one watershed. The larger watershed boundaries in the region (i.e. those contributing to the St. Lawrence River or Ottawa River) extend beyond provincial, national and international borders.

2.1.2 Subwatershed Areas

The SNC's jurisdiction encompasses four locally-significant watersheds: Upper South Nation, Castor River, Bear Brook and the Lower South Nation River. Several smaller subwatersheds drain directly to the St. Lawrence River and Ottawa River through shorter local creeks. These subwatersheds are shown on *Map 2.1*, and detailed in *Table 2.1*.

Table 2.1: Subwatershed areas of the South Nation Source Protection Area

Subwatershed	Drainage Area (ha)	Outlet	Intersecting Municipalities
Upper South Nation River	162,167	South Nation River near Casselman	Augusta, Edwardsburgh/Cardinal, South Dundas, North Dundas, South Stormont, Russell, La Nation, Casselman
Castor River	73,930	South Nation River near Casselman	North Dundas, Ottawa, Russell, La Nation, Casselman
Bear Brook	48,872	South Nation River east of Bourget	Ottawa, Clarence-Rockland, La Nation
Lower South Nation River	98,223	Ottawa River	Casselman, La Nation, North Stormont, North Glengarry, Alfred and Plantagenet

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 meters 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 kilometers to tens of kilometers 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 an elevation difference less than 90 meters. 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 was 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 are 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 meters to greater than 50 meters. Significant thickness of overburden occurs within the Prescott and Russell Sand Plains where the thickness is generally greater than 30 meters and along the St. Lawrence River where the thickness of the overburden increases to more than 35 meters.

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 lead 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 South Nation Source Protection Area is 321.4 km^2, representing 6.6% 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 South Nation Source Protection Area is 628.9 km², representing 12.9% 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 South Nation Source Protection Area, vegetated riparian areas span 1,964 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 SNC 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 2.2*.

Table 2.2: Stream Classification in the South Nation Source Protection Area

Stream Classification	Stream Length (km)
A – Permanent Cold/Cool, No Trout or Salmon	159
B – Permanent Warm, Top Predators	124
C – Permanent Warm, Baitfish	288
D – Permanent Cold/Cool, Trout and/or Salmon	3
E – Permanent Warm, Top Predators	150
F – Intermittent Stream	1,885
U/N – Unclassified	573
Outside of DFO Classification	5,374
Total Stream Length	**8,557**

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 SNC 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

Currently, there are no existing comparisons between aquatic habitat communities impacted and not impacted by anthropogenic factors. Such comparisons will be explored in the near future as more data for non-impacted aquatic habitat communities becomes available. SNC has partnered with the Ministry of the Environment to identify and analyze what are termed "reference sites". These aquatic sites are characterized as being minimally impacted by anthropogenic factors and as such represent the best available conditions within the watershed. Once the data has been collected for these reference sites, they can be compared to impacted sites within the watershed to provide information regarding the effect of anthropogenic factors on aquatic habitat communities.

2.2.13 Species and Habitats at Risk

Species and habitats at risk 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
- Natural Heritage Information Centre, Provincial Rank (SRANK)
- Global Consensus Ranking, (GRANK)

Species that were identified as rare or threatened are listed in *Table 2.3*.Classification codes are defined in *Table 2.4*.

Table 2.3: Rare and Threatened Species, South Nation Source Protection Area

Taxon	Scientific Name	Common Name	Classification[1]			
			COSEWIC	MNR	SRANK	GRANK
Reptile	Clemmys guttata	Spotted Turtle	END	END	S3	G5
Reptile	Apalone spinifera	Spiny Softshell Turtle	THR	THR	S3	G5
Reptile	Emydoidea blandingii	Blanding's Turtle	THR	THR	S3	G4
Reptile	Sternotherus odoratus	Eastern Musk Turtle	THR	THR	S3	G5
Reptile	Graptemys geographica	Northern Map Turtle	SC	SC	S3	G5
Reptile	Chelydra serpentina	Snapping Turtle	SC	SC	S4	G5
Reptile	Pantherophis spiloides	Gray Ratsnake	THR	THR	S3	G5T3
Birds	Coturnicops noveboracensis	Yellow Rail	SC	SC	S4B	G4
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
Birds	Ixobrychus exilis	Least Bittern	THR	THR	S4B	G5

Taxon	Scientific Name	Common Name	Classification[1]			
			COSEWIC	MNR	SRANK	GRANK
Birds	Asio flammeus	Short-eared Owl	SC	SC	S2N,S4B	G5
Birds	Dendroica cerulean	Cerulean Warbler	SC	SC	S3B	G4
Birds	Seiurus motacilla	Louisiana Waterthrush	SC	SC	S3B	G5
Fish	Exoglossum maxillingua	Cutlip Minnow	NAR	THR	S1S2	G5
Fish	Moxostoma valenciennesi	Greater Redhorse			S3	G4
Fish	Moxostoma carinatum	River Redhorse	SC	SC	S2	G4
Fish	Notropis anogenus	Pugnose Shiner	END	END	S2	G3
Fish	Ichthyomyzon fossor	Northern Brook Lamprey	SC	SC	S3	G4
Fish	Aciper fulvescens	Lake Sturgeon	THR	THR	S2	G3G4
Mammals	Myotis septentrionalis	Northern Long-eared Bat			S3?	G4
Mammals	Urocyon cinereoargenteus	Grey Fox	THR	THR	SNA	G5
Insects	Callophrys lanoraieensis	Bog Elfin			S1	G3G4
Insects	Arigomphus cornutus	Horned Clubtail			S3	G4
Insects	Aeshna verticalis	Green-striped Darner			S3	G5
Insects	Williamsonia fletcheri	Ebony Boghaunter			S2	G4
Plants	Astomum muehlenbergianum	A Moss			S2	G5
Plants	Rhododendron canadense	Rhodora			S1	G5
Plants	Carex atlantica	Atlantic Sedge			S1	G5
Plants	Carex folliculate	Northern Long Sedge			S3	G4G5
Plants	Juglans cinerea	Butternut	END	END	S3?	G4
Plants	Listera austtralis	Southern Twayblade			S1	G4
Plants	Panax quinquefolius	American Ginseng	END	END	S2	G3G4
Plants	Platanthera leucophaea	Eastern Prairie Fringed-orchid	END	END	S2	G3
Plants	Platanthera grandiflora	Large Purple Fringed Orchid			S1	G5
Plants	Rumex altissimus	Pale Dock			S2?	G5
Plants	Schoenoplectus smithii	Smith's Bulrush			S3	G5?
Plants	Sparganium androcladum	Branching Burreed			SH	G4G5

Taxon	Scientific Name	Common Name	Classification[1]			
			COSEWIC	MNR	SRANK	GRANK
Plants	Thelypteris simulata	Bog Fern			S1	G4G5
Plants	Utricularia geminiscapa	Twin-stemmed Bladderwort			S3?	G4G5
Plants	Zizia aptera	Heart-leaved Alexanders			S1	G5

Table 2.4: 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.

System	Code	Definition
	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).
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

Surface water quality has been assessed at six locations across the South Nation Source Protection Area. The following parameters were chosen 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 sampling station locations are listed in *Table 2.5* and shown on and shown on *Map 2.12*.

Table 2.5: Surface Water Quality Sampling Stations

Station	River	Location	Number of Years of Data				
			TP	Nitrate	Turbidity	E.coli	Chloride
18207016002	South Nation River	Chesterville	41	8	39	8	41
18207010002	South Nation River	Downstream of Casselman	43	14	42	8	43
18207002002	South Nation River	Downstream of Plantagenet	42	10	40	8	42
18207014502	Castor River	Upstream of Russell	28	22	26	8	28
18207014002	Castor River	Downstream of Russell	26	12	26	8	26
18207000502	Scotch River	Downstream of St-Isidore	31	11	31	8	31

Water quality analyses are shown in *Figure 2.1*, *Figure 2.2*, *Figure 2.3*, *Figure 2.4* and *Figure 2.5*. In general, Total Phosphorus regularly greatly exceeds the PWQO; Nitrate concentrations are below ODWS' maximum allowable concentration; Turbidity levels greatly exceed aesthetic objectives of ODWS; E. coli counts are 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 2.1: Surface Water Quality, Phosphorus

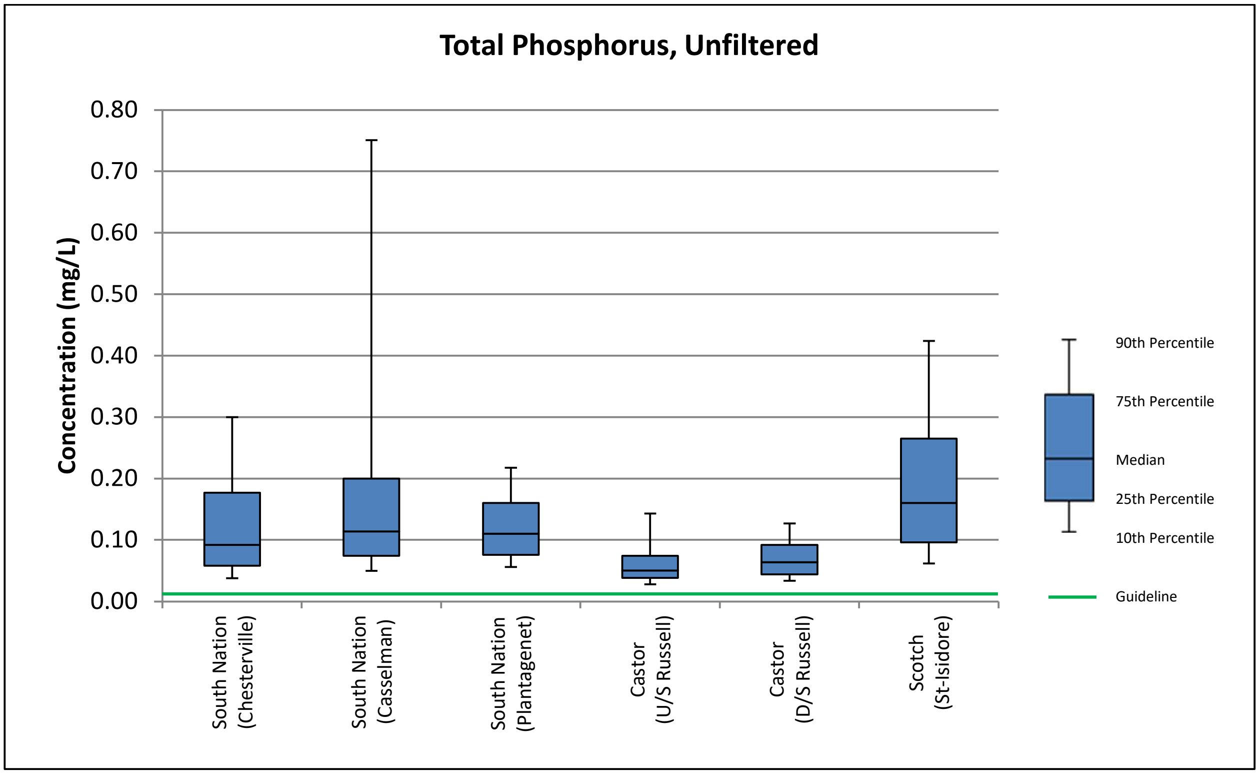


Figure 2.2: Surface Water Quality, Nitrates

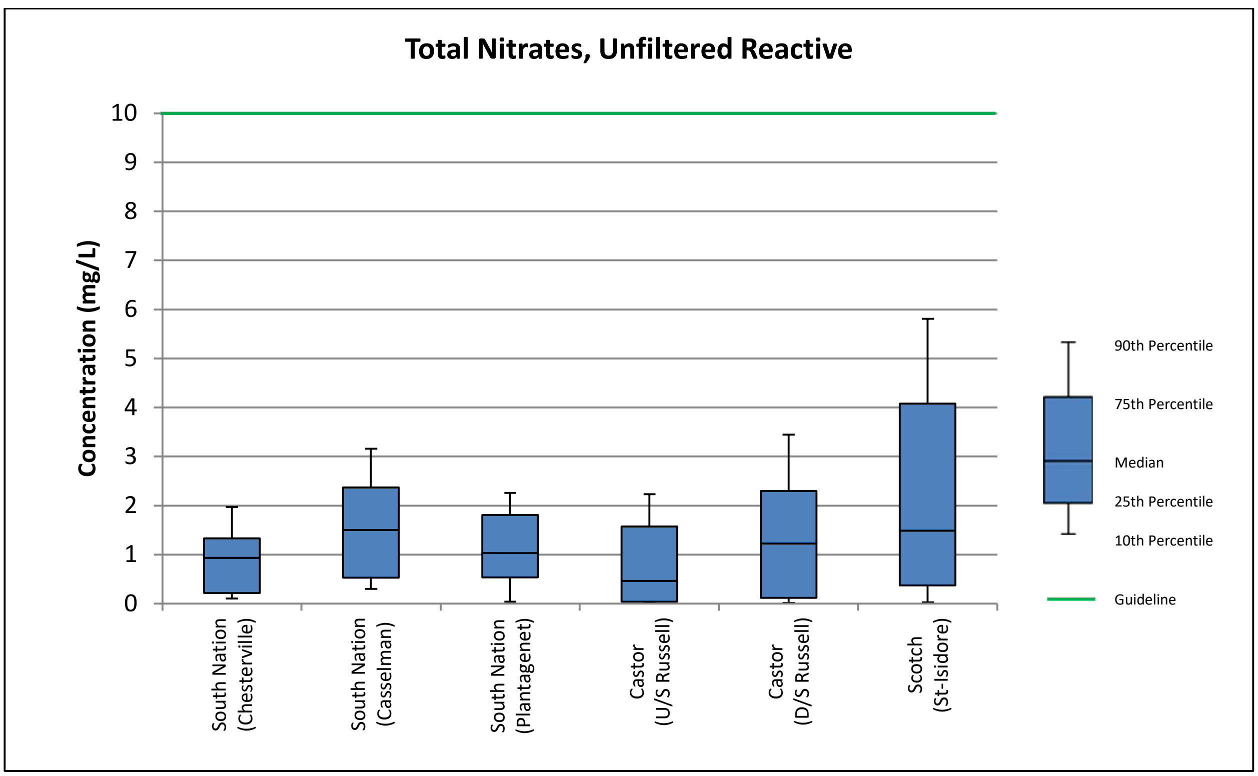


Figure 2.3: Surface Water Quality, Turbidity

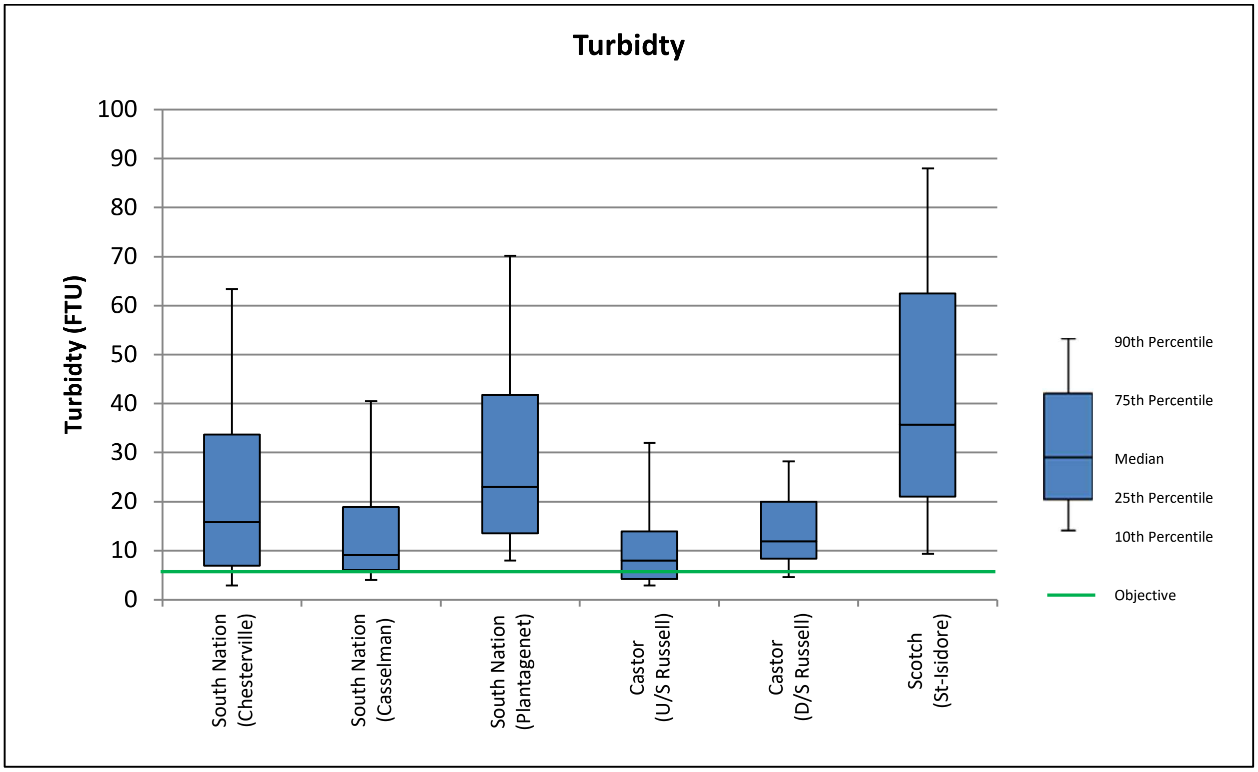


Figure 2.4: Surface Water Quality, Escherichia Coli

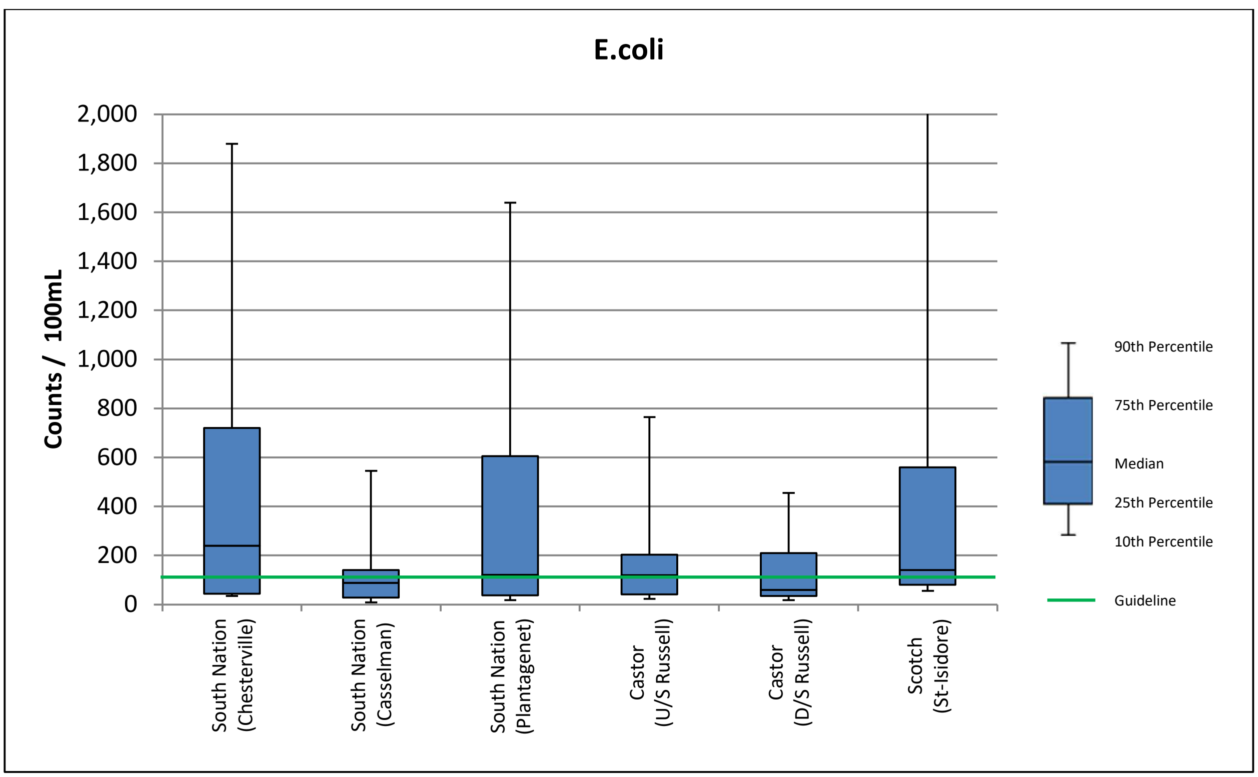
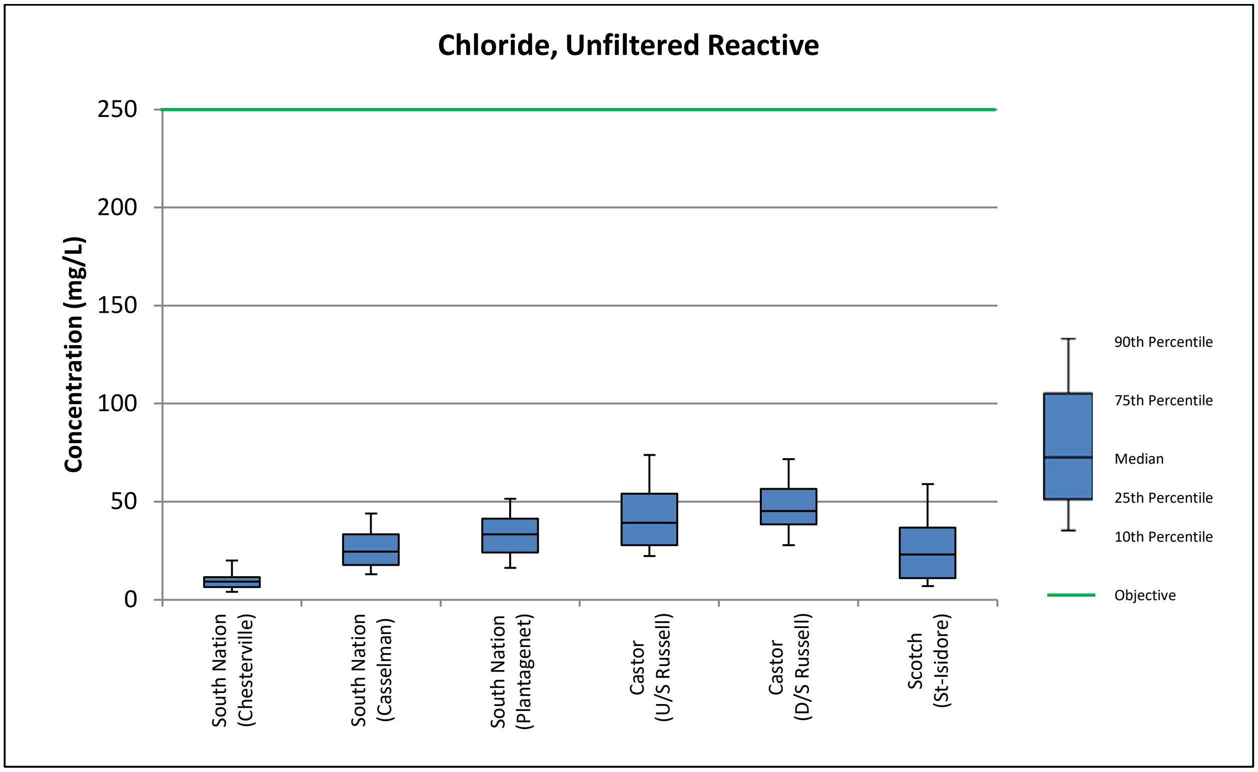


Figure 2.5: Surface Water Quality, Chloride



2.3.2 Groundwater Quality

Regional groundwater quality sampling has been initiated through the Provincial Groundwater Monitoring Network (PGMN). Sixteen 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 2.6*.

Table 2.6: Groundwater Quality Monitoring Stations, South Nation Source Protection Area

PGMN Casing ID	Well Location Description	Parameter	Number of Samples	Average Sampled Concentration (mg/L)	ODWS (mg/L)
W0000094-1	Winchester	Iron	2	0.6	0.3
		Manganese	2	0.54	0.05
W0000095-1	Alfred Bog	Chloride	2	4880	250
		Aluminum	2	0.18	0.1
		Chromium	2	0.1	0.05
		Manganese	2	0.17	0.05
		Hardness	2	1570	80-100
W0000096-1	Maynard	Manganese	1	0.24	0.05

PGMN Casing ID	Well Location Description	Parameter	Number of Samples	Average Sampled Concentration (mg/L)	ODWS (mg/L)
W0000097-5	Metcalf	None	2	---	---
W0000268-1	Berwick	Iron	2	0.36	0.3
W0000269-1	Cassbridge	None	2	---	---
W0000282-3	Cumberland	Iron	3	1.9	0.3
		Manganese	3	0.1	0.05
W0000350-2	Warina (a)	None	1	---	---
W0000350-3	Warina (b)	Manganese	1	0.74	0.05
W0000363-1	High Falls (a)	Iron	1	19.1	0.3
		Manganese	1	1.4	0.05
W0000363-2	High Falls (b)	Iron	1	11.6	0.3
		Manganese	1	1.3	0.05
		Aluminum	1	0.11	0.1
W0000364-1	Jessup's Falls	Chloride	2	1520	250
		Iron	2	1.0	0.3
W0000377-1	Atocas Bay	Chloride	2	5010	250
		Iron	2	1.0	0.3
		Manganese	2	0.05	0.05
		Hardness	2	587	80-100
W0000378-1	Pleasant Valley	Fluoride	2	1.54	1.5
W0000379-1	Beckstead Road	Manganese	2	0.553	0.05
W0000403-1	Froatburn	Iron	1	0.34	0.3
		Hardness	1	230	80-100

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, 22 are entirely or partially within a portion of the South Nation Source Protection Area. A listing of municipalities within the Source Protection Region and South Nation Source Protection Area is shown in *Table 2.7*.

Table 2.7: 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	Yes
Augusta, Township of	Lower Tier	Leeds and Grenville	Yes
Edwardsburgh/Cardinal, Township of	Lower Tier	Leeds and Grenville	Yes
Elizabethtown-Kitley, Township of	Lower Tier	Leeds and Grenville	Yes
North Grenville, Municipality of	Lower Tier	Leeds and Grenville	Yes
Prescott and Russell, United Counties of	Upper Tier	Prescott and Russell	Yes
Alfred and Plantagenet, Township of	Lower Tier	Prescott and Russell	Yes
Casselman, Village of	Lower Tier	Prescott and Russell	Yes
Champlain, Township of	Lower Tier	Prescott and Russell	Yes
Clarence-Rockland, City of	Lower Tier	Prescott and Russell	Yes
East Hawkesbury, Township of	Lower Tier	Prescott and Russell	Yes
Hawkesbury, Town of	Lower Tier	Prescott and Russell	Yes
Russell, Township of	Lower Tier	Prescott and Russell	Yes
The Nation Municipality	Lower Tier	Prescott and Russell	Yes
Stormont, Dundas and Glengarry, United Counties of	Upper Tier	Stormont, Dundas and Glengarry	Yes
North Dundas, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
North Glengarry, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
North Stormont, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
South Dundas, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
South Glengarry, Township of	Lower Tier	Stormont, Dundas and Glengarry	No
South Stormont, Township of	Lower Tier	Stormont, Dundas and Glengarry	Yes
Cornwall, City of	Single Tier	Stormont, Dundas and Glengarry	No
Prescott, Town of	Single Tier	Leeds and Grenville	Yes
Ottawa, City of	Single Tier	Ottawa	Yes

2.4.2 Settlement Areas

The urban and rural settlements designated by municipal official plan are listed in *Table 2.8* and shown on *Map 2.14*.

Table 2.8: 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
Augusta, Township of	n.a.	Algonquin Domville Maitland Maynard North Augusta Riverview Heights Roebuck
Edwardsburgh/Cardinal, Township of	Cardinal	Johnstown Shanly Spencerville
Elizabethtown-Kitley, Township of	n.a.	n.a.
North Grenville, Municipality of	n.a.	Peltons Corners Heckston Oxford Station
Alfred and Plantagenet, Township of	Alfred Plantagenet Wendover Curran[1] Lefaivre[1] Pendleton[1] Treadwell[1]	n.a.
Casselman, Village of	Casselman	n.a.
Champlain, Township of	L'Orignal Vankleek Hill	n.a.
Clarence-Rockland, City of	Rockland Bourget[1] Cheney[1] Clarence Creek[1] Clarence Point[1] Hammond[1] St. Pascal Baylon[1]	n.a.
East Hawkesbury, Township of	Chute-â-Blondeau[1]	n.a.
Hawkesbury, Town of	Hawkesbury	n.a.
Russell, Township of	Embrun Russell Marionville[1]	n.a.

Municipality	Designated Urban Settlement Areas within Source Protection Area Boundary	Designated Rural Settlement Areas within Source Protection Area Boundary
The Nation Municipality	Limoges[1] St-Isidore[1]	Ste. Rose de Prescott Fournier[1] Riceville[1] St-Albert[1] St-Bernardin[1]
North Dundas, Township of	Chesterville Marionville Winchester	Harmony Hallville Inkerman Morewood Mountain Ormond South Mountain
North Glengarry, Township of	Maxville	Dunvegan
North Stormont, Township of	Crysler Finch Moose Creek	Avonmore Berwick Monkland
South Dundas, Township of	Iroquois Morrisburg Williamsburg	Brinston Dixon's Corners Dunbar Dundela Glen Becker Glen Stewart Hainsville Irena Stampville Winchester Springs
South Stormont, Township of	Newington	n.a.
Prescott, Town of	Prescott	n.a.
Ottawa, City of	n.a	Carlsbad Springs Greely Kenmore Navan Notre-Dames-des-Champs Osgoode Sarsfield Vars Vernon

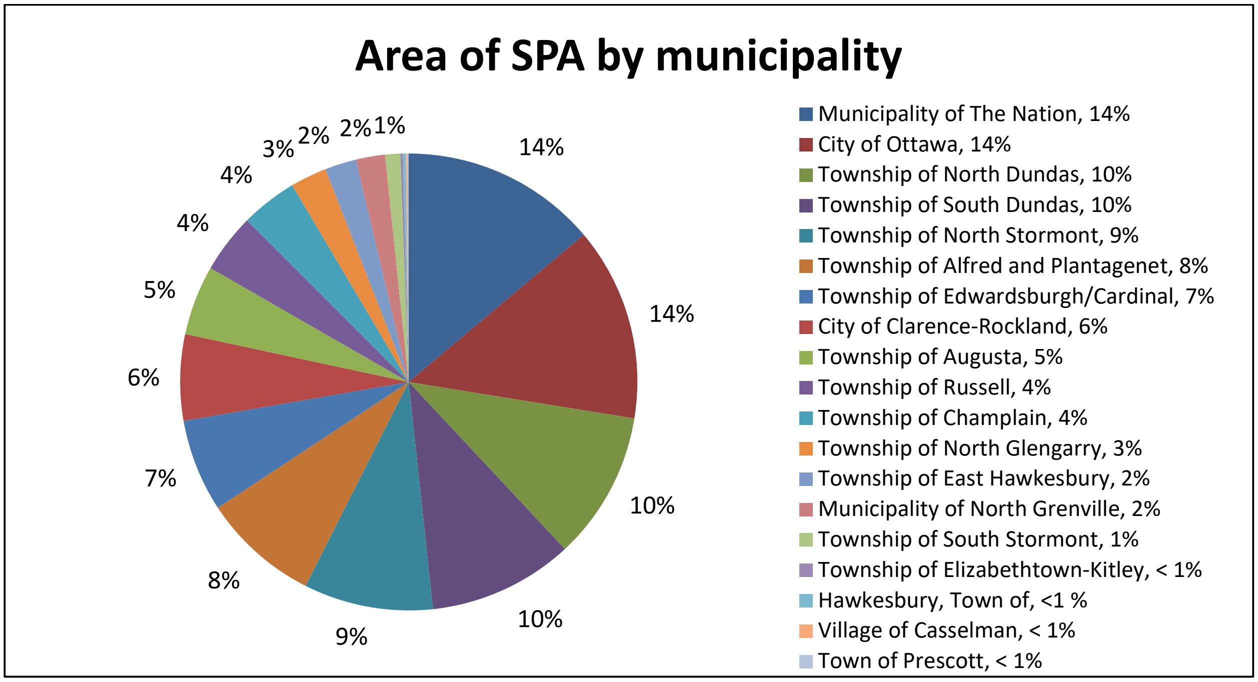
Notes: 1) Designated as "Community Policy Area, under the Official Plan for the United Counties of Prescott-Russell

The percentage of each municipality within the Source Protection Area, and the percentage of Source Protection Area by municipality is summarized in *Table 2.9*and displayed graphically in *Figure 2.6*.

Table 2.9: Municipalities within the Source Protection Area

Municipality	Total Area (km²)	Area within SPA (km²)	Percentage of Municipality	Percentage of SPA
Township of Alfred and Plantagenet	391.7	391.7	100%	8%
Township of Augusta	314.1	233.3	74%	5%
Village of Casselman	5.1	5.1	100%	< 1%
Township of Champlain	207.2	189.9	92%	4%
City of Clarence-Rockland	296.5	289.1	98%	6%
Township of East Hawkesbury	235.1	105.7	45%	2%
Township of Edwardsburgh/Cardinal	311.8	310.7	100%	7%
Township of Elizabethtown-Kitley	554.2	9.1	2%	< 1%
Hawkesbury, Town of	9.5	9.5	100%	< 1%
Township of North Dundas	503.2	497.3	99%	10%
Township of North Glengarry	642.4	121.9	19%	3%
Municipality of North Grenville	350.1	97.2	28%	2%
Township of North Stormont	515.5	434.2	84%	9%
City of Ottawa	2,778.1	649.7	23%	14%
Town of Prescott	5.0	5.0	100%	< 1%
Township of Russell	199.0	199.0	100%	4%
Township of South Dundas	520.0	486.8	94%	10%
Township of South Stormont	447.5	50.8	11%	1%
The Nation Municipality	657.2	657.2	100%	14%
Totals	**8,943.1**	**4,743.2**	**53%**	**100%**

Figure 2.6: 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 2.10*. In total, there are nearly 3200 hectares of Crown Owned property in the Source Protection Area; nearly 80% is managed by the National Capital Commission. Federal Lands are shown on *Map 2.15*.

Table 2.10: Crown Owned Property within the Source Protection Area

DFRP ID	Property	Custodian	Municipality	Land Area (ha)
61093	Alfred Post Office	Canada Post Corporation	Alfred and Plantagenet	0.0
61166	Curran Post Office	Canada Post Corporation	Alfred and Plantagenet	0.1
61332	Plantagenet Post Office	Canada Post Corporation	Alfred and Plantagenet	0.2
8448	Wendover, former front range site	Fisheries and Oceans	Alfred and Plantagenet	0.0
10941	Lots 31, 32, BFC, Con.1, Ottawa River	Fisheries and Oceans	Alfred and Plantagenet	0.1
82214	Sainte-Rosalie Island, former ref. light	Fisheries and Oceans	Alfred and Plantagenet	0.2
82255	Wendover, former rear range site	Fisheries and Oceans	Alfred and Plantagenet	0.0
82269	L'Orignal (upper), former reference light	Fisheries and Oceans	Alfred and Plantagenet	0.0
61258	Maitland Post Office	Canada Post Corporation	Augusta	0.2
57708	CBBA-FM	Canadian Broadcasting Corp.	Augusta	2.8
56534	Pointe au Baril National Historic Site	Parks Canada Agency	Augusta	0.0

DFRP ID	Property	Custodian	Municipality	Land Area (ha)
61140	Casselman Post Office	Canada Post Corporation	Casselman	0.1
7692	Casselman Station	VIA Rail Canada Inc.	Casselman	0.3
61254	L'Orignal Post Office	Canada Post Corporation	Champlain	0.2
61394	Vankleek Hill Post Office	Canada Post Corporation	Champlain	0.1
32166	Ottawa River, Water Lot CL 2201	Fisheries and Oceans	Champlain	0.7
82154	L'Original, former front range site	Fisheries and Oceans	Champlain	0.0
61121	Bourget Post Office	Canada Post Corporation	Clarence-Rockland	0.1
61347	Rockland Post Office	Canada Post Corporation	Clarence-Rockland	0.1
32140	Carillon Slides and Boom Access	Public Works and Gov. Services	East Hawkesbury	0.1
27316	Prescott Border Crossing	Canada Border Services Agency	Edwardsburgh/Cardinal	13.7
61135	Cardinal Post Office	Canada Post Corporation	Edwardsburgh/Cardinal	0.1
61364	Spencerville Post Office	Canada Post Corporation	Edwardsburgh/Cardinal	0.0
9119	Cardinal DGPS and Marine Peripheral	Fisheries and Oceans	Edwardsburgh/Cardinal	4.0
56473	Battle of the Windmill NHS of Canada	Parks Canada Agency	Edwardsburgh/Cardinal	2.1
56539	Fort de Levis NHS of Canada	Parks Canada Agency	Edwardsburgh/Cardinal	0.0
9126	Prescott Harbour	Transport Canada	Edwardsburgh/Cardinal	207.7
61213	Hawkesbury Post Office	Canada Post Corporation	Hawkesbury	0.2
6159	Lot 76, Plan M-7	Public Works and Gov. Services	Hawkesbury	0.1
61144	Chesterville Post Office	Canada Post Corporation	North Dundas	0.1
61360	South Mountain Post Office	Canada Post Corporation	North Dundas	0.2
61412	Winchester Post Office	Canada Post Corporation	North Dundas	0.1
7725	Maxville Station	VIA Rail Canada Inc.	North Glengarry	0.2
61103	Avonmore Post Office	Canada Post Corporation	North Stormont	0.1
61164	Crysler Post Office	Canada Post Corporation	North Stormont	0.1
61191	Finch Post Office	Canada Post Corporation	North Stormont	0.1
61280	Moose Creek Post Office	Canada Post Corporation	North Stormont	0.1
61137	Carlsbad Springs Post Office	Canada Post Corporation	Ottawa	0.4
61206	Greely Post Office	Canada Post Corporation	Ottawa	0.2
61273	Metcalfe Post Office	Canada Post Corporation	Ottawa	0.3
8531	Canadian Forces Station Leitrim	National Defence	Ottawa	234.6
33270	Military Training Site	National Defence	Ottawa	70.5
68440	Training	Royal Canadian Mounted Police	Ottawa	14.5
8523	Ottawa	Transport Canada	Ottawa	0.6
8551	Ottawa Radio Beacon Site	Transport Canada	Ottawa	4.6
22500	Prescott CCG Base	Fisheries and Oceans	Prescott	2.8
56476	Fort Wellington NHS of Canada	Parks Canada Agency	Prescott	3.4

DFRP ID	Property	Custodian	Municipality	Land Area (ha)
5628	Lots 13 to 28 ; Rose Street, Plan 56466	Parks Canada Agency	Prescott	2.0
61183	Embrun Post Office	Canada Post Corporation	Russell	0.1
61350	Russell Post Office	Canada Post Corporation	Russell	0.1
61221	Iroquois Post Office	Canada Post Corporation	South Dundas	0.2
61282	Morrisburg Post Office	Canada Post Corporation	South Dundas	0.2
61410	Williamsburg Post Office	Canada Post Corporation	South Dundas	0.1
83804	Light 92	Fisheries and Oceans	South Dundas	0.2
8508	Iroquois Lock	Transport Canada	South Dundas	101.5
61367	St. Isidore Post Office	Canada Post Corporation	The Nation Municipality	0.1
Various	139 different properties (includes: Pine Grove, Eastern Farm, Mer Bleue, Leitrim Nursery, Capital Golf)	National Capital Commission	Ottawa	2,527.5
Total Land Area				**3,198.0**

2.4.3.1 Indian Reserves

Indian Reserve refers to "tracts of land, the legal title to which is vested in Her Majesty, that has 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: Peir Island, Duck Island, Spencer Island, Drummond Island and Lame Squaw Island. Indian 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 CIA Buildings.

Comprehensive Land Claims Agreements

Comprehensive Land Claims Agreements are negotiated in areas of the country where Aboriginal rights and title have not been addressed by treaty or through other legal means. These agreements are modern-day treaties between Aboriginal claimant groups, Canada and the relevant province or territory. While each one is unique, these agreements usually include such things as land ownership, money, wildlife harvesting rights, participation in land, resource, water, wildlife and environmental management as well as measures to promote economic development and protect Aboriginal culture. Many agreements also include provisions relating to Aboriginal self-government.

The entire South Nation Source Protection Area is within the area designated as Upper Canada Treaties Area, where treaties exist with Onondaga Indian Peoples and Mohawk Indian Peoples.

Algonquin Land Claim

The entire South Nation Source Protection Area has been identified as a part of an Algonquin Land Claim Area. The Land Claim has not yet been settled but an Agreement-in-Principle is in development between the Province and the Algonquin people.

2.4.4 Population

Population counts are provided by Statistics Canada census. The census provides a statistical portrait of Canada and its people. The most recent census was on May 16, 2006. The populations and resulting population densities of the municipalities within the SPA are shown in *Table 2.11*.

Table 2.11: Municipal populations and population densities

Municipality	Population 2001	Population 2006	Percent Change	Total Area (km²)	Population Density (/km²)
Township of Alfred and Plantagenet	8,593	8,654	0.7%	391.7	22
Township of Augusta	7,635	7,510	-1.7%	314.1	24
Village of Casselman	2,910	3,294	11.7%	5.1	640
Township of Champlain	8,586	8,683	1.1%	207.2	42
City of Clarence-Rockland	19,612	20,790	5.7%	296.5	70
Township of East Hawkesbury	3,415	3,368	-1.4%	235.1	14
Township of Edwardsburgh/Cardinal	6,674	6,689	0.2%	311.8	22
Township of Elizabethtown-Kitley	10,039	10,201	1.6%	554.2	18
Hawkesbury, Town of	10,319	10,869	5.1%	9.5	1,149
Township of North Dundas	11,014	11,095	0.7%	503.2	22
Township of North Glengarry	10,589	10,635	0.4%	642.4	17
Municipality of North Grenville	13,581	14,198	4.3%	354.4	41
Township of North Stormont	6,855	6,769	-1.3%	515.5	13
City of Ottawa	774,072	812,129	4.7%	2,778.1	292
Town of Prescott	4,228	4,180	-1.1%	5.0	844
Township of Russell	12,412	13,883	10.6%	199.0	70
Township of South Dundas	10,783	10,535	-2.4%	520.0	20
Township of South Stormont	11,941	12,520	4.6%	447.5	28
The Nation Municipality	10,599	10,643	0.4%	657.2	16
Totals, Average Density	**943,857**	**986,645**	**4.3%**	**8,943.1**	**110**

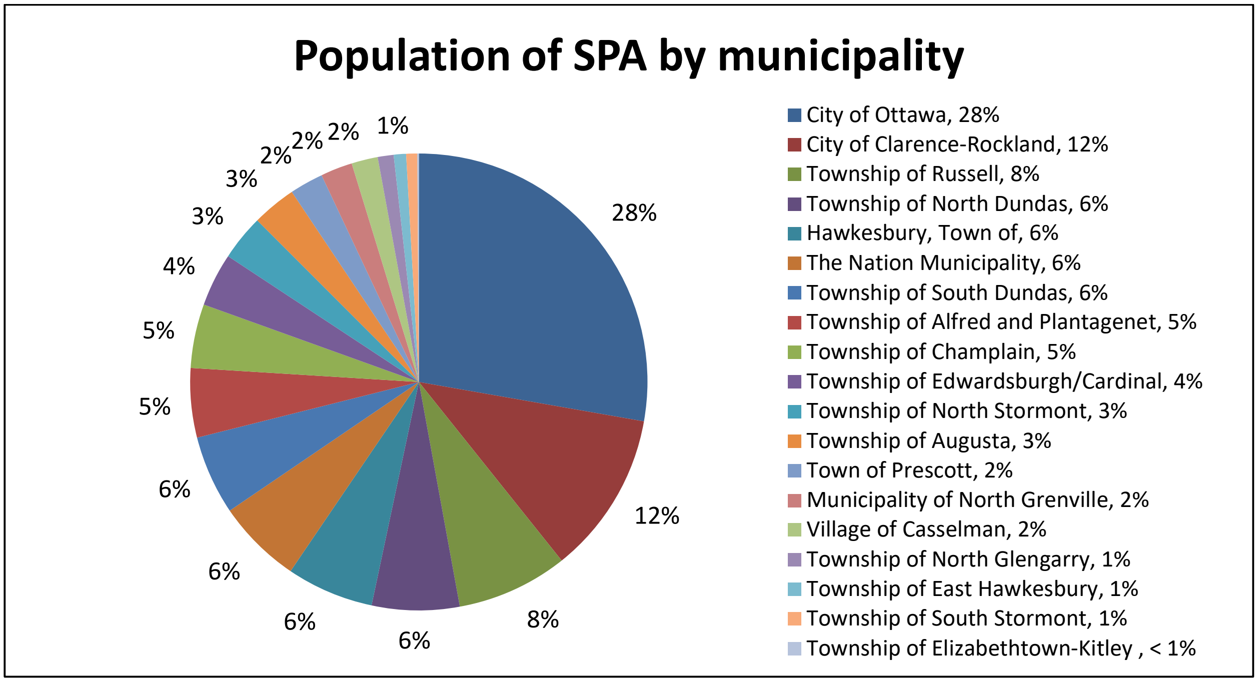
The total population of the Source Protection Area can be estimated by multiplying the population of the municipality by the percentage of that municipality within the Source Protection Area. The results are shown in *Table 2.12* and *Figure 2.7*.

Table 2.12: Population Estimates of the Source Protection Area

Municipality	Population 2006	Percentage of Municipality within Source Protection Area	Approximate population within Source Protection Area	Percentage of Source Protection Area
Township of Alfred and Plantagenet	8,654	100%	8,654	5%
Township of Augusta	7,510	74%	5,557	3%
Village of Casselman	3,294	100%	3,294	2%
Township of Champlain	8,683	92%	7,988	5%
City of Clarence-Rockland	20,790	98%	20,374	12%
Township of East Hawkesbury	3,368	45%	1,516	1%
Township of Edwardsburgh/Cardinal	6,689	100%	6,689	4%
Township of Elizabethtown-Kitley	10,201	2%	204	0%
Hawkesbury, Town of	10,869	100%	10,869	6%
Township of North Dundas	11,095	99%	10,984	6%
Township of North Glengarry	10,635	19%	2,021	1%
Municipality of North Grenville	14,198	28%	3,975	2%
Township of North Stormont	6,769	84%	5,686	3%
City of Ottawa[1]	*See note below*		49,084	28%
Town of Prescott	4,180	100%	4,180	2%
Township of Russell	13,883	100%	13,883	8%
Township of South Dundas	10,535	94%	9,903	6%
Township of South Stormont	12,520	11%	1,377	1%
Municipality of The Nation	10,643	100%	10,643	6%
Totals	**986,645**	**n.a.**	**176,881**	**100%**

Notes: 1) Population estimates for the City of Ottawa based on Ward population within SPA boundary as such: 70% of Ward 19 (Cumberland @ 33,405), 17% of Ward 10 (Gloucester-South Gate @ 44,380) and 80% of Ward 20 (Osgoode @ 22,695).

Figure 2.7: Population of the Source Protection Area by Municipality



2.4.4.1 Growth

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

City of Ottawa

Over the next 20 years, the City's population will push past the one million mark and possibly reach 1.2 million. This level of growth will open new opportunities for the city and its residents, but will also bring enormous change and new challenges.

United Counties of Stormont, Dundas and Glengarry

The population grew by 15.7% between 1986 and 2000. This contrasted a provincial growth rate of 24.9%. The fastest growing areas were those bordering the St. Lawrence and those within the commuter shed of Ottawa and Montreal. With a projected employment decline in the manufacturing and agricultural economic sectors across Canada and in the County, population growth will be dependent on job growth in other economic sectors such as tourism, adult community development (retirement-based development) and high technology.

The Official Plan is to optimize the use of existing residential land and to focus development in urban settlements as a first priority. Rural settlement will be permitted where it can take advantage of existing public services and infrastructure where it does not conflict with stewardship of renewable and non-renewable resources including water resources.

United Counties of Prescott and Russell

The United Counties of Prescott and Russell have experienced tremendous growth over the last three decades. Rapid growth often results in social, political, economic and environmental pressures that can threaten the very qualities that attracted so many to settle in this region. Indeed Prescott and Russell must resolve many growth related problems such as water and sewer service restrictions, landfill capacity, environmental impacts and development pressure on our resource areas.

The Official Plan is to guide 70% or more of population growth to the Urban Policy Area and the Community Policy Area and 30% or less to the Rural Policy Area.

Township of Edwardsburgh/Cardinal

The Official Plan recognizes today's changing requirements and opportunities for growth. New business openings and the expansion of existing businesses are occurring in the expanded Industrial Park and in the communities of Johnstown, Spencerville and Cardinal where there are subdivision lots available for building. The Port of Prescott, owned and operated as a division of the Township of Edwardsburgh/Cardinal, is a major resource for continued growth.

Town of Hawkesbury

The Town has experienced modest growth over the past 10 years or more. Growth has occurred in a controlled and planned manner as new development resulted in extensions of existing residential neighborhoods. The Official Plan is designed to encourage and manage continued modest growth which will result in a forecasted population of approximately 12,600 (low growth scenario) to 13,800 (high growth scenario) by the year 2029. It is the general intent of the Official Plan to continue logical extensions of the Town's development areas and to encourage redevelopment and infill wherever possible.

Town of Prescott

The population of Prescott is in decline. A number of factors are associated with this decline, including an aging population, out-migration of young people, lack of significant immigration, and a general reduction in the size of families. Since 1991, Prescott has experienced a net population decrease of 283 people, or about 6.3 percent. It is estimated that the decline in population will level off in the next decade before increasing very slightly.

Municipality of North Grenville

The impact of Highway 416 and the expanding population of the City of Ottawa will be felt in the Municipality. By 2028, the population will likely increase by 12,901 to approximately 26,668. This growth rate exceeds the Provincial average. As such, the planning horizon for this Plan is to the year 2028. The Municipality currently does not have the infrastructure in place to accommodate all of the anticipated growth. Efficient use of existing serviced land, the logical extension of services and sensitive infilling will accommodate a portion of the growth influx.

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 suburban and rural areas of the City of Ottawa account for approximately one quarter of the Source Protection Area population. It is the largest urban area, followed by the City of Clarence Rockland, accounting for approximately one eighth of the population. The remaining population is mostly rural settlement. Outside of the urban areas, similar to the Raisin Region 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 South Nation Source Protection Area which have been classified through the Safe Drinking Water Act are shown on *Map 2.16* and cross-referenced in *Table 2.13*. System capacity, average taking rate and population served are listed where known.

Table 2.13: Drinking Water Systems, South Nation Source Protection Area

Map Id	DWIS Number	Drinking Water System	Class.'n	Cap. 'y (m^3/day)	Avg. Taking (m^3/day)	Pop.'n Served	Residences Served	Source
S1	220001245	Prescott	LMRS	8700				SW
S2	260013195	NORTH EDWARDSBURG PS	School	closed June 26,2009				GW
S3	260050778	COUNTRYSIDE ESTATES	NMYRRS	129.6		70	45	GW
S4	220003582	Cardinal	LMRS	3,542		1650	550	SW
S5	260006971	Spencerville - Bennett St. Well	LMRS	164.4			15	GW
S6	260086489	CARAVANPARK	NMYRRS	120.96		11	8	GW
S7	220001012	SOUTH DUNDAS REGIONAL WATER TREATMENT PLANT	LMRS	9,504		4000		SW
S8	260012909	DIXONS CORNERS PS	School				12	GW
S9	260023166	SOUTHMOUNTAIN	SNMNRS				7	GW
S10	260069069	NEW SECURITY WELL #6, PARKS COMMISSION	SNMNRS	No data				GW
S11	260073671	2060847 ONTARIO INC.	NMYRRS	241.92		12	12	GW
S12	260043849	PARK DRIVE VILLA	NMYRRS			50	38	GW
S13	260021437	SCHELL ST (WILLIAMSBURG)	SNMNRS			248		

Map Id	DWIS Number	Drinking Water System	Class.'n	Cap. 'y (m³/day)	Avg. Taking (m³/day)	Pop.'n Served	Residences Served	Source
S14	260087269	PALATINE APARTMENTS	NMYRRS	No report				GW
S15	260021450	CTY RD 18 (WILLIAMSBURG)	SNMNRS	No data				GW
S16	260013156	NATIONVIEW PS	School	No data				
S17	260077311	2946 LOUGH ROAD	NMYRRS	241.92		9	7	GW
S18	260013000	INKERMAN PS	School					GW
S19	260021957	HILLCREST HAVEN REST HOME	SNMNRS	241.92		9		GW
S20	260079625	SANDY MOUNTAIN CAMPSITES	NMYRRS			100		GW
S21,S 22, S23	210000586	WINCHESTER (Well 1, 6, 5)	LMRS	1538	119	2275		GW
S24	260015691	TIMOTHY CHRISTIAN SCHOOL	Pr. School	No data				GW
S25	260013182	NORTH DUNDAS DHS	School					GW
S26	260013078	MAPLE RIDGE SR PS	School	No data				GW
S27	210000728	CHESTERVILLE (Production)	LMRS	2,782		1458		GW
S28	210000728	CHESTERVILLE (Standby)	LMRS	2,782		1458		GW
S29, S30	220008051	NEWINGTON(Well 1, 2)	LMRS	328	75	150	114	GW
S31	260013377	TAGWI SECONDARY SCHOOL	School	34.56			9	GW
S32, S33	210003912	FINCH (Well 1, 2)	LMRS	691		440		GW
S34, S35, S36	210000586	WINCHESTER (Well 7a, 7b, 7c)	LMRS	1950	1122			GW
S37	260013312	ROXMORE PS	School			130		GW
S38	260019864	ROXBOROUGH NON PROFIT	NMYRRS			127	83	GW
S39	260074061	MOREWOOD MANOR	NMYRRS			42	21	SW
S40	260013143	MOREWOOD PUBLIC SCHOOL	School			50	38	GW
S41	260013221	NORTH STORMONT PS	School			300		SW
S42	260023777	PAVILLON MARIONVILLE LTD.	SNMNRS				7	GW
S43, S43	220004297	RUSSELL, EMBRUN, MARIONVILLE (Well 2, 1)	LMRS	Officially decommissioned May 2015				GW
S45	260023036	MEADOWLANDS	NMYRRS				6	GW
S46	260012493	CASTOR VALLEY ES	School	No data				GW
S47	260016263	OSGOODE CARE CENTRE	NMYRRS	864		150		GW
S48	260012701	OSGOODE TOWNSHIP HS	School	No data				
S49	260047996	STANLEY APARTMENTS	NMYRRS	145		58	25	GW
S50	260020111	METCALFECHRISTIANSCHOOL	Pr. School	No data				GW
S51	260015496	ST. CATHERINE'S SEP S	School	69.12				GW
S52	220008060	RUSSELL [2]	LMRS	2,765		3561		GW

Map Id	DWIS Number	Drinking Water System	Class.'n	Cap. 'y (m^3/day)	Avg. Taking (m^3/day)	Pop.'n Served	Residences Served	Source
S53	220008649	CRYSLER (Standby)	LMRS	1,685	674	600		GW
S54	260009113	METCALFECO-OPERATIVENURSERY SCHOOL	Day Nursery	No data				GW
S55	260012662	R243 METCALFE PS	School	No data				GW
S56	220008649	CRYSLER (Production)	LMRS	1,685	674	600		GW
S57	260089635	Greely-Shadow Ridge	LMRS	550			154	GW
S58	260089635	Greely-Shadow Ridge	LMRS	550			154	GW
S59	260020124	SPARTAN GROVE	SNMNRS	No data				GW
S60	260074373	6637 HIGHWAY #31	NMYRRS	241.92			9	GW
S61	260023205	GREELY CHILD CARE CENTRE	Day Nursery	No data				GW
S62	220008033	MOOSE CREEK (Well 2)	LMRS	899		400	216	GW
S63	220008033	MOOSE CREEK (Well 3)	LMRS	899		400	216	GW
S64	220008033	MOOSE CREEK (Well 1R)	LMRS	899		400	216	GW
S65	260014859	ST-ALBERT, E	School	No data				GW
S66	260021723	VILLA ST-ALBERT	SNMNRS	No data				GW
S67	260040248	LA RESIDENCE LAJOIE	NMYRRS			30	25	GW
S68	260012545	GREELY PS	School					GW
S69	260076011	1244 STE-MARIE STREET	NMYRRS	241.92		12	10	GW
S70	260029224	RESIDENCE PAQUETTE	SNMNRS				8	GW
S71	260016237	MAXVILLE MANOR	SNMNRS	34.56		120	2	GW
S72	260025233	GLENGARDENVILLAGE	NMYRRS	34.56				GW
S73	260071123	10 MECHANIC STREET W MAXVILLE	NMYRRS			12	12	GW
S74	260014430	IONAACADEMY	School	112				GW
S75	260013104	MAXVILLE PS	School	No data				GW
S76	260033384	SOUTHSIDE MOBILE HOME	NMYRRS	198.72		140	69	GW
S77	260014872	ST.BERNARDSCHOOL	School	No data				GW
S78	260019721	LYNNWOOD MOBILE HOME	NMYRRS	26				GW
S79	210001219	CASSELMAN	LMRS	3,180		2900		SW
S80, S81	260006841	LIMOGES (Well 1, Well 2)	LMRS	2,082		2000		GW
S82,S83	210002263	VARS (Well 1, Well 2)	LMRS	432		800		GW
S84	220003573	ST. ISIDORE [2]	LMRS	907		800		GW
S85	260023985	SARMAC HOMES (RUSSELL)	SNMNRS				45	GW
S86	260066885	PHOENIX GROUP HOME	SNMNRS	69.12		10		GW
S87	260024661	BIRCHGROVE RESIDENCE	SNMNRS	No data				GW

Map Id	DWIS Number	Drinking Water System	Class.'n	Cap.'y (m^3/day)	Avg. Taking (m^3/day)	Pop.'n Served	Residences Served	Source
S88	260007829	LAROSE FOREST MOBILE HOME	NMYRRS	527				GW
S89	260045513	ST. FELIX RESIDENCE	SNMNRS	78		350		
S90	260008076	MARY HOMES TENTH LINE	SNMNRS	No data				GW
S91	260014482	ST. FRANCIS XAVIER ELEMENTARY - HAMMOND	School	No data				GW
S92	260014482	ST. FRANCIS XAVIER CHS	School	No data				
S93	260076258	589 RUSSELL ROAD	NMYRRS	241.96		14	7	GW
S94	260022854	NAVANCOOPERATIVENURSERY SCHOOL	Day Nursery	No data				GW
S95	260022854	EASTERN VALLEYCO-OPERATIVENURSERY SCHOOL	Day Nursery	No data				GW
S96	260014443	POPE JOHN PAUL	School	closed				GW
S97	260022932	BAIRN CROFT RESIDENTIAL	SNMNRS			8		GW
S98	260023543	RESIDENCE ENTR'AMIS	SNMNRS	43				GW
S99	260012649	HERITAGE PS	School	No data				GW
S100	260079495	3560 SARSFIELD ROAD	NMYRRS				8	GW
S101	260016250	SARSFIELD COLONIAL HOME	SNMNRS	No data				GW
S102	260067171	COLONIAL RESIDENCE	SNMNRS	No data				GW
S103	260022022	RESIDENCE HERVE JOLY	NMYRRS	95.04		35	24	GW
S104	260021697	VILLA ST-LUC	SNMNRS	No data				GW
S105	260008619	ROBERTS/SMART CENTRE (CLARENCECREEK)	SNMNRS	No data				GW
S106	210001736	PLANTAGENET TREATMENT[2]	LMRS	1,702		850		SW
S107	260008632	ROBERTS/SMART CENTRE (NORTH PLANTAGENET)	SNMNRS	No data				GW
S108	260070655	ROCKLEDGEESTATESMOBILEHOMEPARK	NMYRRS	242				GW
S109	260013013	LAGGAN PS	School	No data				GW
S110	260002395	VANKLEEK HILL DIST.'N SYSTEM[1]	LMRS	2,773		1810		
S111	260037102	L'ORIGNAL DIST.'N SYSTEM[1]	LMRS	1,089		1800		
S112	210000639	ROCKLAND TREATMENT PLANT	LMRS	5,901		21500		SW
S113	260045422	EVERGREEN CAMPING	NMYRRS	242				GW
S114	260007205	ALARY INC.	NMYRRS	354		127	83	GW
S115	260004293	WENDOVER TREATMENT PLANT	LMRS	1,521		845		SW
S116	260072917	FAUTEUXMOBILEHOMEPARK	NMYRRS	112.32			13	GW
S117	260077623	1862 HWY 34	NMYRRS				9	GW

Map Id	DWIS Number	Drinking Water System	Class.'n	Cap. 'y (m^3/day)	Avg. Taking (m^3/day)	Pop.'n Served	Residences Served	Source
S118	260064831	MEADOWBROOKTRAILER PARK - CHAMPLAIN	NMYRRS	164.16			11	GW
S119	260074204	374 FRONT ROAD EAST	NMYRRS				6	GW
S120	260072826	GRATTONMOBILEHOMEPARK	NMYRRS				6	GW
S121	260072826	307 FRONT ROAD EASTMOBILE HOME PARK	NMYRRS	103.68		24	26	GW
S122	220002832	HAWKESBURY WATER	LMRS	27,276		10300	3576	SW
S123	260079508	268 FRONT ROAD	NMYRRS					GW
S124	260036348	PRESCOTT CONDOMINIUM	NMYRRS	100		42	21	SW
S125	220002841	LEFAIVRE TREATMENT PLANT	LMRS	2,903		2400		SW

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) These are distribution systems only. Treated water is supplied from another system.
2) These systems have since been decommissioned.

3 Water Quantity Threats Assessment

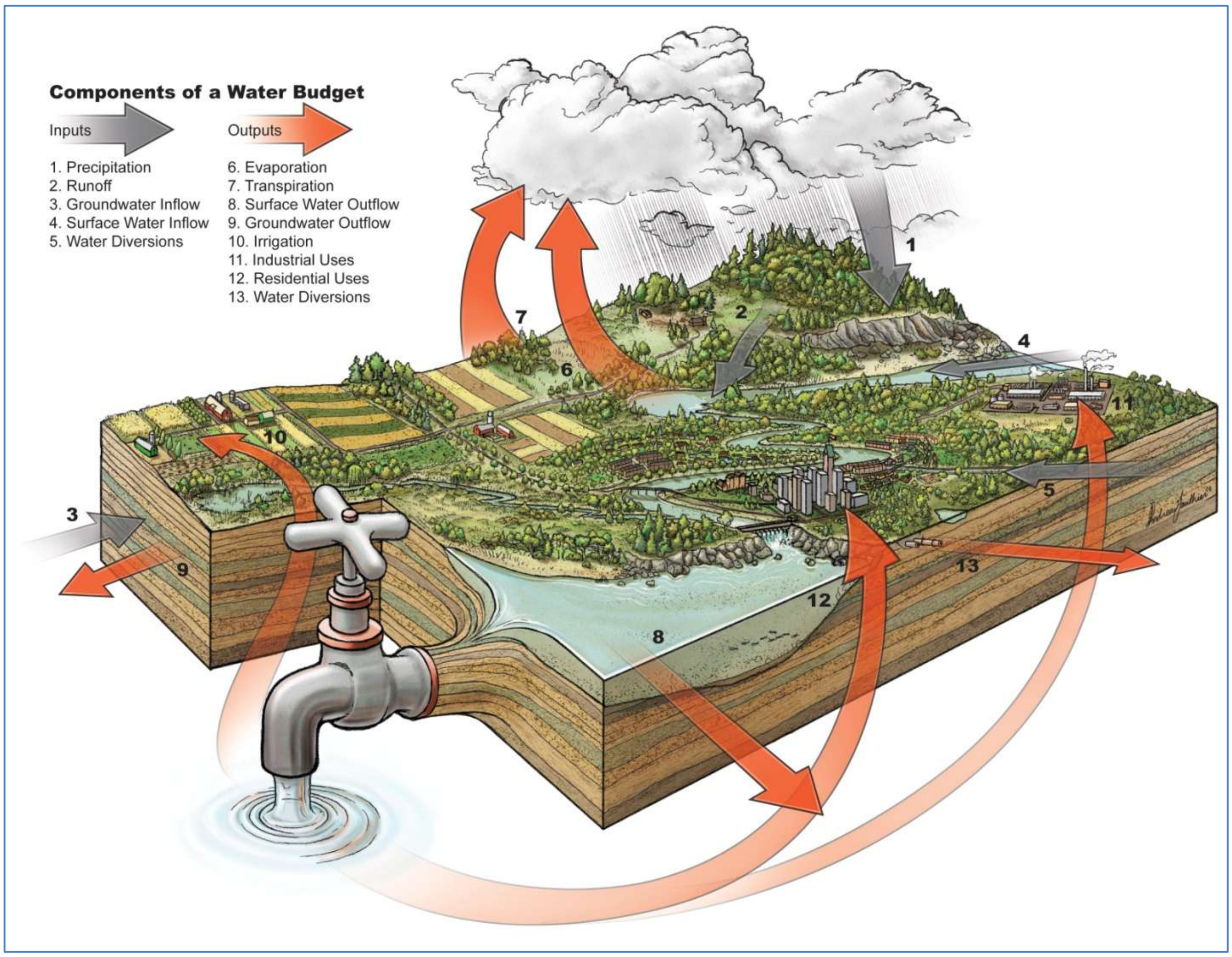
Ontario Regulation (O. Reg.) 287/07 (General) lists 2 activities that are prescribed as drinking water threats (PDWTs) with respect to water quantity:

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.

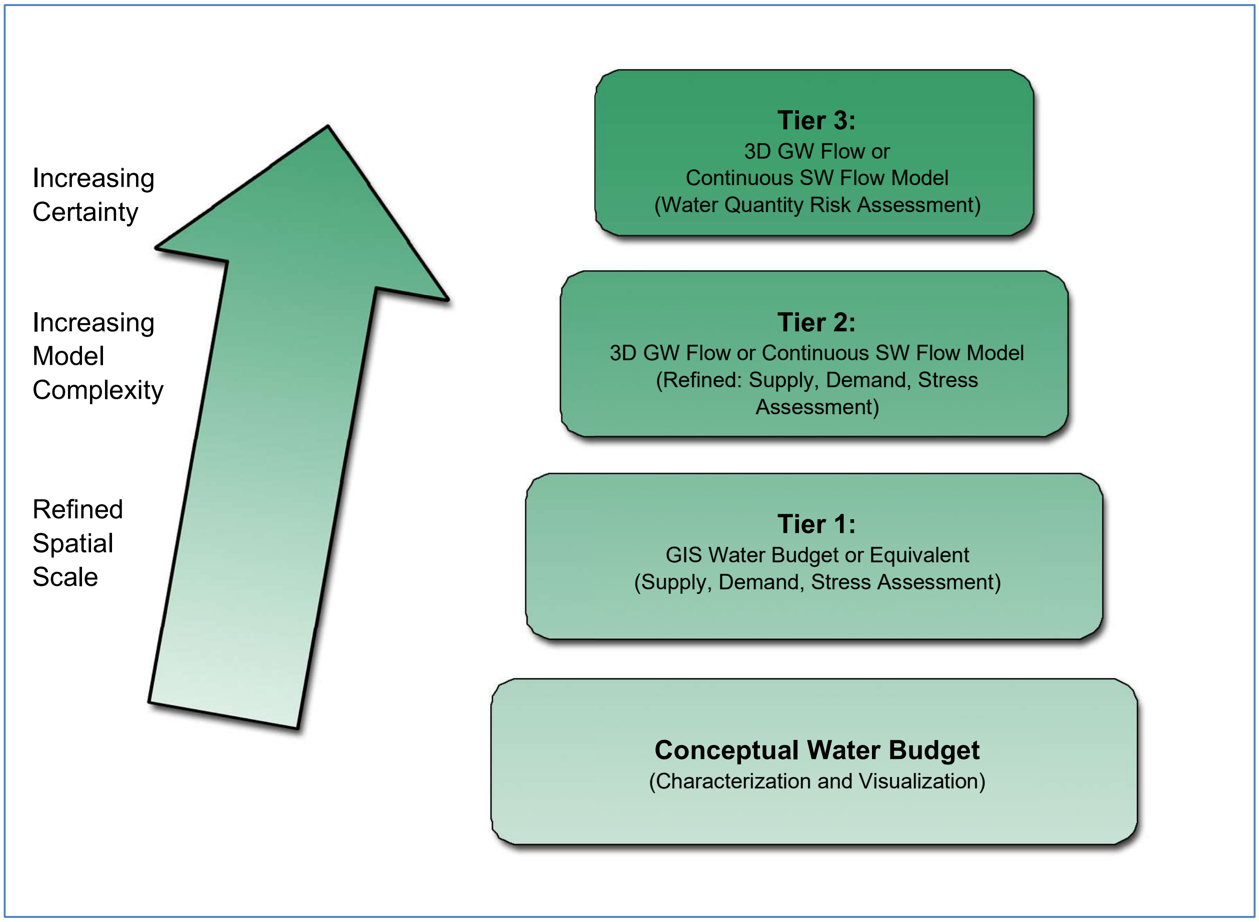
A water budget looks at how much water enters a watershed, how much water is stored and how much water leaves. This information helps determine how much water is available for human uses, while ensuring there is still enough left for natural processes (e.g. there has to be enough water in a watershed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

Figure 3.1: Components of a Water Budget



The water budget process can include up to four tiers, which start simple and get 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 and the smaller the area of study. The purpose of moving from one tier of water budget to another is so those involved in Source Protection Planning can be certain about the amount of stress a water supply is under and be sure the complex work is focused on areas that really need it. The water budget framework is presented in *Figure 3.2*.

Figure 3.2: 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 3.1* and shown in *Figure 3.3* and *Figure 3.4*.Average annual precipitation for the South Nation Source Protection Area was determined to be 971mm/year (with 17mm standard deviation).

Table 3.1: 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 3.3: Average Normal Monthly Precipitation of the Source Protection Region

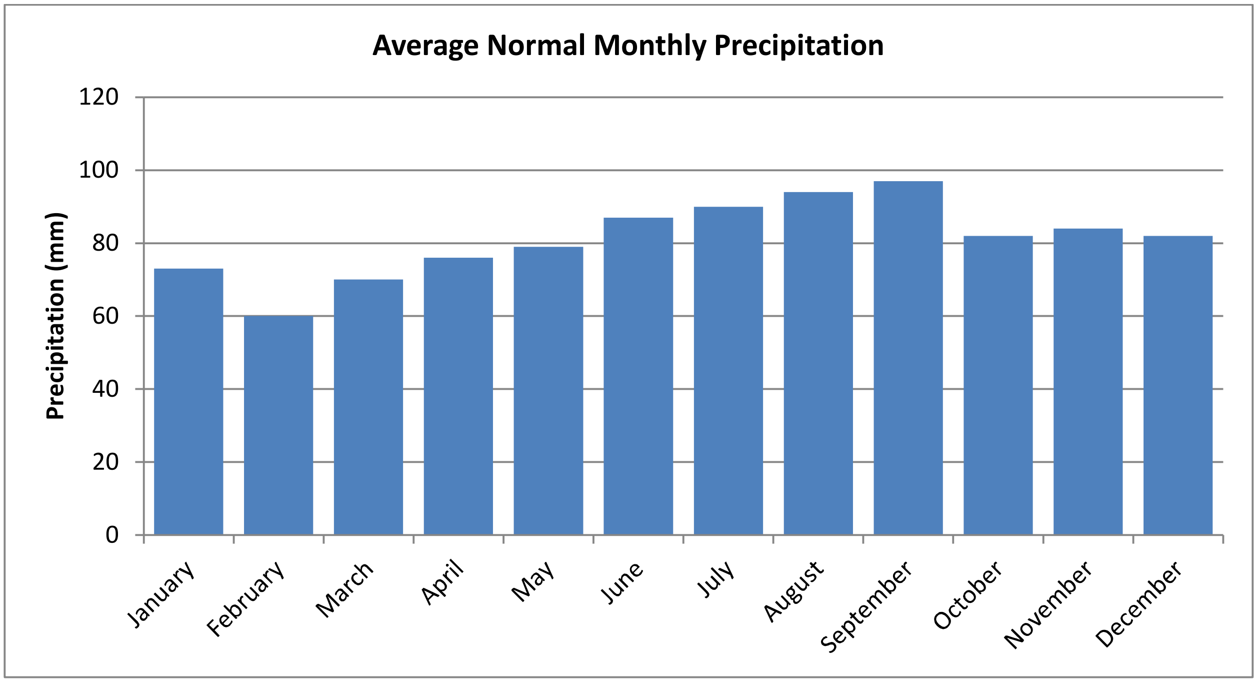
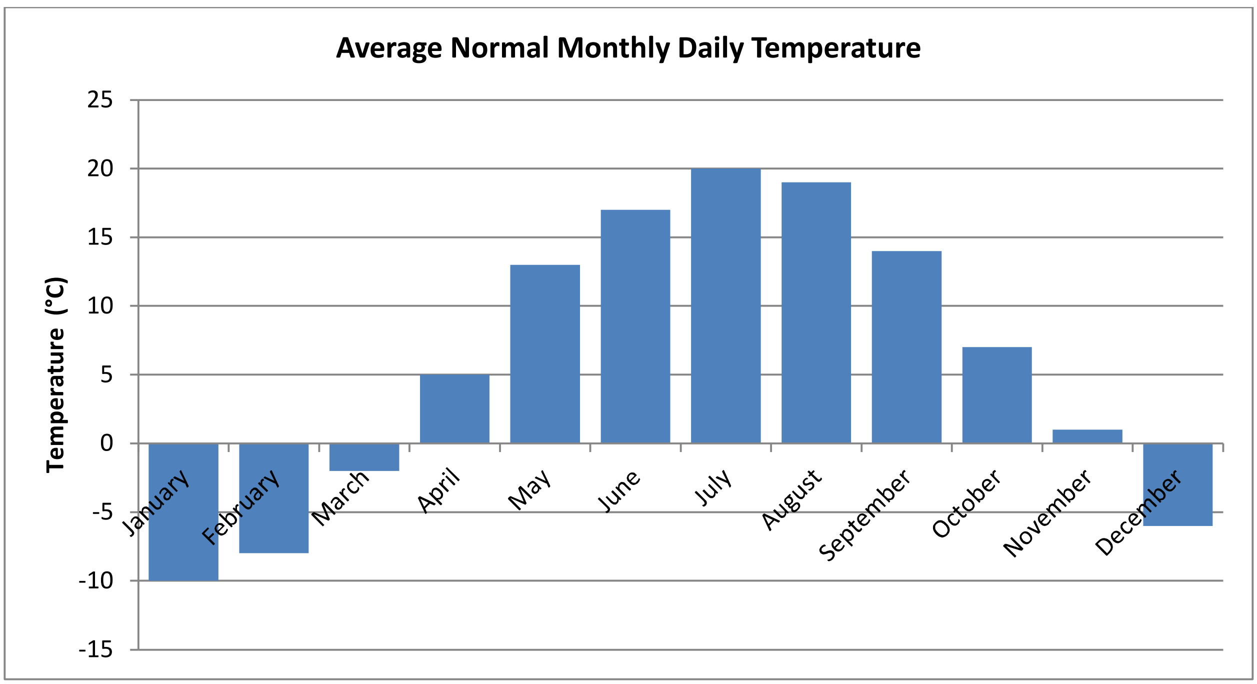


Figure 3.4: Average Normal Monthly Daily Temperature of the Source Protection Region



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 are shown in *Table 3.2*.

Table 3.2: 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 South Nation Source Protection Area is estimated to be 417 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 variousbedrock and overburden features. The locations of these sections are shown in *Figure 3.5* and *Figure 3.6*.

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 3.7*.

Figure 3.5: Location of Regional and Stream Cross Sections, Source Protection Region

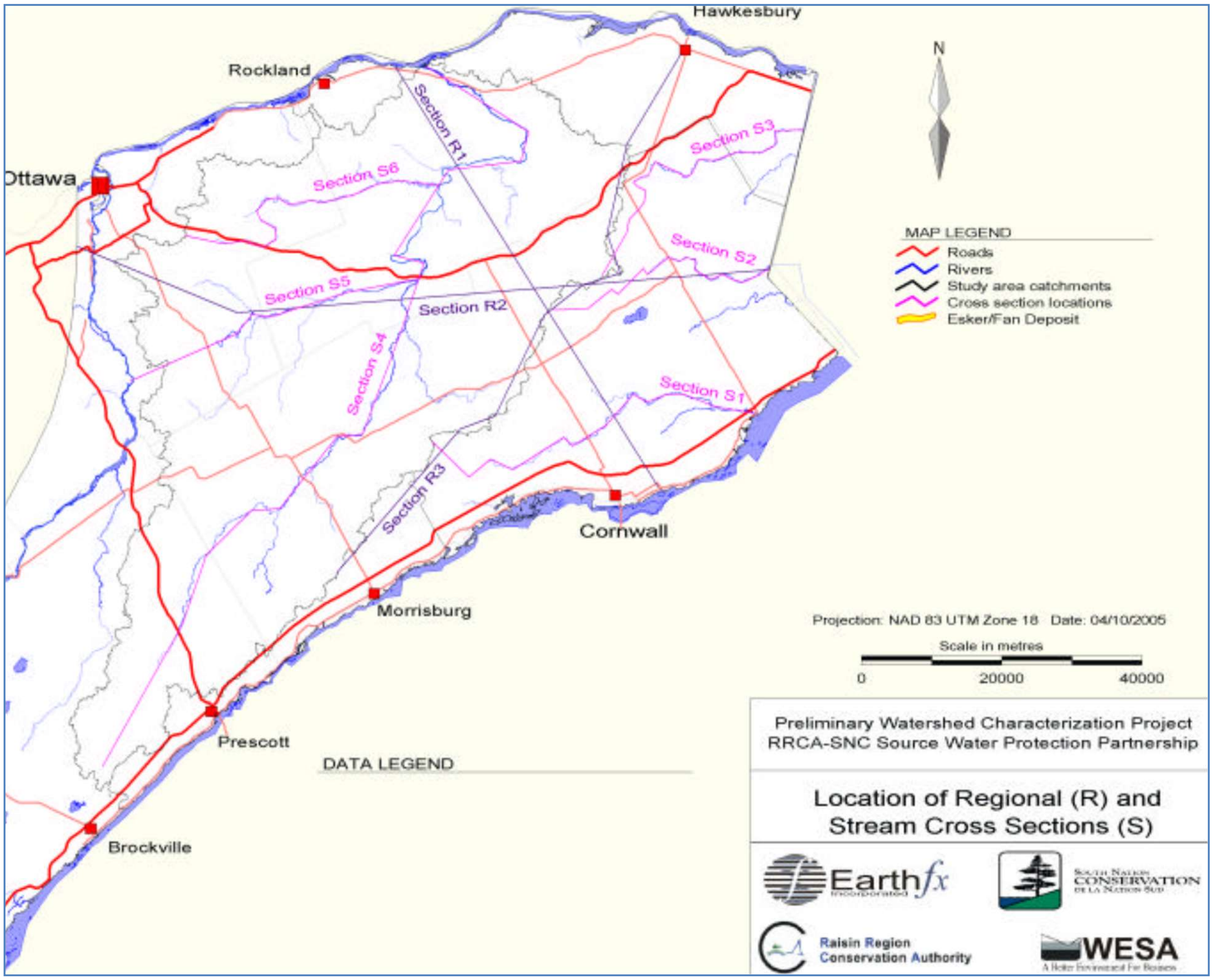


Figure 3.6: Location of Bedrock Valley, Esker and Fault Cross Sections, Source Protection Region

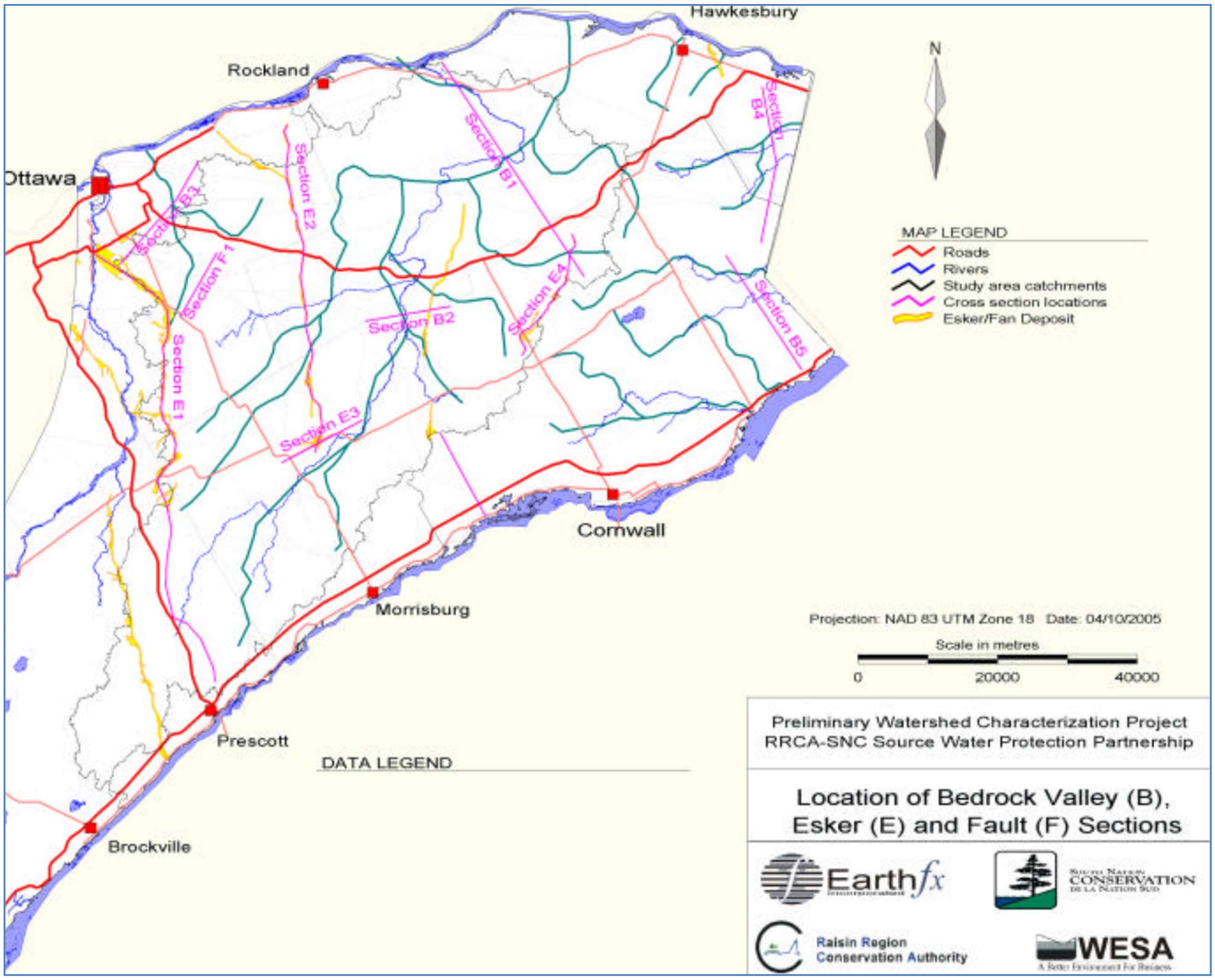
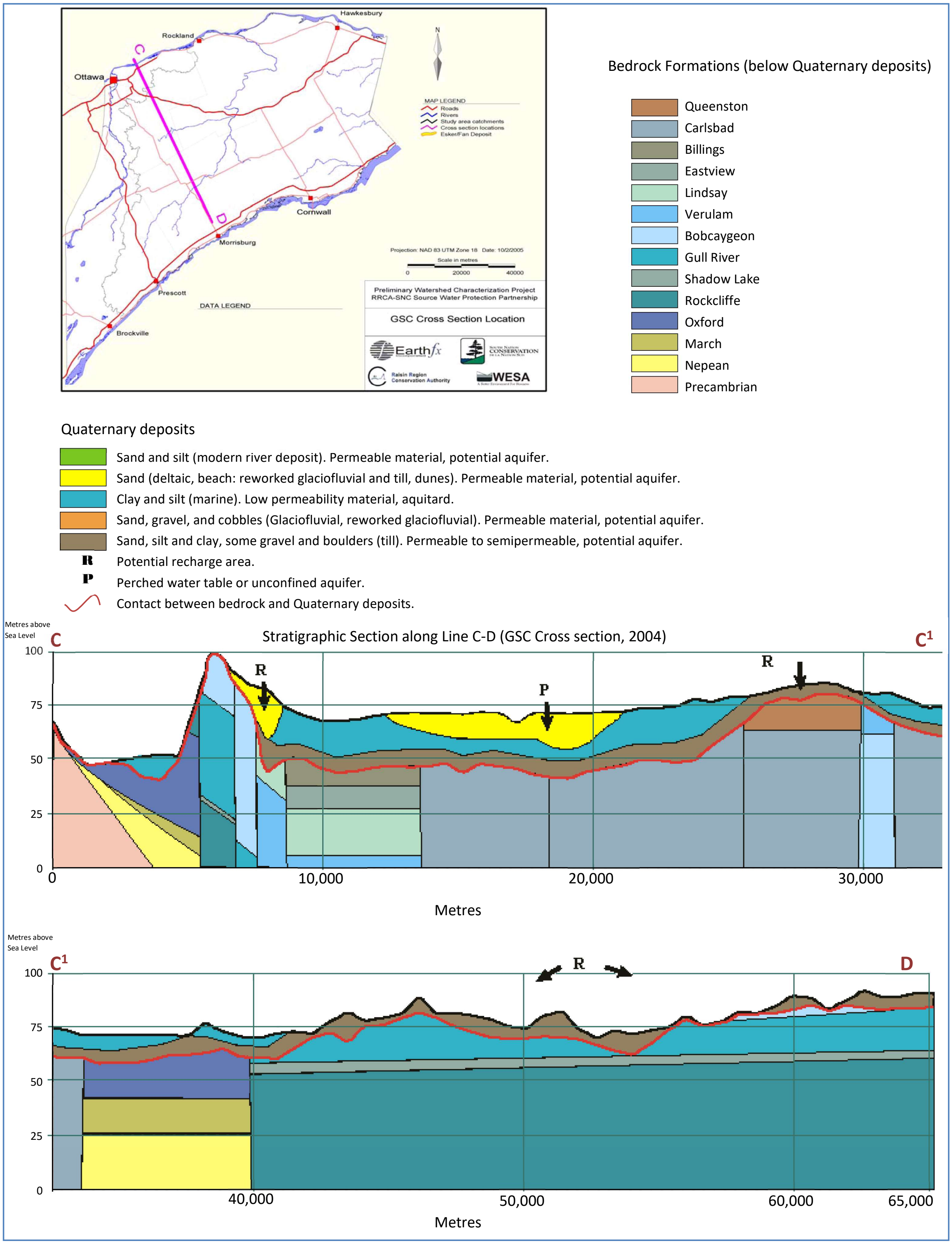


Figure 3.7: Regional Cross Section Showing Aquifers and Aquitards



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 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 and the Ottawa River, the South Nation Source Protection Area comprises the following significant surface water bodies: South Nation River, Payne River, Castor River, Bear Brook, Scotch River, Moose Creek, and several large municipal drains.

3.1.9.1 Surface Water Flows

Long term stream gauge data is available for several stations in the Source Protection Area. Three in particular are representative of the watershed conditions for the purpose of the conceptual understanding: South Nation River (near Plantagenet Springs), Bear Brook (near Bourget) and Payne River (near Berwick). Combined, these stations account for over 4,400 km^2 of drainage area. 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 3.3* and shown in *Figure 3.8* and *Figure 3.9*.

Table 3.3: Long Term Monthly Stream Flows, South Nation Source Protection Area

Month	South Nation River near Plantagenet Springs (02LB005)[1]		Bear Brook near Bourget (02LB008)[2]		Payne River near Berwick (02LB022)[3]	
	m^3/s	mm /year	m^3/s	mm /year	m^3/s	mm /year
January	22.3	16	2.6	16	1.2	21
February	21.4	14	3.9	21	1.6	26
March	121.8	86	15.9	97	4.6	82
April	198.5	135	23.5	138	6.0	103
May	37.8	27	5.2	31	1.5	26
June	15.6	11	3.0	18	0.6	11
July	9.0	6	1.1	7	0.3	6
August	6.9	5	1.2	7	0.3	4
September	6.5	4	1.4	8	0.4	6
October	17.2	12	3.2	20	1.1	20
November	32.4	22	5.5	32	1.9	32
December	31.6	22	5.1	31	1.8	32
Total for Year	**n.a.**	**359**	**n.a**	**426**	**n.a**	**367**

Notes:
1) Gauged watershed area is approximately 3810 km^2; period of analysis is 1915 to 2003 (89 years)
2) Gauged watershed area is approximately 440 km^2; period of analysis is 1976 to 2003 (28 years)
3) Gauged watershed area is approximately 85km^2; period of analysis is 1976 to 2003 (28 years)

Figure 3.8: Long Term Monthly Stream Flows, South Nation Source Protection Area

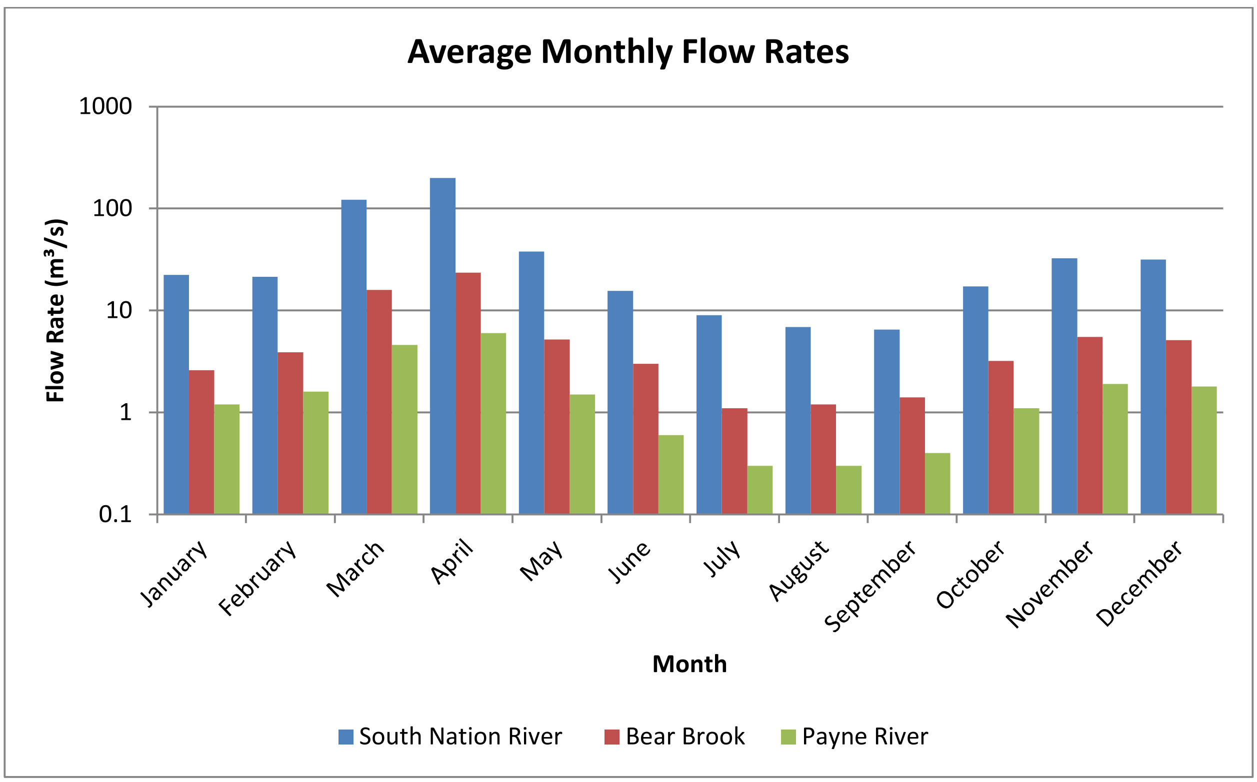
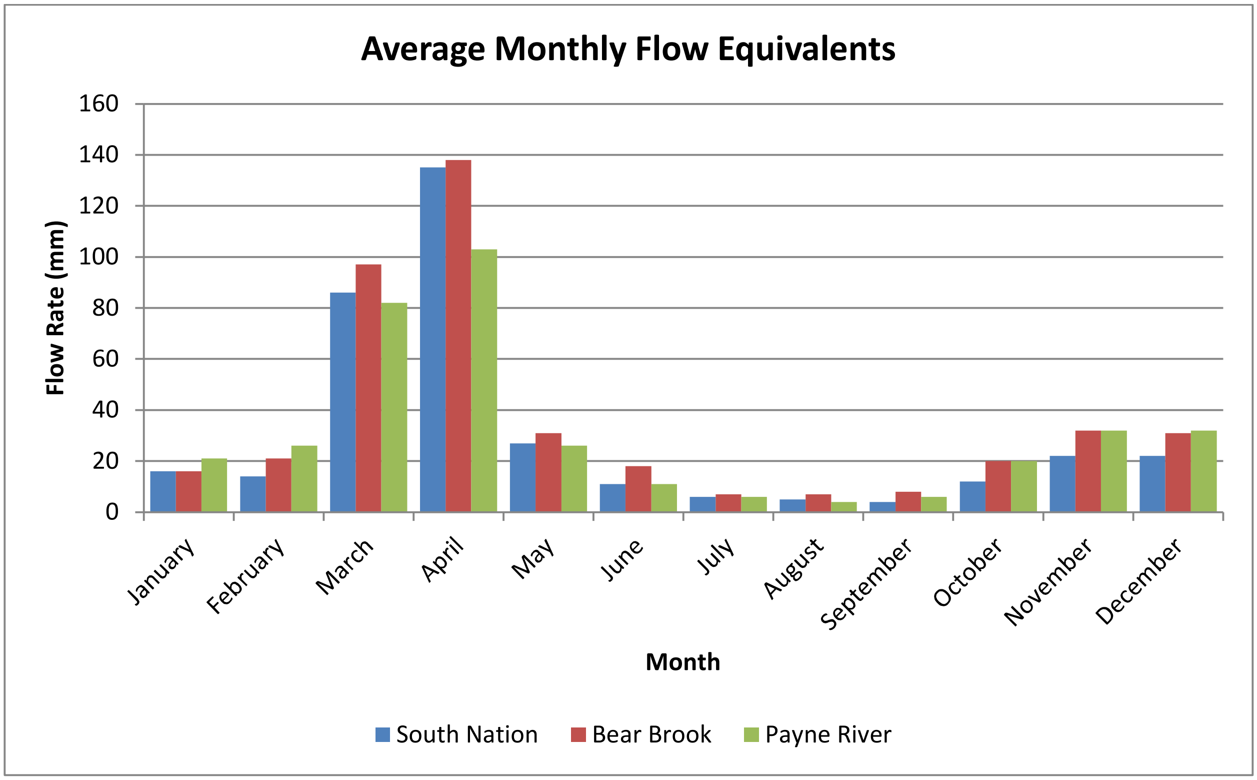


Figure 3.9: Long Term Monthly Stream Flow Equivalents, South Nation Source Protection Area



3.1.9.2 Surface Water Control Structures

The SNC maintains and operates several control structures along the reaches of its watercourses. The structures provide flood control, erosion control, low flow augmentation, hydroelectric generation and recreation.

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

Chesterville Dam

The Chesterville Dam was constructed in 1978 to replace an existing flashboard weir as part of an extensive South Nation River flood control and low-flow augmentation scheme. The dam is located near the town of Chesterville within the Township of North Dundas and controls a total drainage area of 1050 km². It consists of a 6-bay reinforced concrete structure. The main purpose of the dam is to provide flood control.

Crysler Dam

The Crysler Dam consists of an overflow section and a two-bay stop log sluiceway section. The dam is located in the Town of Crysler in the Township of North Stormont and controls a total drainage area of approximately 1300 km². The dam was originally built around 1900 and compromised the overflow section, north and south retaining wall, a north abutment, an intake sluiceway and a mill. In 1975 the dam was significantly modified by plugging the mill's intake sluiceway, strengthening the overflow dam stone and timber crib construction, adding a downstream concrete/stone apron, and constructing a new stop log sluiceway and low-flow augmentation and associated channel on the south river bank. The dam currently is used for recreation and low-flow augmentation.

Crysler Dyke

The Crysler Dyke was constructed in 1984 as a flood control project along the bank of the South Nation River within the village of Crysler. Flooding was a recurring problem in the area mainly due to ice jams, occurring every 2 to 3 years. The Crysler Dyke is approximately 391 meters long and varying from 1 to 3 meters high. A small detention pond and culvert system has been designed as well to handle local runoff with 3 storm sewer outfalls to the South Nation River outfit with flap gates.

Casselman Weir

The Casselman Weir was constructed in 1958 in the Village of Casselman, likely incorporating an existing timber crib weir. It currently consists of an overflow section and a one-bay stop log sluiceway section. In 1987, the construction of a 375 kW hydroelectric plant diverted water from immediately upstream of the weir. In 1996, the weir was raised by 0.6 m (2 ft) to increase water storage. The weir is used for recreation, low-flow augmentation, municipal water supply and hydroelectric requirements.

Russell Weir

The Russell Weir is located in the Town of Russell within the Township of Russell. In 1916, a reinforced concrete dam was built 60 m east of the existing road bridge at Russell, but it subsequently failed in 1959. In 1967, a 79 m long, 3.8 m high reinforced concrete weir was built downstream from the original 1916 dam site.

Plantagenet Weir

The Plantagenet Weir is south of Plantagenet, approximately 30 m north of the existing Railway Bridge crossing on the South Nation River. The purpose of this concrete weir is to provide flood control.

Seguinbourg Berm

The Seguinbourg Berm is located on the South Nation River at Casselman, Ontario. It was built to protect a section of the valley side from river erosion and to load the toe of the slope preventing its failure.

Spencerville Weir

SNC also operates and maintains the Spencerville Weir, which is owned and operated by the Spencerville Mill Preservation Society. The Spencerville Weir is located on the South Nation River in the village of Spencerville adjacent to the old Spencerville Mill in Lot 26, Concession VI of Edwardsburg Township. It was built in the last century to provide a millpond to operate the mill.

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 eleven systems that have a surface water intake, eight of which are municipal drinking water systems. The surface water intake locations are shown on *Map 3.6*.Four municipal surface water intakes are in the Ottawa River; three are in the St. Lawrence River and one within an “in-land” river (Village of Casselman). 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 3.4*.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 3.4: 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 11% of the wells in the Source Protection Area are overburden wells. Known surficial aquifer complexes are listed in *Table 3.5*.

Table 3.5: 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.

Source Protection Area	Aquifer	Notes
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 in SNC generally converges toward the South Nation River. To the northeast there is some divergence of groundwater flow away from the trace of the South Nation River; this occurs in the vicinity of Bourget, and farther to the northeast towards Hawkesbury. There are buried bedrock valleys in these areas and the direction of groundwater flow appears to follow the traces of the bedrock valleys. Along the northern boundary of SNC there appears to be a groundwater divide effectively containing shallow groundwater flow within the CA boundary.

Important groundwater resources within Eastern Ontario are the coarse-grained esker and fan complexes. Even though there are a number of wells completed within these esker deposits, their signature is not recognizable on the potentiometric surface. This is attributed to the relatively few wells completed in the overburden (and even less completed within the eskers) and the fact that the surface watercourses dominate the contouring of the potentiometric surface. Generally groundwater flow within the esker will be parallel to its length.

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 meters. Within the bedrock zones, horizontal flow is dominant. Groundwater flows out of the Source Protection Region 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

Groundwater drinking water systems are identified in *Section 2.6*. Of those systems identified there are eleven active municipal drinking water systems. 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 3.6* and represented on *Map 3.12*.

Table 3.6: Summary of Water Taking Permits (October 2009), South Nation Source Protection Area

General Purpose	Groundwater		Surface Water		Ground and Surface		Total Combined	
	# Permits	Max. Volume (m^3/year)	# Permits	Max. Volume (m^3/year)	# Permits	Max. Volume (m^3/year)	# Permits	Max. Volume (m^3/year)
Agricultural	13	18,826,750	8	2,263,598	8	16,977,586	29	38,067,933
Commercial	12	1,123,247	9	24,694,628	10	1,713,740	31	27,531,615
Dewatering	23	28,643,251	2	-	17	33,081,512	42	61,724,763
Dewatering Construction	3	784,137	1	7,500	9	44,028,904	13	44,820,541
Industrial	9	1,975,365	7	260,947,004	5	70,185,080	21	333,107,450
Miscellaneous[1]	1	1,296	31	317,805,681	4	2,089,826	36	319,896,803
Remediation	21	809,369					21	809,369
Recreational			1	-	2	37,661	3	37,661
Water Supply	46	15,306,160	13	24,561,319	5	208,940	64	40,076,420
Grand Total	**128**	**67,469,575**	**72**	**630,279,730**	**60**	**168,323,250**	**260**	**866,072,555**

Notes: 1) Most miscellaneous permits are for wildlife conservation (water impoundment structures, 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, water impoundments or construction purposes).

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 65,000 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 9.1 million cubic meters 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 occurs at a very local scale; recharge occurring within topographically higher regions, and discharge occurring tens of meters to a few kilometers 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 surfacewatercourse.

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 Source Protection Area, groundwater recharge is estimated conceptually to be 290 mm; with only 3mm 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 3.7*.

Table 3.7: Average Annual Baseflow Estimates, South Nation Source Protection Area

Gauge Location	Annual Discharge (mm/year)	Baseflow Fraction	Annual Baseflow (mm/year)
South Nation River near Plantagenet Springs (02LB005)	359	0.55	199
Bear Brook near Bourget (02LB008)	407	0.53	215
Payne River near Berwick (02LB022)	358	0.52	186

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.

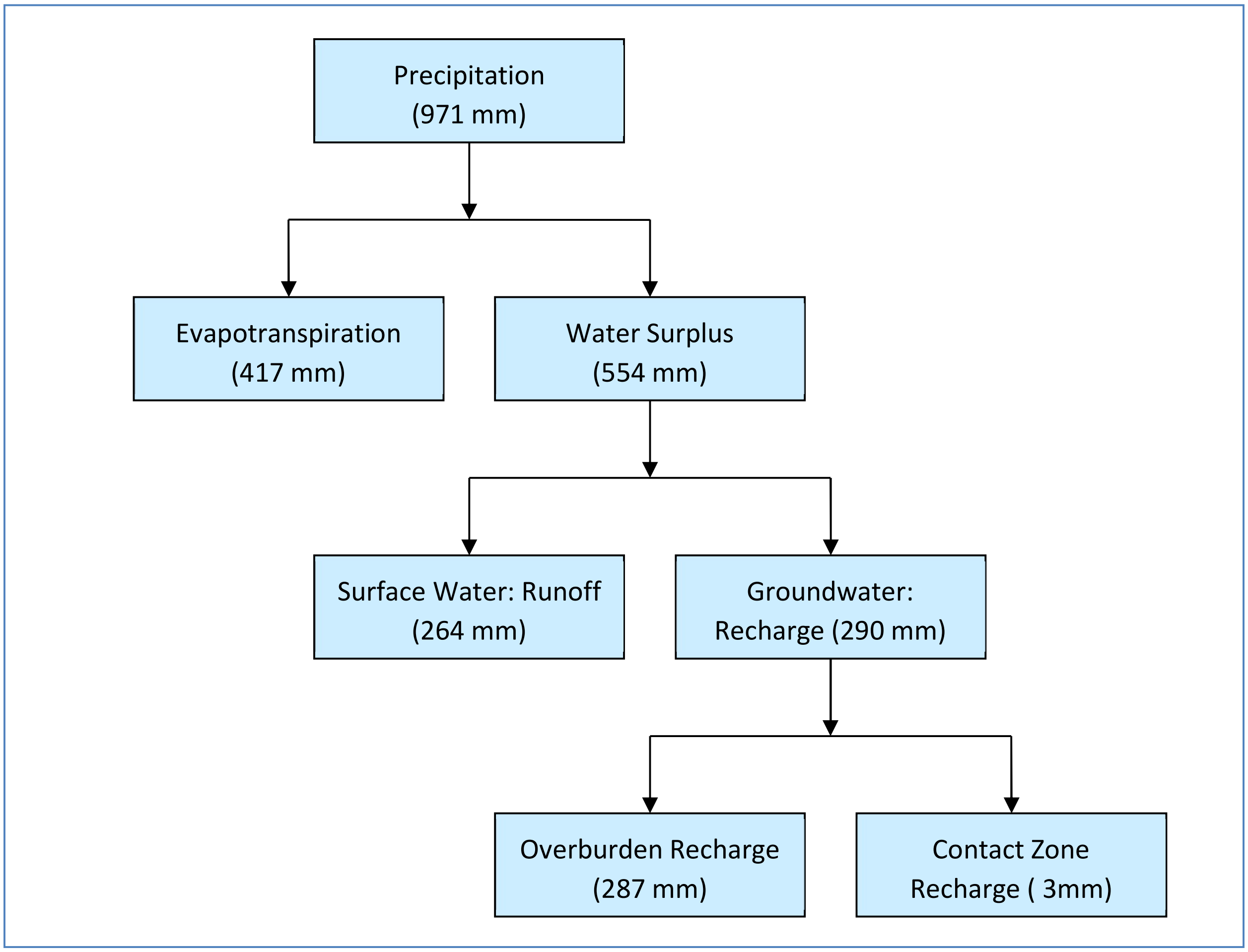
At a conceptual level, the components of the water budget are analyzed on an average annual basis. This analysis is conducted with an assumption of steady state (no change in storage). For this analysis, the water budget does not consider anthropogenic water inputs and outputs.

The natural water budget for the South Nation Source Protection Area is summarized in *Table 3.8* and shown in *Figure 3.10*.

Table 3.8: Components of the Natural Water Budget, South Nation Source Protection Area

Component	Mean (mm/yr)	Standard Deviation (mm/yr)	Minimum (mm/yr)	Maximum (mm/yr)	Range (mm/yr)
Precipitation	971	17	943	1023	80
Actual Evapotranspiration	417	140	150	640	490
Water Surplus	554	142	305	852	547
Surface Water (Fast Runoff)	264	104	31	635	604
Groundwater Recharge (Overburden and Contact Zone)	290	80	40	665	705
Groundwater Contact Zone Recharge	3	7	-86	111	197

Figure 3.10: 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. The delineation of subwatersheds resulted in 67 over the Source Protection Region and 53within the South Nation Source Protection Area. The subwatersheds are shown on *Map 3.14* and detailed in *Table 3.9*.

Table 3.9: Subwatersheds for Tier 1 Water Budget Analysis, South Nation Source Protection Area

SWS Reference #	Area (km²)	Common Subwatershed Name
14	152.4	Doran Creek
15	33.8	Glen Becker and Mariatown
16	38.9	Horse Creek
17	64.8	Louis Lafleur Drain and Bouvier Drain
18	55.9	Caledonia Creek
19	58.7	McKinnon Creek
20	61.5	Paxton Creek and Fournier
21	85.2	Bercier Drain and Riceville
22	96.6	South Indian Creek
23	26.1	North, South and Drain of Wolf Creek
24	88.5	Lower Moose Creek
25	104.1	West Branch of Scotch River
26	55.3	Piperville Drain
27	50.7	Bear River and Southern Bear Brook, Rochon Drain
28	29.8	Fifth Concession, Branch of York, Lower York Drains

SWS Reference #	Area (km²)	Common Subwatershed Name
29	124.7	North Castor River
30	70.8	Butternut Creek
31	97.5	Little Castor Creek
32	103.5	Middle Castor River and Craig Street
33	57.9	Cheney Drain
34	28.6	Upper Payne River
35	74.4	East Castor River
36	35.9	Foley Gillies Drain
37	125.1	Henderson Creek
38	58.6	Grantley Creek
39	23.9	Mullin Drain
40	140.7	North Branch of South Nation River
41	73.7	Hoasic Creek
42	79.5	Sandy Creek
43	29.2	Ault Monroe Drain
44	119.6	South Branch of South Nation River
45	84.4	Upper Black Creek
46	45.0	Indian Creek
47	145.5	Lord's Mills
48	134.5	Russell
49	287.1	Middle South Nation River and Cahore Drain
50	162.5	Clarence, Walsh Hayes, Nelson Charlebois Drains
51	285.6	Main Mouth of South Nation River
52	89.4	Belmeade
53	114.1	Central Cobb's Lake Creek and Bussiere Drain
54	31.0	Crown Swamp
55	149.9	Main Branch of Payne River and hart Creek
56	73.5	Main Branch of Hess Creek
57	152.0	Lower Headwaters of South Nation River
58	68.0	Drains to Ottawa River
59	100.3	Drains to Ottawa River

SWS Reference #	Area (km²)	Common Subwatershed Name
60	53.6	Drains to Ottawa River
61	80.5	Drains to Ottawa River
62	79.2	Drains to Ottawa River
63	106.5	Drains to Ottawa River
64	149.6	Drains to Ottawa River
67	91.4	East Branch of Scotch 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 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 3.10*.

Table 3.10: Tier 1 Consumptive Water Takings

SWS	Surface Water Takings (m³/s)		Groundwater Takings (m³/s)				Total Combined Taking (mm/yr)
	Municipal	PTTW	Municipal	PTTW	Agricultural	Private	
14				0.000	0.004	0.001	1
15					0.004	0.001	4
16					0.002	0.000	1
17		0.013		0.004	0.001		9
18					0.003	0.000	2

SWS	Surface Water Takings (m^3/s)		Groundwater Takings (m^3/s)				Total Combined Taking (mm/yr)
	Municipal	PTTW	Municipal	PTTW	Agricultural	Private	
19					0.007	0.000	4
20					0.003	0.000	2
21		0.001	0.000	0.001	0.005	0.001	3
22			0.002	0.002	0.007	0.001	4
23					0.001	0.000	2
24			0.000		0.003	0.001	1
25					0.003	0.001	1
26		0.009		0.007	0.007	0.000	13
27				0.004	0.006	0.000	6
28					0.002	0.000	2
29				0.048	0.015	0.000	16
30		0.001			0.003	0.000	2
31			0.006		0.004	0.001	4
32		0.012		0.022	0.013	0.000	14
33			0.001		0.004	0.000	3
34					0.001	0.000	1
35			0.005		0.003	0.001	3
36					0.001	0.000	1
37		0.194	0.002	0.203	0.004	0.001	102
38				0.015	0.002	0.000	9
39					0.001	0.000	1
40				0.004	0.003	0.001	2
41					0.003	0.001	2
42					0.003	0.001	1
43					0.001	0.000	2
44					0.002	0.001	1
45					0.003	0.001	1
46					0.001	0.000	1
47					0.003	0.001	1

SWS	Surface Water Takings (m^3/s)		Groundwater Takings (m^3/s)				Total Combined Taking (mm/yr)
	Municipal	PTTW	Municipal	PTTW	Agricultural	Private	
48					0.011	0.001	3
49	0.002			0.013	0.011	0.002	3
50			0.001		0.014	0.001	3
51		0.004		0.001	0.013	0.002	2
52					0.010	0.000	4
53		0.019			0.004	0.001	7
54					0.002	0.000	2
55			0.001		0.004	0.001	1
56					0.003	0.000	2
57				0.005	0.003	0.001	2
58					0.003	0.000	1
59				0.001	0.004	0.001	2
60				0.001	0.002	0.000	1
61				0.001	0.002	0.001	1
62				0.001	0.003	0.001	2
63		0.012		0.023	0.003	0.001	11
64				0.001	0.006	0.001	2
67			0.000	0.008	0.003	0.001	4

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, the 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 3.10*); 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

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

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 in *Table 3.11*.

Table 3.11: Tier 1 Monthly and Annual Water Budgets by Subwatershed

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
14	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.5	12.1	5.2	4.7	4.1	3.4	7.7	12.8	4.1	8	24.1	89.2
	IF	11.7	3.1	43.6	22.2	12.1	6.3	0.3	1.6	24.3	2.1	9.2	14.8	151.2
	BF	31.7	5.3	37.6	33.6	13	3.8	3	6	21.7	11.9	20.3	29.5	217.6

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	ET	0	1.4	2	18	72	95.2	110.2	84	55.1	23.7	2.7	1.1	465.5
	Deep	2.5	0.8	6.7	4	2.1	0.9	1.4	1.5	4.2	2.2	3.6	3.3	33.3
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	43.8	10.9	93.3	61	29.8	14.2	6.7	15.3	58.8	18.1	37.5	68.4	458
15	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.5	12.1	5.2	4.7	4.1	3.4	7.7	12.8	4.1	8	24.1	89.2
	IF	11.7	3.1	43.6	22.2	12.1	6.3	0.3	1.6	24.3	2.1	9.2	14.8	151.2
	BF	31.7	5.3	37.6	33.6	13	3.8	3	6	21.7	11.9	20.3	29.5	217.6
	ET	0	1.4	2	18	72	95.2	110.2	84	55.1	23.7	2.7	1.1	465.5
	Deep	2.5	0.8	6.7	4	2.1	0.9	1.4	1.5	4.2	2.2	3.6	3.3	33.3
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	43.8	10.9	93.3	61	29.8	14.2	6.7	15.3	58.8	18.1	37.5	68.4	458
16	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
17	Precip	2.2	8.9	146.1	88.1	73.4	76.2	65	111	143.8	60.5	89.9	56.4	921.4
	OF	0.3	1	18	7.7	5.8	5	4.2	9.5	16.1	5.1	9.8	6.5	89
	IF	6.6	0.7	69.8	19.4	6.4	2.3	0	2.4	37.6	0.3	13.5	12.5	171.5
	BF	15.8	1.5	15.4	35.4	11.3	3.5	2	5.3	18.5	7.3	17.9	16.9	151
	ET	0	0.1	8.1	27.3	65.8	89.5	95.8	81	52.8	23.5	6.7	0.3	451
	Deep	1.4	0.6	9	10.8	4.8	2.5	2.1	3.7	7.9	4.2	7.9	4.1	59
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	22.7	3.2	103.3	62.5	23.5	10.8	6.1	17.2	72.2	12.7	41.2	36	411.4
18	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
19	Precip	2.2	8.9	146.1	88.1	73.4	76.2	65	111	143.8	60.5	89.9	56.4	921.4

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	OF	0.3	1	18	7.7	5.8	5	4.2	9.5	16.1	5.1	9.8	6.5	89
	IF	6.6	0.7	69.8	19.4	6.4	2.3	0	2.4	37.6	0.3	13.5	12.5	171.5
	BF	15.8	1.5	15.4	35.4	11.3	3.5	2	5.3	18.5	7.3	17.9	16.9	151
	ET	0	0.1	8.1	27.3	65.8	89.5	95.8	81	52.8	23.5	6.7	0.3	451
	Deep	1.4	0.6	9	10.8	4.8	2.5	2.1	3.7	7.9	4.2	7.9	4.1	59
	SWin	41	5.8	186.5	112.9	42.5	19.4	11.1	31.1	130.4	22.9	74.3	64.9	742.9
	SWout	63.7	9.1	289.7	175.5	66	30.2	17.2	48.4	202.6	35.6	115.5	100.9	1154.4
20	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
21	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	45.6	17.5	248.5	166.1	55	34.1	20.7	38.8	117.3	26.4	73.6	97.5	941.2
	SWout	49.8	19.5	354.4	245.3	73.6	43.8	24	48.6	186.9	33.4	108	124.8	1312.1
22	Precip	2.2	8.9	146.1	88.1	73.4	76.2	65	111	143.8	60.5	89.9	56.4	921.4
	OF	0.3	1	18	7.7	5.8	5	4.2	9.5	16.1	5.1	9.8	6.5	89
	IF	6.6	0.7	69.8	19.4	6.4	2.3	0	2.4	37.6	0.3	13.5	12.5	171.5
	BF	15.8	1.5	15.4	35.4	11.3	3.5	2	5.3	18.5	7.3	17.9	16.9	151
	ET	0	0.1	8.1	27.3	65.8	89.5	95.8	81	52.8	23.5	6.7	0.3	451
	Deep	1.4	0.6	9	10.8	4.8	2.5	2.1	3.7	7.9	4.2	7.9	4.1	59
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	22.7	3.2	103.3	62.5	23.5	10.8	6.1	17.2	72.2	12.7	41.2	36	411.4
23	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
24	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
25	Precip	6.6	3.6	165.6	95.8	77.7	62	116.1	119.6	78.5	40.4	96.3	99.1	961.2
	OF	0.9	1	22.3	7.5	6.1	4.4	8.7	9.9	7.9	2.9	9.4	14.8	96
	IF	3.6	0.1	73.3	25	1.8	0.7	0.2	1.3	6.2	0.2	4.9	13.3	130.7
	BF	29	11.4	14.7	33.9	20.7	14.3	5.1	11.9	20.8	12.4	15.6	27.7	217.6
	ET	0	1.4	2	18	72	93.3	110.2	86.2	55.5	28	13	1.1	480.8
	Deep	0.5	0.2	3	3.4	1.6	1.1	2.2	2	2.1	0.9	2.9	2.1	21.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	33.6	12.5	110.3	66.5	28.6	19.4	14	23.2	34.9	15.5	30	55.9	444.3
26	Precip	2.2	8.9	146.1	88.1	73.4	76.2	65	111	143.8	60.5	89.9	56.4	921.4
	OF	0.3	1	18	7.7	5.8	5	4.2	9.5	16.1	5.1	9.8	6.5	89
	IF	6.6	0.7	69.8	19.4	6.4	2.3	0	2.4	37.6	0.3	13.5	12.5	171.5
	BF	15.8	1.5	15.4	35.4	11.3	3.5	2	5.3	18.5	7.3	17.9	16.9	151
	ET	0	0.1	8.1	27.3	65.8	89.5	95.8	81	52.8	23.5	6.7	0.3	451
	Deep	1.4	0.6	9	10.8	4.8	2.5	2.1	3.7	7.9	4.2	7.9	4.1	59
	SWin	20.8	3	94.7	57.4	21.6	9.9	5.6	15.8	66.2	11.6	37.8	33	377.3
	SWout	43.5	6.2	198	119.9	45.1	20.6	11.8	33.1	138.4	24.3	78.9	68.9	788.7
27	Precip	2.2	8.9	146.1	88.1	73.4	76.2	65	111	143.8	60.5	89.9	56.4	921.4
	OF	0.3	1	18	7.7	5.8	5	4.2	9.5	16.1	5.1	9.8	6.5	89
	IF	6.6	0.7	69.8	19.4	6.4	2.3	0	2.4	37.6	0.3	13.5	12.5	171.5
	BF	15.8	1.5	15.4	35.4	11.3	3.5	2	5.3	18.5	7.3	17.9	16.9	151
	ET	0	0.1	8.1	27.3	65.8	89.5	95.8	81	52.8	23.5	6.7	0.3	451
	Deep	1.4	0.6	9	10.8	4.8	2.5	2.1	3.7	7.9	4.2	7.9	4.1	59
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	22.7	3.2	103.3	62.5	23.5	10.8	6.1	17.2	72.2	12.7	41.2	36	411.4
28	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.8	9.9	6.5	5.7	4.8	11	18.7	5.6	10.6	5.9	102.3

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	IF	16.8	0.2	76.3	48	7	0.9	0	1.8	57.4	1	10.4	13.9	233.7
	BF	12.8	4.1	6.6	15.5	11.4	7.6	1.9	2.3	7.7	5.7	10.6	11.2	97.3
	ET	0	1.4	6.6	33.8	66.7	86.8	75.4	89.2	47.5	26.7	9.5	1.1	444.7
	Deep	3.1	2.9	9.6	11.6	7.7	6.5	2.9	5.6	8.9	5.5	10.8	5.8	80.8
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	29.8	5	105.8	73.5	24.8	14.2	6.7	15	83.9	12.4	31.5	31	433.4
29	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.4	9.7	6.3	5.5	4.6	10.8	18.3	5.5	10.4	5.7	100
	IF	16.7	0.2	75.3	47.6	7	0.9	0	2.1	55.9	1	10.8	14	231.4
	BF	12.8	4.1	6.7	15.8	11.6	7.7	1.9	2.2	7.8	5.7	10.2	10.9	97.6
	ET	0	1.4	7.7	34	66.9	87.3	75.7	89.2	48.1	26.8	9.5	1.1	447.7
	Deep	2	1.8	11.5	14.2	8.6	6.8	1.7	5.4	10.4	5.4	12.7	6	86.5
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	29.7	4.9	104.3	73.1	25	14.2	6.6	15	82	12.2	31.4	30.7	429
30	Precip	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
31	Precip	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
32	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.4	9.7	6.3	5.5	4.6	10.8	18.3	5.5	10.4	5.7	100
	IF	16.7	0.2	75.3	47.6	7	0.9	0	2.1	55.9	1	10.8	14	231.4
	BF	12.8	4.1	6.7	15.8	11.6	7.7	1.9	2.2	7.8	5.7	10.2	10.9	97.6
	ET	0	1.4	7.7	34	66.9	87.3	75.7	89.2	48.1	26.8	9.5	1.1	447.7
	Deep	2	1.8	11.5	14.2	8.6	6.8	1.7	5.4	10.4	5.4	12.7	6	86.5

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	SWin	35.8	5.9	125.7	88.1	30.1	17.1	7.9	18.1	98.8	14.7	37.9	37	517
	SWout	65.6	10.8	230	161.2	55.1	31.3	14.5	33.1	180.7	26.9	69.3	67.7	946.1
33	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.8	9.9	6.5	5.7	4.8	11	18.7	5.6	10.6	5.9	102.3
	IF	16.8	0.2	76.3	48	7	0.9	0	1.8	57.4	1	10.4	13.9	233.7
	BF	12.8	4.1	6.6	15.5	11.4	7.6	1.9	2.3	7.7	5.7	10.6	11.2	97.3
	ET	0	1.4	6.6	33.8	66.7	86.8	75.4	89.2	47.5	26.7	9.5	1.1	444.7
	Deep	3.1	2.9	9.6	11.6	7.7	6.5	2.9	5.6	8.9	5.5	10.8	5.8	80.8
	SWin	102.6	17.1	364.5	253.2	85.5	48.9	23	51.8	289	42.6	108.7	106.7	1493.5
	SWout	132.4	22.1	470.3	326.6	110.3	63.1	29.6	66.8	372.9	54.9	140.2	137.7	1926.9
34	Precip	3.6	7.1	167.9	93.7	77.7	62	116.1	119.6	78.5	40.4	96.3	103.9	966.7
	OF	0.4	0.7	24	8.2	5.5	3.9	7.8	8.9	7.1	2.8	8.9	12.7	90.7
	IF	4.2	0.3	76.6	24.8	2.6	1.3	0.5	2.5	9.5	0.5	9.3	19.5	151.8
	BF	11.3	2.8	11.6	33.1	9.8	5	1.9	5.8	12.4	4.7	12	24.7	135.2
	ET	0	0.3	7.6	26.9	72.1	94	111	87.1	55.8	24.2	6.6	0.6	486.1
	Deep	1.8	0.9	14.8	16.9	6.6	4.4	8.6	8.3	8.4	3.9	12.8	11.9	99.6
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	15.9	3.9	112.2	66.1	17.9	10.3	10.2	17.2	29.1	7.9	30.2	56.9	377.8
35	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.8	9.9	6.5	5.7	4.8	11	18.7	5.6	10.6	5.9	102.3
	IF	16.8	0.2	76.3	48	7	0.9	0	1.8	57.4	1	10.4	13.9	233.7
	BF	12.8	4.1	6.6	15.5	11.4	7.6	1.9	2.3	7.7	5.7	10.6	11.2	97.3
	ET	0	1.4	6.6	33.8	66.7	86.8	75.4	89.2	47.5	26.7	9.5	1.1	444.7
	Deep	3.1	2.9	9.6	11.6	7.7	6.5	2.9	5.6	8.9	5.5	10.8	5.8	80.8
	SWin	50.1	8.3	177.9	123.6	41.7	23.9	11.2	25.3	141.1	20.8	53	52.1	729
	SWout	79.9	13.3	283.7	197	66.5	38.1	17.9	40.3	224.9	33.1	84.6	83	1162.3
36	Precip	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
37	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.8	9.9	6.5	5.7	4.8	11	18.7	5.6	10.6	5.9	102.3
	IF	16.8	0.2	76.3	48	7	0.9	0	1.8	57.4	1	10.4	13.9	233.7

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	BF	12.8	4.1	6.6	15.5	11.4	7.6	1.9	2.3	7.7	5.7	10.6	11.2	97.3
	ET	0	1.4	6.6	33.8	66.7	86.8	75.4	89.2	47.5	26.7	9.5	1.1	444.7
	Deep	3.1	2.9	9.6	11.6	7.7	6.5	2.9	5.6	8.9	5.5	10.8	5.8	80.8
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	29.8	5	105.8	73.5	24.8	14.2	6.7	15	83.9	12.4	31.5	31	433.4
38	Precip	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
39	Precip	4.3	45.5	80.8	71.1	73.4	76.2	65	111	143.8	60.5	87.9	96.8	916.2
	OF	0.5	8.1	10.2	6.2	6.3	5.4	4.5	10.3	17	5.5	10.5	17.7	102.1
	IF	11.4	6.7	25.4	15.5	10.7	5	0.2	0.9	18.7	1.7	7	21.8	125
	BF	17.7	9.8	13.3	11.4	6.9	4	3.2	3.5	6.1	7.1	9.7	15.2	108
	ET	0	1.4	2	18	72	93	105.9	80.9	53	23.8	4.8	1.1	456
	Deep	0.6	13.8	23.2	12	10	4.4	0.1	1	19.1	1.5	13	22.8	121.5
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	29.6	24.6	48.9	33.1	23.9	14.4	7.9	14.7	41.8	14.3	27.2	54.7	335.1
40	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.5	2.8	13.4	5.7	5.3	4.5	3.7	8.5	14.2	4.6	8.9	24.1	96.2
	IF	10.9	3	41.4	21	11.5	6	0.2	1.5	22.3	1.9	8.5	14.5	142.8
	BF	30.9	5.1	38.8	34.4	13.5	4.4	3.5	6.4	22.2	12	20.4	29.2	220.8
	ET	0	1.4	2	18	72	94.5	109.1	83.2	54.5	23.6	2.7	1.1	462.1
	Deep	2.5	0.8	6.9	4	2.2	1.1	1.5	1.6	4.2	2.2	3.6	3.4	34
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	42.3	10.9	93.6	61.1	30.3	14.9	7.4	16.4	58.7	18.5	37.8	67.8	459.8
41	Precip	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

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	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
42	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.5	12.1	5.2	4.7	4.1	3.4	7.7	12.8	4.1	8	24.1	89.2
	IF	11.7	3.1	43.6	22.2	12.1	6.3	0.3	1.6	24.3	2.1	9.2	14.8	151.2
	BF	31.7	5.3	37.6	33.6	13	3.8	3	6	21.7	11.9	20.3	29.5	217.6
	ET	0	1.4	2	18	72	95.2	110.2	84	55.1	23.7	2.7	1.1	465.5
	Deep	2.5	0.8	6.7	4	2.1	0.9	1.4	1.5	4.2	2.2	3.6	3.3	33.3
	SWin	128.4	32	273.5	178.8	87.4	41.6	19.6	44.9	172.4	53.1	109.9	200.5	1342.7
	SWout	172.2	42.9	366.8	239.8	117.2	55.8	26.3	60.2	231.2	71.2	147.4	268.9	1799.9
43	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.5	12.1	5.2	4.7	4.1	3.4	7.7	12.8	4.1	8	24.1	89.2
	IF	11.7	3.1	43.6	22.2	12.1	6.3	0.3	1.6	24.3	2.1	9.2	14.8	151.2
	BF	31.7	5.3	37.6	33.6	13	3.8	3	6	21.7	11.9	20.3	29.5	217.6
	ET	0	1.4	2	18	72	95.2	110.2	84	55.1	23.7	2.7	1.1	465.5
	Deep	2.5	0.8	6.7	4	2.1	0.9	1.4	1.5	4.2	2.2	3.6	3.3	33.3
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	43.8	10.9	93.3	61	29.8	14.2	6.7	15.3	58.8	18.1	37.5	68.4	458
44	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.5	12.1	5.2	4.7	4.1	3.4	7.7	12.8	4.1	8	24.1	89.2
	IF	11.7	3.1	43.6	22.2	12.1	6.3	0.3	1.6	24.3	2.1	9.2	14.8	151.2
	BF	31.7	5.3	37.6	33.6	13	3.8	3	6	21.7	11.9	20.3	29.5	217.6
	ET	0	1.4	2	18	72	95.2	110.2	84	55.1	23.7	2.7	1.1	465.5
	Deep	2.5	0.8	6.7	4	2.1	0.9	1.4	1.5	4.2	2.2	3.6	3.3	33.3
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	43.8	10.9	93.3	61	29.8	14.2	6.7	15.3	58.8	18.1	37.5	68.4	458
45	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.5	12.1	5.2	4.7	4.1	3.4	7.7	12.8	4.1	8	24.1	89.2
	IF	11.7	3.1	43.6	22.2	12.1	6.3	0.3	1.6	24.3	2.1	9.2	14.8	151.2
	BF	31.7	5.3	37.6	33.6	13	3.8	3	6	21.7	11.9	20.3	29.5	217.6
	ET	0	1.4	2	18	72	95.2	110.2	84	55.1	23.7	2.7	1.1	465.5
	Deep	2.5	0.8	6.7	4	2.1	0.9	1.4	1.5	4.2	2.2	3.6	3.3	33.3
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	43.8	10.9	93.3	61	29.8	14.2	6.7	15.3	58.8	18.1	37.5	68.4	458
46	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.4	11.4	4.9	4.5	3.8	3.2	7.2	12.1	3.9	7.5	22.2	83.3
	IF	11	3	42	21.4	11.7	6.2	0.2	1.5	22.5	1.9	8.7	14.9	145
	BF	31.4	5.2	39.6	35.1	13.8	4.5	3.6	6.4	22.6	12.2	20.6	29.8	224.6

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	ET	0	1.4	2	18	72	95.6	110.7	84.3	55.4	23.8	2.7	1.1	467
	Deep	2.5	0.9	7	4.1	2.2	1.1	1.5	1.7	4.3	2.2	3.7	3.4	34.6
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	42.9	10.6	92.9	61.4	30	14.4	7	15.1	57.2	18	36.8	66.8	452.9
47	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.4	2.4	11.4	4.9	4.5	3.8	3.2	7.2	12.1	3.9	7.5	22.2	83.3
	IF	11	3	42	21.4	11.7	6.2	0.2	1.5	22.5	1.9	8.7	14.9	145
	BF	31.4	5.2	39.6	35.1	13.8	4.5	3.6	6.4	22.6	12.2	20.6	29.8	224.6
	ET	0	1.4	2	18	72	95.6	110.7	84.3	55.4	23.8	2.7	1.1	467
	Deep	2.5	0.9	7	4.1	2.2	1.1	1.5	1.7	4.3	2.2	3.7	3.4	34.6
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	42.9	10.6	92.9	61.4	30	14.4	7	15.1	57.2	18	36.8	66.8	452.9
48	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.4	9.7	6.3	5.5	4.6	10.8	18.3	5.5	10.4	5.7	100
	IF	16.7	0.2	75.3	47.6	7	0.9	0	2.1	55.9	1	10.8	14	231.4
	BF	12.8	4.1	6.7	15.8	11.6	7.7	1.9	2.2	7.8	5.7	10.2	10.9	97.6
	ET	0	1.4	7.7	34	66.9	87.3	75.7	89.2	48.1	26.8	9.5	1.1	447.7
	Deep	2	1.8	11.5	14.2	8.6	6.8	1.7	5.4	10.4	5.4	12.7	6	86.5
	SWin	133.7	22.1	472	329.3	111.9	63.8	29.8	67.4	372.5	55.2	141.5	138.5	1937.7
	SWout	163.5	27	576.3	402.4	136.8	78	36.3	82.4	454.4	67.4	172.9	169.2	2366.7
49	Precip	4.4	44.5	79.8	71.1	73.4	76.2	65	111	143.8	60.5	87.9	96.3	913.8
	OF	0.5	7.9	9.6	6.1	6.2	5.3	4.4	10.1	16.7	5.4	10.3	18.6	100.9
	IF	12.1	6.6	24.2	15.6	11	5.2	0.2	1	19.1	1.7	7.2	20.8	124.3
	BF	18.2	10	13.6	11.8	7.1	4.1	3.3	3.6	6.2	7.2	9.8	15	109.5
	ET	0	1.4	2	18	72	93.2	106.2	81.1	53.2	23.6	4.6	1.1	456.4
	Deep	0.7	14.1	21.3	12.4	10.3	4.6	0.1	1.1	19.5	1.6	13.2	22.4	121
	SWin	244.9	75.7	657	441.3	188.9	101.4	52.6	110.9	445.4	105	237.7	370.6	3031.7
	SWout	275.6	100.1	704.4	474.8	213.1	115.9	60.5	125.4	487.2	119.3	264.9	425	3366.4
50	Precip	2.2	8.9	146.1	88.1	73.4	76.2	65	111	143.8	60.5	89.9	56.4	921.4
	OF	0.3	1	18	7.7	5.8	5	4.2	9.5	16.1	5.1	9.8	6.5	89
	IF	6.6	0.7	69.8	19.4	6.4	2.3	0	2.4	37.6	0.3	13.5	12.5	171.5
	BF	15.8	1.5	15.4	35.4	11.3	3.5	2	5.3	18.5	7.3	17.9	16.9	151
	ET	0	0.1	8.1	27.3	65.8	89.5	95.8	81	52.8	23.5	6.7	0.3	451
	Deep	1.4	0.6	9	10.8	4.8	2.5	2.1	3.7	7.9	4.2	7.9	4.1	59
	SWin	45.6	6.5	207.3	125.5	47.2	21.6	12.3	34.6	144.9	25.5	82.6	72.2	825.8
	SWout	68.3	9.7	310.5	188.1	70.8	32.3	18.5	51.9	217.1	38.2	123.8	108.1	1237.3

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
51	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	337	114.9	1144.7	772.6	303.5	162.1	83.3	184.3	770.3	161.7	419.1	565.5	5019.2
	SWout	341.2	117	1250.7	851.7	322.1	171.8	86.6	194.1	839.9	168.6	453.6	592.7	5390.1
52	Precip	1.6	4.9	162.3	100.8	73.4	76.2	65	111	143.8	60.5	88.6	46	934.1
	OF	0.2	0.6	22.4	9.7	6.3	5.5	4.6	10.8	18.3	5.5	10.4	5.7	100
	IF	16.7	0.2	75.3	47.6	7	0.9	0	2.1	55.9	1	10.8	14	231.4
	BF	12.8	4.1	6.7	15.8	11.6	7.7	1.9	2.2	7.8	5.7	10.2	10.9	97.6
	ET	0	1.4	7.7	34	66.9	87.3	75.7	89.2	48.1	26.8	9.5	1.1	447.7
	Deep	2	1.8	11.5	14.2	8.6	6.8	1.7	5.4	10.4	5.4	12.7	6	86.5
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	29.7	4.9	104.3	73.1	25	14.2	6.6	15	82	12.2	31.4	30.7	429
53	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
54	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	12.1	5.8	302.2	225.7	53.1	27.7	9.4	27.9	198.5	19.8	98.2	77.6	1058.1
	SWout	16.4	7.9	408.2	304.8	71.8	37.4	12.7	37.7	268	26.7	132.7	104.9	1429
55	Precip	3.6	7.1	167.9	93.7	77.7	62	116.1	119.6	78.5	40.4	96.3	103.9	966.7
	OF	0.4	0.7	24	8.2	5.5	3.9	7.8	8.9	7.1	2.8	8.9	12.7	90.7
	IF	4.2	0.3	76.6	24.8	2.6	1.3	0.5	2.5	9.5	0.5	9.3	19.5	151.8
	BF	11.3	2.8	11.6	33.1	9.8	5	1.9	5.8	12.4	4.7	12	24.7	135.2
	ET	0	0.3	7.6	26.9	72.1	94	111	87.1	55.8	24.2	6.6	0.6	486.1

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Deep	1.8	0.9	14.8	16.9	6.6	4.4	8.6	8.3	8.4	3.9	12.8	11.9	99.6
	SWin	3	0.7	21.4	12.6	3.4	2	1.9	3.3	5.5	1.5	5.8	10.9	72.1
	SWout	19	4.6	133.6	78.7	21.3	12.2	12.2	20.5	34.6	9.4	36	67.7	449.9
56	Precip	4.3	45.5	80.8	71.1	73.4	76.2	65	111	143.8	60.5	87.9	96.8	916.2
	OF	0.5	8.1	10.2	6.2	6.3	5.4	4.5	10.3	17	5.5	10.5	17.7	102.1
	IF	11.4	6.7	25.4	15.5	10.7	5	0.2	0.9	18.7	1.7	7	21.8	125
	BF	17.7	9.8	13.3	11.4	6.9	4	3.2	3.5	6.1	7.1	9.7	15.2	108
	ET	0	1.4	2	18	72	93	105.9	80.9	53	23.8	4.8	1.1	456
	Deep	0.6	13.8	23.2	12	10	4.4	0.1	1	19.1	1.5	13	22.8	121.5
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	29.6	24.6	48.9	33.1	23.9	14.4	7.9	14.7	41.8	14.3	27.2	54.7	335.1
57	Precip	4.3	27.2	129.5	74.9	73.4	76.2	65	111	143.8	60.5	88.6	109.7	964.2
	OF	0.5	2.8	13.4	5.7	5.3	4.5	3.7	8.5	14.2	4.6	8.9	24.1	96.2
	IF	10.9	3	41.4	21	11.5	6	0.2	1.5	22.3	1.9	8.5	14.5	142.8
	BF	30.9	5.1	38.8	34.4	13.5	4.4	3.5	6.4	22.2	12	20.4	29.2	220.8
	ET	0	1.4	2	18	72	94.5	109.1	83.2	54.5	23.6	2.7	1.1	462.1
	Deep	2.5	0.8	6.9	4	2.2	1.1	1.5	1.6	4.2	2.2	3.6	3.4	34
	SWin	92.9	23.3	203	133.5	65.6	31.9	15.6	34.1	126	39.7	81.1	146.5	993.2
	SWout	135.2	34.3	296.6	194.6	95.9	46.8	23	50.5	184.7	58.2	118.9	214.3	1453
58	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
59	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
60	Precip	6.5	9.8	191.3	98.6	77.7	62	116.1	119.6	78.5	40.4	96.5	88.1	985

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	OF	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
	IF	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
	BF	9	1.5	15.3	38.4	10.1	6.2	3.5	8.1	15.9	4.7	21	17	150.6
	ET	0	1.4	2	18	72	91.8	104.3	84.1	54.6	24.1	2.7	1.1	456.2
	Deep	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
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	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
61	Precip	6.5	9.8	191.3	98.6	77.7	62	116.1	119.6	78.5	40.4	96.5	88.1	985
	OF	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
	IF	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
	BF	9	1.5	15.3	38.4	10.1	6.2	3.5	8.1	15.9	4.7	21	17	150.6
	ET	0	1.4	2	18	72	91.8	104.3	84.1	54.6	24.1	2.7	1.1	456.2
	Deep	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
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	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
62	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
63	Precip	6.5	9.8	191.3	98.6	77.7	62	116.1	119.6	78.5	40.4	96.5	88.1	985
	OF	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
	IF	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
	BF	9	1.5	15.3	38.4	10.1	6.2	3.5	8.1	15.9	4.7	21	17	150.6
	ET	0	1.4	2	18	72	91.8	104.3	84.1	54.6	24.1	2.7	1.1	456.2
	Deep	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
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	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
64	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9
67	Precip	1.8	12.2	180.6	119.6	73.4	76.2	65	111	143.8	60.5	89.4	42.7	976.1
	OF	0.8	1.5	16	7	4.3	3.8	3.2	7.2	12.2	3.6	7.1	3.7	70.4
	IF	0.1	0.1	38.1	21.2	6.1	1.3	0	1.3	42.2	0.1	10.3	11.2	131.9
	BF	3.3	0.5	51.9	51	8.3	4.6	0.1	1.2	15.2	3.2	17.1	12.3	168.6
	ET	0	1.4	2	18	72	92.8	95.4	78.6	52.7	28	10.8	1.1	452.9
	Deep	0.1	0.4	43.5	15.7	5.8	1.3	0	1.3	42.2	0.1	16.7	19.9	146.9
	SWin	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWout	4.2	2	106	79.1	18.6	9.7	3.3	9.8	69.6	6.9	34.4	27.2	370.9

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 53 (South Nation) and 14 (Raisin) subwatersheds. The thresholds for qualifying water quantity stress levels are shown in *Table 3.12*.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 3.12: 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 3.13*.Future demand stress assessments were carried out for the single subwatershed in the Source Protection Area that has a municipal drinking water system not on the St. Lawrence River or Ottawa River (Village of Casselman). The results of the future demand stress assessment are shown in *Table 3.14*.

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 3.13: Tier 1 Surface Water Stress Assessment, Current Demand (flows in m³/s)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
14	Q_{SUPPLY}	1.791	0.437	4.787	3.305	1.190	0.555	0.226	0.500	1.584	0.832	1.714	2.552
	$Q_{RESERVE}$	0.724	0.249	1.987	2.523	0.563	0.247	0.152	0.264	0.329	0.555	0.991	1.412
	Q_{DEMAND}	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%
15	Q_{SUPPLY}	0.397	0.097	1.062	0.733	0.264	0.123	0.050	0.111	0.351	0.185	0.380	0.566
	$Q_{RESERVE}$	0.161	0.055	0.441	0.560	0.125	0.055	0.034	0.058	0.073	0.123	0.220	0.313
	Q_{DEMAND}	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%
16	Q_{SUPPLY}	0.094	0.016	1.262	1.370	0.200	0.068	0.022	0.106	0.217	0.101	0.304	0.390
	$Q_{RESERVE}$	0.028	0.008	0.203	0.615	0.039	0.018	0.005	0.017	0.023	0.026	0.140	0.119
	Q_{DEMAND}	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%
17	Q_{SUPPLY}	0.309	0.049	1.036	1.229	0.318	0.159	0.074	0.216	0.409	0.261	0.759	0.631
	$Q_{RESERVE}$	0.095	0.024	0.323	0.867	0.139	0.060	0.046	0.064	0.106	0.117	0.351	0.241
	Q_{DEMAND}	0.013	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
	$\%_{DEMAND}$	6%	58%	2%	4%	7%	13%	46%	8%	4%	9%	3%	3%
18	Q_{SUPPLY}	0.135	0.022	1.814	1.968	0.287	0.098	0.031	0.152	0.312	0.146	0.437	0.560
	$Q_{RESERVE}$	0.041	0.011	0.292	0.883	0.056	0.026	0.007	0.025	0.033	0.038	0.201	0.170
	Q_{DEMAND}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
19	Q_{SUPPLY}	0.786	0.124	2.633	3.126	0.808	0.404	0.188	0.549	1.040	0.664	1.931	1.605
	$Q_{RESERVE}$	0.240	0.062	0.820	2.204	0.353	0.153	0.118	0.163	0.270	0.298	0.893	0.614
	Q_{DEMAND}	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	Q_{SUPPLY}	0.148	0.025	1.996	2.166	0.316	0.108	0.034	0.168	0.343	0.160	0.481	0.617
	$Q_{RESERVE}$	0.045	0.012	0.321	0.972	0.062	0.028	0.008	0.027	0.037	0.042	0.221	0.188
	Q_{DEMAND}	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%
21	Q_{SUPPLY}	1.436	0.502	6.832	7.366	1.551	0.583	0.176	0.676	1.737	1.019	2.078	2.594
	$Q_{RESERVE}$	0.815	0.372	1.644	3.736	0.600	0.220	0.033	0.150	0.243	0.567	1.113	1.138
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	$\%_{DEMAND}$	0%	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
22	Q_{SUPPLY}	0.461	0.073	1.544	1.832	0.473	0.237	0.110	0.322	0.609	0.389	1.132	0.941
	$Q_{RESERVE}$	0.141	0.036	0.481	1.292	0.207	0.090	0.069	0.096	0.158	0.175	0.523	0.360
	Q_{DEMAND}	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%
23	Q_{SUPPLY}	0.063	0.010	0.845	0.917	0.134	0.046	0.014	0.071	0.145	0.068	0.204	0.261
	$Q_{RESERVE}$	0.019	0.005	0.136	0.412	0.026	0.012	0.003	0.012	0.016	0.018	0.094	0.079
	Q_{DEMAND}	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%
24	Q_{SUPPLY}	0.213	0.035	2.872	3.116	0.455	0.155	0.049	0.241	0.494	0.231	0.692	0.887
	$Q_{RESERVE}$	0.064	0.018	0.462	1.398	0.089	0.041	0.012	0.039	0.053	0.060	0.318	0.270
	Q_{DEMAND}	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%
25	Q_{SUPPLY}	1.011	0.431	1.103	1.150	0.644	0.274	0.078	0.194	0.752	0.559	0.699	0.824
	$Q_{RESERVE}$	0.686	0.337	0.722	0.946	0.423	0.139	0.009	0.072	0.137	0.447	0.479	0.599
	Q_{DEMAND}	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%
26	Q_{SUPPLY}	0.506	0.080	1.695	2.012	0.520	0.260	0.121	0.354	0.669	0.427	1.242	1.033
	$Q_{RESERVE}$	0.155	0.040	0.528	1.418	0.227	0.098	0.076	0.105	0.174	0.192	0.575	0.395
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.024	0.023	0.023	0.024	0.002	0.002	0.002
	$\%_{DEMAND}$	1%	5%	0%	0%	1%	15%	51%	9%	5%	1%	0%	0%
27	Q_{SUPPLY}	0.242	0.038	0.811	0.962	0.249	0.124	0.058	0.169	0.320	0.204	0.594	0.494

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	$Q_{RESERVE}$	0.074	0.019	0.253	0.678	0.109	0.047	0.036	0.050	0.083	0.092	0.275	0.189
	Q_{DEMAND}	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%
28	Q_{SUPPLY}	0.294	0.080	0.615	0.839	0.267	0.123	0.049	0.067	0.344	0.240	0.497	0.255
	$Q_{RESERVE}$	0.157	0.049	0.058	0.412	0.135	0.065	0.024	0.012	0.052	0.156	0.277	0.159
	Q_{DEMAND}	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%
29	Q_{SUPPLY}	0.952	0.231	2.131	2.218	0.738	0.363	0.136	0.230	0.975	0.618	1.286	1.222
	$Q_{RESERVE}$	0.453	0.152	0.577	1.402	0.378	0.179	0.093	0.065	0.162	0.414	0.721	0.649
	Q_{DEMAND}	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%
30	Q_{SUPPLY}	0.181	0.029	1.664	1.371	0.555	0.203	0.058	0.361	0.374	0.396	0.765	2.026
	$Q_{RESERVE}$	0.046	0.014	0.179	0.925	0.119	0.078	0.013	0.054	0.079	0.097	0.168	0.263
	Q_{DEMAND}	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004	0.004	0.000	0.000	0.000
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	3%	9%	1%	1%	0%	0%	0%
31	Q_{SUPPLY}	0.249	0.040	2.291	1.889	0.764	0.279	0.080	0.498	0.515	0.545	1.053	2.790
	$Q_{RESERVE}$	0.064	0.019	0.247	1.274	0.164	0.108	0.018	0.075	0.109	0.134	0.231	0.362
	Q_{DEMAND}	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%
32	Q_{SUPPLY}	1.742	0.423	3.899	4.059	1.350	0.665	0.250	0.421	1.785	1.132	2.353	2.236
	$Q_{RESERVE}$	0.829	0.279	1.055	2.566	0.692	0.327	0.171	0.120	0.297	0.757	1.320	1.187
	Q_{DEMAND}	0.012	0.013	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
	$\%_{DEMAND}$	1%	9%	0%	1%	2%	4%	15%	4%	1%	3%	1%	1%
33	Q_{SUPPLY}	2.539	0.690	5.310	7.253	2.303	1.063	0.426	0.576	2.969	2.072	4.293	2.204
	$Q_{RESERVE}$	1.357	0.427	0.504	3.560	1.169	0.558	0.211	0.102	0.448	1.346	2.391	1.370
	Q_{DEMAND}	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%
34	Q_{SUPPLY}	0.117	0.025	0.442	0.456	0.146	0.064	0.020	0.110	0.145	0.051	0.215	0.347
	$Q_{RESERVE}$	0.058	0.014	0.090	0.285	0.051	0.019	0.005	0.042	0.068	0.017	0.088	0.175
	Q_{DEMAND}	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%
35	Q_{SUPPLY}	1.968	0.534	4.116	5.622	1.785	0.824	0.330	0.446	2.301	1.606	3.328	1.708
	$Q_{RESERVE}$	1.052	0.331	0.391	2.759	0.906	0.432	0.163	0.079	0.347	1.044	1.853	1.062
	Q_{DEMAND}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
36	Q_{SUPPLY}	0.092	0.015	0.844	0.696	0.282	0.103	0.030	0.183	0.190	0.201	0.388	1.028
	$Q_{RESERVE}$	0.023	0.007	0.091	0.469	0.061	0.040	0.007	0.028	0.040	0.049	0.085	0.133
	Q_{DEMAND}	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%
37	Q_{SUPPLY}	1.234	0.335	2.581	3.526	1.120	0.517	0.207	0.280	1.443	1.007	2.087	1.071
	$Q_{RESERVE}$	0.660	0.208	0.245	1.730	0.568	0.271	0.102	0.050	0.218	0.654	1.162	0.666
	Q_{DEMAND}	0.000	0.000	0.000	0.296	0.286	0.296	0.286	0.286	0.296	0.286	0.296	0.000
	$\%_{DEMAND}$	0%	0%	0%	17%	52%	120%	273%	124%	24%	81%	32%	0%
38	Q_{SUPPLY}	0.149	0.024	1.378	1.135	0.460	0.168	0.048	0.299	0.309	0.328	0.633	1.678
	$Q_{RESERVE}$	0.038	0.012	0.148	0.766	0.099	0.065	0.011	0.045	0.066	0.081	0.139	0.218
	Q_{DEMAND}	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%
39	Q_{SUPPLY}	0.071	0.071	0.029	0.677	0.419	0.187	0.087	0.026	0.130	0.155	0.142	0.233
	$Q_{RESERVE}$	0.025	0.025	0.013	0.159	0.292	0.056	0.025	0.006	0.030	0.045	0.042	0.068
	Q_{DEMAND}	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%
40	Q_{SUPPLY}	1.724	0.412	4.686	3.299	1.150	0.500	0.234	0.569	1.676	0.830	1.591	2.689
	$Q_{RESERVE}$	0.680	0.231	2.066	2.440	0.653	0.287	0.180	0.309	0.318	0.517	0.969	1.430
	Q_{DEMAND}	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%
41	Q_{SUPPLY}	0.188	0.030	1.733	1.428	0.578	0.211	0.061	0.376	0.389	0.412	0.797	2.110
	$Q_{RESERVE}$	0.048	0.015	0.187	0.963	0.124	0.082	0.014	0.057	0.083	0.101	0.175	0.274
	Q_{DEMAND}	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%
42	Q_{SUPPLY}	3.643	0.889	9.738	6.722	2.422	1.129	0.461	1.018	3.222	1.693	3.487	5.192
	$Q_{RESERVE}$	1.474	0.507	4.042	5.132	1.146	0.503	0.308	0.536	0.670	1.129	2.015	2.872
	Q_{DEMAND}	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%
43	Q_{SUPPLY}	0.343	0.084	0.916	0.632	0.228	0.106	0.043	0.096	0.303	0.159	0.328	0.488
	$Q_{RESERVE}$	0.139	0.048	0.380	0.483	0.108	0.047	0.029	0.050	0.063	0.106	0.190	0.270
	Q_{DEMAND}	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%
44	Q_{SUPPLY}	1.405	0.343	3.756	2.593	0.934	0.435	0.178	0.393	1.243	0.653	1.345	2.003

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	$Q_{RESERVE}$	0.568	0.196	1.559	1.980	0.442	0.194	0.119	0.207	0.258	0.436	0.777	1.108
	Q_{DEMAND}	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%
45	Q_{SUPPLY}	0.991	0.242	2.650	1.830	0.659	0.307	0.125	0.277	0.877	0.461	0.949	1.413
	$Q_{RESERVE}$	0.401	0.138	1.100	1.397	0.312	0.137	0.084	0.146	0.182	0.307	0.548	0.782
	Q_{DEMAND}	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%
46	Q_{SUPPLY}	0.509	0.125	1.470	1.068	0.365	0.171	0.074	0.155	0.488	0.273	0.523	0.789
	$Q_{RESERVE}$	0.209	0.071	0.617	0.811	0.177	0.081	0.054	0.078	0.099	0.175	0.307	0.438
	Q_{DEMAND}	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%
47	Q_{SUPPLY}	1.645	0.403	4.754	3.453	1.179	0.552	0.240	0.501	1.577	0.884	1.691	2.552
	$Q_{RESERVE}$	0.677	0.231	1.996	2.621	0.573	0.263	0.175	0.253	0.320	0.566	0.993	1.416
	Q_{DEMAND}	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%
48	Q_{SUPPLY}	5.441	1.456	13.997	12.675	4.406	2.244	0.860	1.478	5.836	3.744	7.546	7.132
	$Q_{RESERVE}$	2.600	0.947	3.587	8.670	2.215	1.062	0.563	0.503	1.005	2.420	4.279	3.785
	Q_{DEMAND}	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%
49	Q_{SUPPLY}	17.339	4.458	60.316	47.957	17.260	7.768	3.279	8.597	19.251	12.676	26.505	44.604
	$Q_{RESERVE}$	7.249	2.632	18.013	32.688	8.345	4.066	1.725	2.981	4.535	6.764	12.489	16.429
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
50	Q_{SUPPLY}	2.185	0.345	7.323	8.694	2.246	1.122	0.524	1.528	2.891	1.847	5.369	4.464
	$Q_{RESERVE}$	0.668	0.173	2.282	6.129	0.980	0.425	0.328	0.454	0.751	0.829	2.483	1.706
	Q_{DEMAND}	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%
51	Q_{SUPPLY}	22.584	5.649	96.316	88.341	26.536	10.147	3.989	13.321	27.655	15.796	39.208	62.925
	$Q_{RESERVE}$	9.218	3.339	25.766	55.774	10.812	5.475	2.150	4.374	5.705	8.697	17.822	21.366
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
52	Q_{SUPPLY}	0.683	0.166	1.528	1.591	0.529	0.261	0.098	0.165	0.700	0.444	0.922	0.876
	$Q_{RESERVE}$	0.325	0.109	0.414	1.006	0.271	0.128	0.067	0.047	0.116	0.297	0.517	0.465
	Q_{DEMAND}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
53	Q_{SUPPLY}	0.275	0.046	3.702	4.017	0.586	0.200	0.063	0.311	0.636	0.297	0.892	1.144
	$Q_{RESERVE}$	0.083	0.023	0.596	1.803	0.114	0.052	0.015	0.050	0.068	0.078	0.410	0.348
	Q_{DEMAND}	0.018	0.020	0.018	0.019	0.018	0.019	0.018	0.018	0.019	0.018	0.019	0.018
	$\%_{DEMAND}$	10%	89%	1%	1%	4%	13%	38%	7%	3%	8%	4%	2%
54	Q_{SUPPLY}	0.288	0.048	3.878	4.208	0.614	0.209	0.066	0.326	0.667	0.312	0.934	1.199
	$Q_{RESERVE}$	0.087	0.024	0.624	1.888	0.120	0.055	0.016	0.053	0.072	0.081	0.429	0.365
	Q_{DEMAND}	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%
55	Q_{SUPPLY}	0.612	0.128	2.317	2.390	0.767	0.336	0.105	0.577	0.761	0.266	1.126	1.820
	$Q_{RESERVE}$	0.306	0.075	0.471	1.496	0.268	0.102	0.024	0.220	0.354	0.087	0.462	0.919
	Q_{DEMAND}	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%
56	Q_{SUPPLY}	0.219	0.088	2.083	1.288	0.576	0.268	0.079	0.399	0.478	0.436	0.716	2.199
	$Q_{RESERVE}$	0.078	0.041	0.490	0.898	0.172	0.077	0.017	0.092	0.138	0.130	0.209	0.568
	Q_{DEMAND}	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%
57	Q_{SUPPLY}	5.843	1.412	16.294	11.755	4.023	1.738	0.853	1.838	5.646	2.973	5.473	8.928
	$Q_{RESERVE}$	2.346	0.799	7.040	8.731	2.138	0.956	0.618	0.983	1.140	1.903	3.458	4.925
	Q_{DEMAND}	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%
58	Q_{SUPPLY}	0.164	0.027	2.205	2.393	0.349	0.119	0.038	0.185	0.379	0.177	0.531	0.681
	$Q_{RESERVE}$	0.049	0.013	0.355	1.074	0.068	0.031	0.009	0.030	0.041	0.046	0.244	0.207
	Q_{DEMAND}	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%
59	Q_{SUPPLY}	0.241	0.040	3.254	3.531	0.515	0.176	0.056	0.273	0.559	0.261	0.784	1.006
	$Q_{RESERVE}$	0.073	0.020	0.524	1.585	0.101	0.046	0.013	0.044	0.060	0.068	0.360	0.306
	Q_{DEMAND}	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%
60	Q_{SUPPLY}	0.119	0.024	1.428	1.057	0.205	0.092	0.037	0.189	0.197	0.069	0.338	0.356
	$Q_{RESERVE}$	0.059	0.016	0.224	0.490	0.072	0.037	0.006	0.068	0.077	0.024	0.130	0.147
	Q_{DEMAND}	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%
61	Q_{SUPPLY}	0.179	0.036	2.145	1.588	0.308	0.138	0.056	0.284	0.296	0.104	0.507	0.534

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	$Q_{RESERVE}$	0.088	0.025	0.337	0.737	0.108	0.056	0.009	0.102	0.116	0.036	0.195	0.221
	Q_{DEMAND}	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%
62	Q_{SUPPLY}	0.191	0.032	2.570	2.788	0.407	0.139	0.044	0.216	0.442	0.206	0.619	0.794
	$Q_{RESERVE}$	0.058	0.016	0.414	1.251	0.079	0.036	0.011	0.035	0.047	0.054	0.285	0.242
	Q_{DEMAND}	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%
63	Q_{SUPPLY}	0.236	0.048	2.835	2.099	0.408	0.182	0.074	0.375	0.392	0.137	0.671	0.706
	$Q_{RESERVE}$	0.117	0.033	0.446	0.974	0.143	0.074	0.011	0.135	0.153	0.048	0.258	0.293
	Q_{DEMAND}	0.000	0.000	0.000	0.000	0.000	0.036	0.035	0.035	0.036	0.000	0.000	0.000
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	33%	56%	15%	15%	0%	0%	0%
64	Q_{SUPPLY}	0.360	0.060	4.856	5.269	0.769	0.262	0.083	0.408	0.835	0.390	1.169	1.501
	$Q_{RESERVE}$	0.109	0.030	0.782	2.364	0.150	0.069	0.020	0.066	0.090	0.102	0.538	0.456
	Q_{DEMAND}	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%
67	Q_{SUPPLY}	0.220	0.037	2.965	3.217	0.470	0.160	0.051	0.249	0.510	0.238	0.714	0.916
	$Q_{RESERVE}$	0.066	0.018	0.477	1.444	0.092	0.042	0.012	0.040	0.055	0.062	0.328	0.279
	Q_{DEMAND}	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 3.14: 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
49	Q_{SUPPLY}	17.339	4.458	60.316	47.957	17.260	7.768	3.279	8.597	19.251	12.676	26.505	44.604
	$Q_{RESERVE}$	7.249	2.632	18.013	32.688	8.345	4.066	1.725	2.981	4.535	6.764	12.489	16.429
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

3.2.8 Tier 1 Surface Water Stress Assessment

The maximum monthly percent water demand for subwatersheds #17, 26, 37, 53 and 63 showed significant stress in one or more months under the current demand scenario. The remaining subwatersheds were considered low stress. Subwatershed #49 contains a municipal drinking water source (Village of Casselman), 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 40% and resulted in little change on the stress calculations. Subwatershed #49 is not considered moderately or significantly stressed in the future scenario.

The municipal drinking water supply for the Village of Casselman has not 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 3.15*. Future demand stress assessments were carried out for the six subwatersheds in the Source Protection Area that have a municipal drinking water system (Vars, Limoges, Moose Creek, Greely, Embrun/Marionville, Chesterville, Winchester, Crysler, Newington and Finch). The results of the future demand stress assessment are shown in *Table 3.16*.

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

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
14	Q_{SUPPLY}	1.052	1.052	1.052	1.052	1.052	1.052	1.052	1.052	1.052	1.052	1.052	1.052	1.052
	$Q_{RESERVE}$	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.012	0.012	0.003	0.003	0.003	0.003	0.005
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	1%
15	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	0.233
	$Q_{RESERVE}$	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.013	0.013	0.003	0.003	0.003	0.003	0.005
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	6%	6%	1%	1%	1%	1%	2%
16	Q_{SUPPLY}	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
	$Q_{RESERVE}$	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.001	0.001	0.001	0.001	0.002
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
17	Q_{SUPPLY}	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310
	$Q_{RESERVE}$	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.010	0.010	0.004	0.004	0.004	0.004	0.005
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	4%	4%	2%	2%	2%	2%	2%
18	Q_{SUPPLY}	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299
	$Q_{RESERVE}$	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.010	0.010	0.002	0.002	0.002	0.002	0.003
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	1%
19	Q_{SUPPLY}	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281
	$Q_{RESERVE}$	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.041	0.041	0.001	0.001	0.001	0.001	0.008
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	16%	16%	0%	0%	0%	0%	3%
20	Q_{SUPPLY}	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329
	$Q_{RESERVE}$	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.010	0.010	0.002	0.002	0.002	0.002	0.003
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
21	Q_{SUPPLY}	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455
	$Q_{RESERVE}$	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.019	0.019	0.004	0.004	0.004	0.004	0.007
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	5%	5%	1%	1%	1%	1%	2%
22	Q_{SUPPLY}	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462
	$Q_{RESERVE}$	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
	Q_{DEMAND}	0.007	0.007	0.007	0.007	0.007	0.007	0.037	0.037	0.007	0.007	0.007	0.007	0.012
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	9%	9%	2%	2%	2%	2%	3%
23	Q_{SUPPLY}	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
	$Q_{RESERVE}$	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.006	0.006	0.001	0.001	0.001	0.001	0.002
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	5%	5%	1%	1%	1%	1%	1%
24	Q_{SUPPLY}	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473
	$Q_{RESERVE}$	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.012	0.012	0.003	0.003	0.003	0.003	0.004
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
25	Q_{SUPPLY}	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712
	$Q_{RESERVE}$	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.010	0.010	0.003	0.003	0.003	0.003	0.004
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	2%	2%	0%	0%	0%	0%	1%
26	Q_{SUPPLY}	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265
	$Q_{RESERVE}$	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.018	0.055	0.055	0.018	0.003	0.003	0.003	0.014
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	8%	23%	23%	8%	1%	1%	1%	6%

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
27	Q_{SUPPLY}	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
	$Q_{RESERVE}$	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	Q_{DEMAND}	0.005	0.005	0.005	0.005	0.005	0.005	0.037	0.037	0.005	0.005	0.005	0.005	0.010
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	17%	17%	2%	2%	2%	2%	5%
28	Q_{SUPPLY}	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092
	$Q_{RESERVE}$	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.007	0.007	0.001	0.001	0.001	0.001	0.002
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	8%	8%	1%	1%	1%	1%	2%
29	Q_{SUPPLY}	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
	$Q_{RESERVE}$	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
	Q_{DEMAND}	0.037	0.037	0.037	0.037	0.051	0.065	0.145	0.145	0.065	0.051	0.051	0.037	0.063
	$\%_{DEMAND}$	11%	11%	11%	11%	15%	19%	42%	42%	19%	15%	15%	11%	18%
30	Q_{SUPPLY}	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249
	$Q_{RESERVE}$	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.009	0.009	0.002	0.002	0.002	0.002	0.003
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	1%
31	Q_{SUPPLY}	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344
	$Q_{RESERVE}$	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
	Q_{DEMAND}	0.009	0.009	0.009	0.009	0.009	0.009	0.021	0.021	0.009	0.009	0.009	0.009	0.011
	$\%_{DEMAND}$	3%	3%	3%	3%	3%	3%	7%	7%	3%	3%	3%	3%	4%
32	Q_{SUPPLY}	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
	$Q_{RESERVE}$	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	Q_{DEMAND}	0.007	0.007	0.007	0.007	0.007	0.055	0.124	0.124	0.055	0.007	0.007	0.007	0.035
	$\%_{DEMAND}$	3%	3%	3%	3%	3%	19%	43%	43%	19%	3%	3%	3%	12%
33	Q_{SUPPLY}	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179
	$Q_{RESERVE}$	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.021	0.021	0.002	0.002	0.002	0.002	0.005
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	13%	13%	2%	2%	2%	2%	3%
34	Q_{SUPPLY}	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
	$Q_{RESERVE}$	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
35	Q_{SUPPLY}	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229
	$Q_{RESERVE}$	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Q_{DEMAND}	0.007	0.007	0.007	0.007	0.007	0.007	0.013	0.013	0.007	0.007	0.007	0.007	0.008
	$\%_{DEMAND}$	3%	3%	3%	3%	3%	3%	6%	6%	3%	3%	3%	3%	4%
36	Q_{SUPPLY}	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127
	$Q_{RESERVE}$	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
37	Q_{SUPPLY}	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
	$Q_{RESERVE}$	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
	Q_{DEMAND}	0.005	0.005	0.005	0.297	0.312	0.312	0.320	0.320	0.312	0.312	0.312	0.005	0.210
	$\%_{DEMAND}$	2%	2%	2%	86%	90%	90%	92%	92%	90%	90%	90%	2%	60%
38	Q_{SUPPLY}	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207
	$Q_{RESERVE}$	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	Q_{DEMAND}	0.002	0.002	0.061	0.061	0.061	0.002	0.006	0.006	0.002	0.002	0.002	0.002	0.017
	$\%_{DEMAND}$	1%	1%	33%	33%	33%	1%	3%	3%	1%	1%	1%	1%	9%
39	Q_{SUPPLY}	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
	$Q_{RESERVE}$	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
40	Q_{SUPPLY}	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985
	$Q_{RESERVE}$	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099
	Q_{DEMAND}	0.007	0.007	0.007	0.007	0.007	0.007	0.014	0.014	0.007	0.007	0.007	0.007	0.008
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
41	Q_{SUPPLY}	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260
	$Q_{RESERVE}$	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.009	0.009	0.003	0.003	0.003	0.003	0.004
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	2%
42	Q_{SUPPLY}	0.549	0.549	0.549	0.549	0.549	0.549	0.549	0.549	0.549	0.549	0.549	0.549	0.549
	$Q_{RESERVE}$	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.008	0.008	0.003	0.003	0.003	0.003	0.004
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
43	Q_{SUPPLY}	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201
	$Q_{RESERVE}$	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.001	0.001	0.001	0.001	0.001
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
44	Q_{SUPPLY}	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825	0.825
	$Q_{RESERVE}$	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.005	0.003	0.003	0.003	0.003	0.003
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%
45	Q_{SUPPLY}	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582
	$Q_{RESERVE}$	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.007	0.007	0.002	0.002	0.002	0.002	0.003
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
46	Q_{SUPPLY}	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
	$Q_{RESERVE}$	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.005	0.005	0.001	0.001	0.001	0.001	0.001
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	2%	2%	0%	0%	0%	0%	1%
47	Q_{SUPPLY}	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036	1.036
	$Q_{RESERVE}$	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.014	0.014	0.002	0.002	0.002	0.002	0.004
	$\%_{DEMAND}$	0%	0%	0%	0%	0%	0%	2%	2%	0%	0%	0%	0%	1%
48	Q_{SUPPLY}	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416
	$Q_{RESERVE}$	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.054	0.054	0.003	0.003	0.003	0.003	0.012
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	14%	14%	1%	1%	1%	1%	3%
49	Q_{SUPPLY}	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
	$Q_{RESERVE}$	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Q_{DEMAND}	0.021	0.021	0.021	0.021	0.021	0.021	0.044	0.044	0.021	0.021	0.021	0.021	0.025
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	5%	5%	2%	2%	2%	2%	3%
50	Q_{SUPPLY}	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778
	$Q_{RESERVE}$	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.072	0.072	0.004	0.004	0.004	0.004	0.016
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	10%	10%	1%	1%	1%	1%	2%
51	Q_{SUPPLY}	1.527	1.527	1.527	1.527	1.527	1.527	1.527	1.527	1.527	1.527	1.527	1.527	1.527
	$Q_{RESERVE}$	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153
	Q_{DEMAND}	0.011	0.011	0.011	0.011	0.011	0.011	0.044	0.044	0.011	0.011	0.011	0.011	0.016
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
52	Q_{SUPPLY}	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277
	$Q_{RESERVE}$	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.052	0.052	0.002	0.002	0.002	0.002	0.010
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	21%	21%	1%	1%	1%	1%	4%
53	Q_{SUPPLY}	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610
	$Q_{RESERVE}$	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.015	0.015	0.004	0.004	0.004	0.004	0.006
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
54	Q_{SUPPLY}	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166
	$Q_{RESERVE}$	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
	Q_{DEMAND}	0.001	0.001	0.001	0.001	0.001	0.001	0.007	0.007	0.001	0.001	0.001	0.001	0.002
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	5%	5%	1%	1%	1%	1%	1%
55	Q_{SUPPLY}	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643
	$Q_{RESERVE}$	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
	Q_{DEMAND}	0.005	0.005	0.005	0.005	0.005	0.005	0.011	0.011	0.005	0.005	0.005	0.005	0.006
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
56	Q_{SUPPLY}	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
	$Q_{RESERVE}$	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.009	0.009	0.003	0.003	0.003	0.003	0.004
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	2%
57	Q_{SUPPLY}	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064
	$Q_{RESERVE}$	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
	Q_{DEMAND}	0.008	0.008	0.008	0.008	0.008	0.008	0.013	0.013	0.008	0.008	0.008	0.008	0.009
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
58	Q_{SUPPLY}	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363
	$Q_{RESERVE}$	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.002	0.002	0.005	0.005	0.002	0.002	0.002	0.002	0.003
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
59	Q_{SUPPLY}	0.536	0.536	0.536	0.536	0.536	0.536	0.536	0.536	0.536	0.536	0.536	0.536	0.536
	$Q_{RESERVE}$	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.018	0.018	0.004	0.004	0.004	0.004	0.006
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	4%	4%	1%	1%	1%	1%	1%
60	Q_{SUPPLY}	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
	$Q_{RESERVE}$	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
	Q_{DEMAND}	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.003	0.002	0.002	0.002	0.003
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
61	Q_{SUPPLY}	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
	$Q_{RESERVE}$	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.004	0.004	0.004	0.004	0.004
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
62	Q_{SUPPLY}	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423
	$Q_{RESERVE}$	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
	Q_{DEMAND}	0.003	0.003	0.003	0.003	0.003	0.003	0.009	0.009	0.003	0.003	0.003	0.003	0.004
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
63	Q_{SUPPLY}	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508
	$Q_{RESERVE}$	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
	Q_{DEMAND}	0.014	0.014	0.014	0.014	0.014	0.048	0.051	0.051	0.048	0.014	0.014	0.014	0.026
	$\%_{DEMAND}$	3%	3%	3%	3%	3%	11%	11%	11%	11%	3%	3%	3%	6%
64	Q_{SUPPLY}	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
	$Q_{RESERVE}$	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
	Q_{DEMAND}	0.006	0.006	0.006	0.006	0.006	0.006	0.016	0.016	0.006	0.006	0.006	0.006	0.007
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%
67	Q_{SUPPLY}	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
	$Q_{RESERVE}$	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
	Q_{DEMAND}	0.010	0.010	0.010	0.010	0.010	0.010	0.015	0.015	0.010	0.010	0.010	0.010	0.011
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	4%	4%	2%	2%	2%	2%	3%

Monthly Basis	Annual Basis	
23 – 25%	8 – 10%	Indicates Low Stress, but sensitivity analysis required (if municipal water source)
25 – 50%	10 – 25%	Indicates Moderate Stress
> 50 %	>25 %	Indicates Significant Stress

Table 3.16: 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
22	Q_{SUPPLY}	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462
	$Q_{RESERVE}$	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
	Q_{DEMAND}	0.012	0.012	0.012	0.012	0.012	0.012	0.043	0.043	0.012	0.012	0.012	0.012	0.017
	$\%_{DEMAND}$	3%	3%	3%	3%	3%	3%	10%	10%	3%	3%	3%	3%	4%
24	Q_{SUPPLY}	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473	0.473
	$Q_{RESERVE}$	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

SWS	Param.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Q_{DEMAND}	0.004	0.004	0.004	0.004	0.004	0.004	0.013	0.013	0.004	0.004	0.004	0.004	0.005
	$\%_{DEMAND}$	1%	1%	1%	1%	1%	1%	3%	3%	1%	1%	1%	1%	1%
29	Q_{SUPPLY}	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
	$Q_{RESERVE}$	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
	Q_{DEMAND}	0.037	0.037	0.037	0.037	0.051	0.065	0.145	0.145	0.065	0.051	0.051	0.037	0.063
	$\%_{DEMAND}$	11%	11%	11%	11%	15%	19%	42%	42%	19%	15%	15%	11%	18%
31	Q_{SUPPLY}	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344	0.344
	$Q_{RESERVE}$	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
	Q_{DEMAND}	0.018	0.018	0.018	0.018	0.018	0.018	0.030	0.030	0.018	0.018	0.018	0.018	0.020
	$\%_{DEMAND}$	6%	6%	6%	6%	6%	6%	10%	10%	6%	6%	6%	6%	7%
35	Q_{SUPPLY}	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229
	$Q_{RESERVE}$	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	Q_{DEMAND}	0.011	0.011	0.011	0.011	0.011	0.011	0.017	0.017	0.011	0.011	0.011	0.011	0.012
	$\%_{DEMAND}$	5%	5%	5%	5%	5%	5%	8%	8%	5%	5%	5%	5%	6%
37	Q_{SUPPLY}	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
	$Q_{RESERVE}$	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
	Q_{DEMAND}	0.007	0.007	0.007	0.299	0.313	0.313	0.322	0.322	0.313	0.313	0.313	0.007	0.211
	$\%_{DEMAND}$	2%	2%	2%	86%	90%	90%	93%	93%	90%	90%	90%	2%	61%
55	Q_{SUPPLY}	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643
	$Q_{RESERVE}$	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
	Q_{DEMAND}	0.012	0.012	0.012	0.012	0.012	0.012	0.018	0.018	0.012	0.012	0.012	0.012	0.013
	$\%_{DEMAND}$	2%	2%	2%	2%	2%	2%	3%	3%	2%	2%	2%	2%	2%

3.2.10 Tier 1 Groundwater Stress Assessment

Three groundwater subwatersheds (#29, 32 and 38) showed moderate stress in one or more months and annually under the current demand scenario. One groundwater subwatershed (#37) showed significant stress in the monthly and annual assessment for current demand. Subwatershed #26 showed slightly less than moderate stress in the monthly scenario. The percent demand was still high enough to warrant a sensitivity analysis. However, as this subwatershed does not supply a municipal groundwater system, it was not carried forward. The remaining subwatersheds were considered low stress.

Subwatersheds #22, 24, 29, 31, 35, 37 and 55 supply one or more wells for ten municipal groundwater systems, 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 150%, 27%, 7%, 29%, 13%, 7%, 19% and 7% for Vars, Limoges, Moose Creek, Embrun/Marionville, Chesterville, Winchester, Crysler, Newington and Finch respectively. The increased consumption had little change on the stress calculations. Subwatershed #29 was originally found to be moderately stressed, and continued to be so. Subwatershed # 37 was originally found to be significantly stressed, and continued to be so in the future scenario. These two subwatersheds will be carried forward to a Tier 2 groundwater stress assessment.

There have been no documented shortages for municipal groundwater drinking water supplies in the Source Protection Area; therefore, no additional groundwater subwatersheds will be carried forward to Tier 2 groundwater stress assessment.

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 3.17* and shown on and shown on 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 3.18*.

Table 3.17: 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		
14	Low	n/a	Yes[2]		Low	Low	n/a	n/a	No	
15	Low	n/a	Yes[2]		Low	Low	n/a	n/a	No	
16	Low	n/a	No		Low	Low	n/a	n/a	No	
17	Significant	n/a[1]	No		Low	Low	n/a	n/a	No	
18	Low	n/a	No		Low	Low	n/a	n/a	No	
19	Low	n/a	No		Low	Low	n/a	n/a	No	
20	Low	n/a	No		Low	Low	n/a	n/a	No	
21	Low	n/a	No		Low	Low	n/a	n/a	No	
22	Low	n/a	No		Low	Low	Low	Low	Yes	No
23	Low	n/a	No		Low	Low	n/a	n/a	No	
24	Low	n/a	No		Low	Low	Low	Low	Yes	No
25	Low	n/a	No		Low	Low	n/a	n/a	No	
26	Significant	n/a[1]	No		~ Moderate	Low	n/a[1]	n/a[1]	No	
27	Low	n/a	No		Low	Low	n/a	n/a	No	
28	Low	n/a	No		Low	Low	n/a	n/a	No	
29	Low	n/a	No		Moderate	Moderate	Moderate	Moderate	Yes	Yes
30	Low	n/a	No		Low	Low	n/a	n/a	No	
31	Low	n/a	No		Low	Low	Low	Low	Yes	No
32	Low	n/a	No		Moderate	Moderate	n/a[1]	n/a[1]	No	
33	Low	n/a	No		Low	Low	n/a	n/a	No	
34	Low	n/a	No		Low	Low	n/a	n/a	No	

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		
35	Low	n/a	No		Low	Low	Low	Low	Yes	No
36	Low	n/a	No		Low	Low	n/a	n/a	No	
37	Significant	n/a[1]	No		Significant	Significant	Significant	Significant	Yes	Yes
38	Low	n/a	No		Moderate	~ Moderate	n/a[1]	n/a[1]	No	
39	Low	n/a	No		Low	Low	n/a	n/a	No	`
40	Low	n/a	No		Low	Low	n/a	n/a	No	
41	Low	n/a	No		Low	Low	n/a	n/a	No	
42	Low	n/a	No		Low	Low	n/a	n/a	No	
43	Low	n/a	No		Low	Low	n/a	n/a	No	
44	Low	n/a	No		Low	Low	n/a	n/a	No	
45	Low	n/a	No		Low	Low	n/a	n/a	No	
46	Low	n/a	No		Low	Low	n/a	n/a	No	
47	Low	n/a	No		Low	Low	n/a	n/a	No	
48	Low	n/a	No		Low	Low	n/a	n/a	No	
49	Low	Low	Yes	No	Low	Low	n/a	n/a	No	
50	Low	n/a	No		Low	Low	n/a	n/a	No	
51	Low	n/a	No		Low	Low	n/a	n/a	No	
52	Low	n/a	No		Low	Low	n/a	n/a	No	
53	Significant	n/a	No		Low	Low	n/a	n/a	No	
54	Low	n/a	No		Low	Low	n/a	n/a	No	
55	Low	n/a	No		Low	Low	Low	Low	Yes	No
56	Low	n/a	No		Low	Low	n/a	n/a	No	
57	Low	n/a	No		Low	Low	n/a	n/a	No	
58	Low	n/a	No		Low	Low	n/a	n/a	No	
59	Low	n/a	Yes[2]		Low	Low	n/a	n/a	No	
60	Low	n/a	No		Low	Low	n/a	n/a	No	
61	Low	n/a	No		Low	Low	n/a	n/a	No	
62	Low	n/a	No		Low	Low	n/a	n/a	No	
63	Significant	n/a[1]	Yes[2]		Low	Low	n/a	n/a	No	
64	Low	n/a	Yes[2]		Low	Low	n/a	n/a	No	
67	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 or Ottawa River)
2) These surface water subwatersheds have municipal drinking water systems; however, the source water is the St. Lawrence River or Ottawa River and future demand stress assessments are not required.

Table 3.18: Subwatersheds to be considered for Tier 2 Stress Assessment

SWS	Surface Water or Groundwater	Water Quantity Stress Level	Rationale for Tier 2 Assessment
29	Groundwater	Moderate	The Current and Future demand scenarios for this groundwater subwatershed show moderate stress for July and August, as well as on an annual basis. The municipal drinking water supply for Shadow Ridge subdivision (Greely) draws water from this subwatershed.
37	Groundwater	Significant	The Current and Future demand scenarios for this groundwater subwatershed are significantly stressed (to the order of >80% demand) for 8 months of the year. The annual water demand is also at 60%. The municipal drinking water supply for Winchester has 3 wells which draw water from this subwatershed.

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 analysis for the South Nation subwatersheds identified two subwatersheds that required Tier 2 analyses, SWS 29 (Greely) and SWS 37 (Winchester). The Tier 2 analyses of these subwatersheds are 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 Greely and Winchester subwatersheds are shown in Map 3.14 listed in Table 3.1 and the monthly time scale for the analysis is described in Section 3.2.2.

A comprehensive document, “Tier 2 Water Budget: Subwatersheds 29 and 37 South Nation River Watershed”, 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 3.19*. The Greely and Winchester subwatersheds do 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 3.20* below in order to assign a stress level.

Table 3.19 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 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	Description
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 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 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

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 3.11: Tier 2 Stress Assessment Process

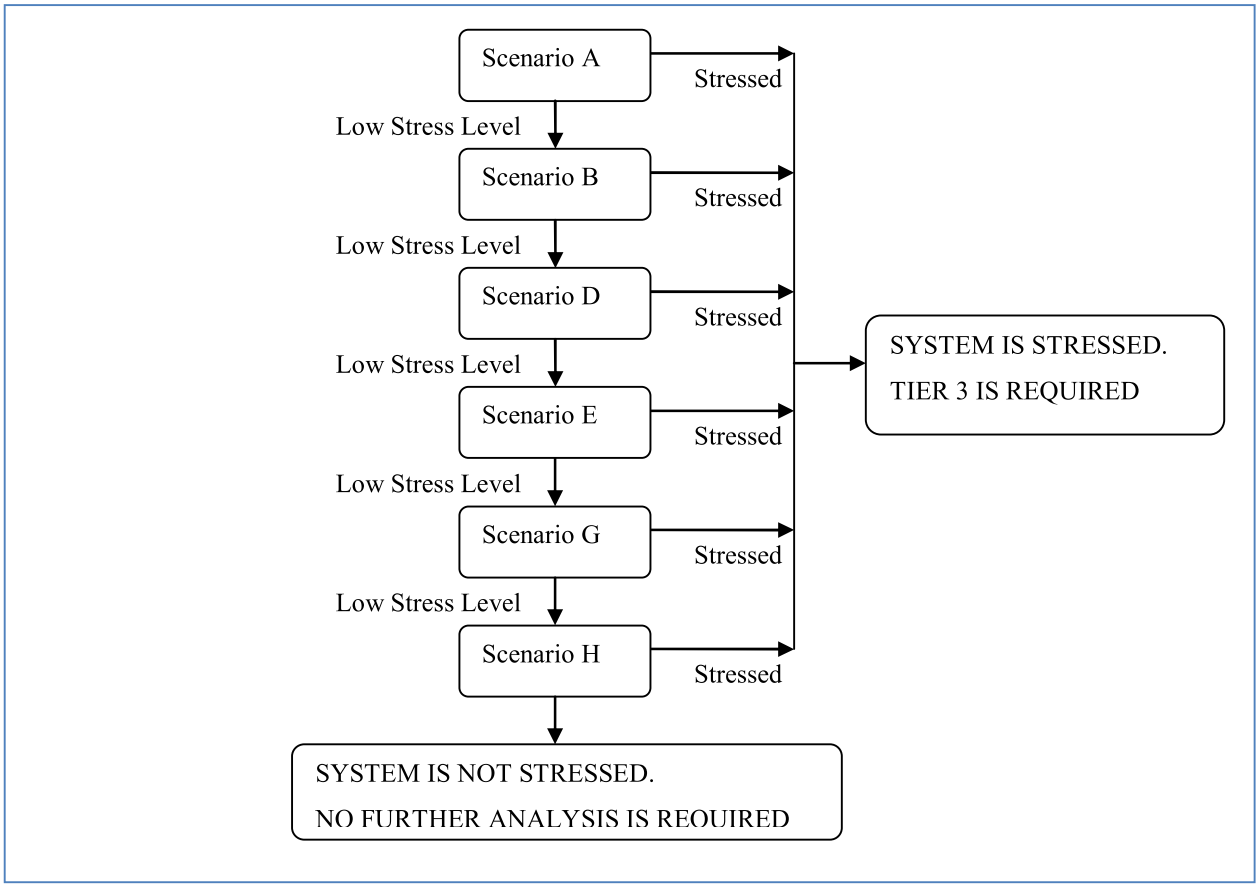


Table 3.20 Groundwater Stress Thresholds

Groundwater Quantity Stress Assignment (% Water Demand)	Current Conditions		Future Demand	
	Average Annual	Monthly Maximum	Average Annual	Monthly Maximum
Significant	>25%	> 50 %	>25%	> 50 %
Moderate	10 - 25%	25 - 50 %	10 - 25%	25 - 50 %
Low	0 - 10%	0 - 25 %	0 - 10%	0 - 25 %

3.3.2 Tier 2 Water Takings

Groundwater takings were computed for each subwatershed. Total anthropogenic consumptive water demand was taken as the sum of takings under municipal takings, takings under the Permit to Take Water program (PTTW), and takings not subject to PTTW (agricultural and domestic). Consumptive factors, the measure of how much water is consumed versus returned to the system, were taken from Provincial Guidance.

Unpermitted demands quantified in Tier 1 were not changed in the Tier 2 assessment. These were determined to be insignificant compared with other water budget components and were not used in the groundwater model, though they were included in the stress assessment.

The Tier 2 estimates for PTTW takings were refined from Tier 1 by using actual water demand values rather than maximum permitted values, where data was available; maximum takings were used where actual takings were not reported. Actual values came from the Water Taking Reporting System as well as directly from permit holders. Investigation into non-reported values from Lafarge in both watersheds led to significant decreases in permitted takings. In Greely, it was found that a PTTW for aggregate washing was no longer being used. Another aggregate washing PTTW in Winchester was removed, and it was discovered that pond storage had been erroneously reported as a PTTW taking in the Tier 1 report. The appropriate changes were made to the permitted takings in the calculation of demand.

The municipal takings were not changed from the Tier 1 assessment. Future demand was the same as current demand for Greely because future growth will be supplied by the Ottawa River. Future demand in Winchester will be double the current demand.

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 (*Equation 3.1*). 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.

A numerical model was developed for the Greely and Winchester subwatershed surface water system using a program called Hydrological Simulation Program FORTRAN (HSPF). The groundwater system was simulated using a numerical model called MODFLOW.

The surface water model was created by simulating the physical system in the South Nation watershed. Data for topography, land use, soil type, and climate (e.g. precipitation and temperature) were input into HSPF. Surface water flows in the South Nation River were simulated by changing the hydrological responses of different land uses and soil types until the calculated surface water flows in the South Nation River were as close as possible to the observed flows in the South Nation River. This process calculated the groundwater recharge to the Winchester and Greely subwatersheds, which was used to simulate groundwater recharge in the groundwater numerical model.

The groundwater system was simulated by creating a hydrostratigraphic model based on geological data from the Geological Survey of Canada (GSC). Layers of rock were defined in the model and assigned different properties, based on existing data and professional judgment. Additional physical properties of the system were simulated in the model by inputting data on climate (precipitation and temperature), land use, and topography, which were obtained from previous reports or were estimated using professional judgment. Groundwater recharge was input from the HSPF model results. Groundwater takings from municipal wells and private wells (PTTW) were also included in the model.

The model was designed to estimate the amount of water flowing into the subwatershed area as a component of water supply in calculating water demand, and to simulate water levels in the wells under drought conditions. Model calibration was done by adjusting the input parameters (e.g. rock properties) so groundwater levels in the model matched actual groundwater levels that were measured in each watershed.

For Scenarios A (current demand, average conditions - *Table 3.21*) and B (future demand, average conditions - *Table 3.22*), both Greely and Winchester subwatersheds were found to have a low level of stress at less than 10%.

Table 3.21 Tier 2 Groundwater Stress Assessment, Scenario A - Current Demand, Average Conditions (mm/month)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
29	Q_{SUPPLY}	34	34	34	34	34	34	34	34	34	34	34	34	408
	$Q_{RESERVE}$	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	18.9
	Q_{DEMAND}	0.05	0.05	0.05	0.05	0.5	0.5	2.23	2.27	0.43	0.33	0.33	0.05	6.8
	$\%_{DEMAND}$	0.2%	0.1%	0.2%	0.1%	1.5%	1.6%	6.9%	7.0%	1.3%	1.0%	1.0%	0.2%	1.8%
37	Q_{SUPPLY}	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	381.8
	$Q_{RESERVE}$	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	17.1
	Q_{DEMAND}	0.12	0.11	0.11	0.11	0.47	0.5	0.76	0.8	0.6	0.61	0.49	0.11	4.8
	$\%_{DEMAND}$	0.4%	0.3%	0.4%	0.4%	1.5%	1.6%	2.5%	2.6%	2.0%	2.0%	1.6%	0.4%	1.3

Table 3.22: Tier 2 Groundwater Stress Assessment, Scenario B - Future Demand, Average Conditions (mm/month)

SWS	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
29	Q_{SUPPLY}	34	34	34	34	34	34	34	34	34	34	34	34	408
	$Q_{RESERVE}$	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	18.9
	Q_{DEMAND}	0.05	0.05	0.05	0.05	0.5	0.5	2.23	2.27	0.43	0.33	0.33	0.05	6.8
	$\%_{DEMAND}$	0.2%	0.1%	0.2%	0.1%	1.5%	1.6%	6.9%	7.0%	1.3%	1.0%	1.0%	0.2%	1.8%
37	Q_{SUPPLY}	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	381.8
	$Q_{RESERVE}$	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	17.1
	Q_{DEMAND}	0.16	0.15	0.14	0.15	0.5	0.54	0.8	0.83	0.64	0.65	0.53	0.15	5.2
	$\%_{DEMAND}$	0.5%	0.5%	0.5%	0.5%	1.7%	1.8%	2.6%	2.7%	2.1%	2.1%	1.7%	0.5%	1.4%

3.3.4 Tier 2 Drought Analysis (Scenarios D, E, G and H)

Greely and Winchester subwatersheds were found to have low stress levels in Scenarios A and B, so the systems were evaluated for drought conditions in scenarios D,E,G and H (2 and 10 year, present and future conditions), according to the Technical Rules. The results showed all predicted water levels near the municipal wells were significantly above the well screen, indicating low levels of stress for both Greely and Winchester in all scenarios (*Table 3.23*).

Table 3.23 Tier 2 Predicted Groundwater Level above Well Screens for Scenarios D, E, G and H

Scenario	Greely 1	Greely 2	Winchester 1	Winchester 5	Winchester 6
Base Case (Average Recharge, Existing Demand)	10.1	10.1	9.8	10.9	10.1
Scenario D - Two Year Drought, Existing Demand	6.3	6.3	9.8	10.9	10.1
Scenario E - Two Year Drought, Future Demand	6.3	6.3	9.8	10.9	10.1
Scenario G - Ten Year Drought, Existing Demand	9.5	9.5	9.8	10.9	10.1
Scenario H - Ten Year Drought, Future Demand	9.5	9.5	9.8	10.9	10.1

3.3.5 Tier 2 Groundwater Stress Assessment

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. The maximum monthly and annual percent water demand for the Greely and Winchester subwatersheds both showed low stress levels for every scenario. Demand was lower upon refinement of the Tier 1 Water Demand in the watersheds due to the removal of PTTWs. Based on this result, neither Greely nor Winchester require a Tier 3 Water Stress Assessment. The Tier 2 Groundwater Water Stress Assessment is shown on *Map 3.17*.

3.3.6 Tier 2 Stress Assessment Uncertainty

In this Tier 2 evaluation extensive meteorological data were used, models for both the Greely subwatershed the Winchester subwatershed were satisfactory calibrated, and permitted water demands were certain. The uncertainty therefore is considered to be low.

3.4 Tier 3 Water Budget

A Tier 3 water budget assessment is not necessary for any localized area within the Source Protection Area. The local percent water demand has been shown to be within the tolerance ranges for the natural cycle to supply sufficient amounts of water for ecological and anthropogenic needs.

3.5 Enumeration of Water Quantity Threats

As there are no subwatersheds that have been shown to be stressed beyond a Tier-1 assessment, there are no water quantity threats identified for the Source Protection Area.

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. Significant Groundwater Recharge Areas (SGRAs);
3. Wellhead Protection Areas (WHPAs);
4. 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 on a number of factors, including how deep it is 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 4.1*. Areas of high vulnerability are those areas with scores that are less than 30.

Table 4.1: 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 4.2*.

Table 4.2: Aquifer Vulnerability Assessment, South Nation Source Protection Area

Vulnerability Category	Total Area (km^2)	Percentage of Total Area
Low	355	8 %
Medium	870	18 %
High (i.e. HVA)	3,502	74 %

4.1.2 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. 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.

4.1.2.1 Vulnerable 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.

4.1.2.2 *Vulnerability Scoring*

The Groundwater Intrinsic Susceptibility Index (ISI) method was used to assess vulnerability of the SGRAs as discussed in *Section 4.1.1.2*. Vulnerability thresholds are listed in *Table 4.3*.

Table 4.3: Vulnerability Scoring for Significant Groundwater Recharge Areas

Vulnerability Category	ISI Score	Vulnerability Score
Low	> 80	2
Medium	30 to 80	4
High	< 30	6

Final SGRA vulnerability assessment is shown on *Map 4.2*and listed in *Table 4.4*.

Table 4.4: Significant Groundwater Recharge Areas Assessment, South Nation Source Protection Area

Vulnerability Category	Total Area (km²)	Percentage of Total Area
None (i.e. Not SGRA)	3,032	64 %
Low	9	< 1 %
Medium	115	2 %
High	1,571	33 %

4.1.2.3 *Tier 2 Significant Groundwater Recharge Areas*

Groundwater recharge was re-calculated for the two subwatersheds where a Tier-2 water budget was undertaken (SWS29 and SWS37). The Tier 2 calculations were carried out with more detail and contain greater certainty than the recharge values used for the Tier 1 Water Budget. The Tier 2 SGRAs were delineated in the same manner as the Tier 1 SGRAs, using Method 1 as described in *Section 4.1.2.1*. SGRA delineations for SWS29 and SWS37 were carried out using the new recharge values. The average rate of groundwater recharge for the South Nation watershed was 229 mm/year. The threshold for a significant recharge area for SWS39 and SWS37 was then computed to be 263 mm/year (1.15 times the average). Groundwater vulnerability was determined following the method outlined in *Section 4.1.2.2*. The revised SGRAs are shown in *Map 4.3*.

4.1.3 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 South Nation Source Protection Area, there are ten municipal groundwater systems:

1. Vars (City of Ottawa)
2. Limoges (The Nation Municipality)
3. Shadow Ridge, Greely (City of Ottawa)
4. Crysler (Township of North Stormont)
5. Moose Creek (Township of North Stormont)
6. Finch (Township of North Stormont)
7. Winchester (Township of North Dundas)
8. Chesterville (Township of North Dundas)
9. Newington (Township of South Stormont)
10. Bennett Street Well, Spencerville (Township of Edwardsburgh/Cardinal)

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.

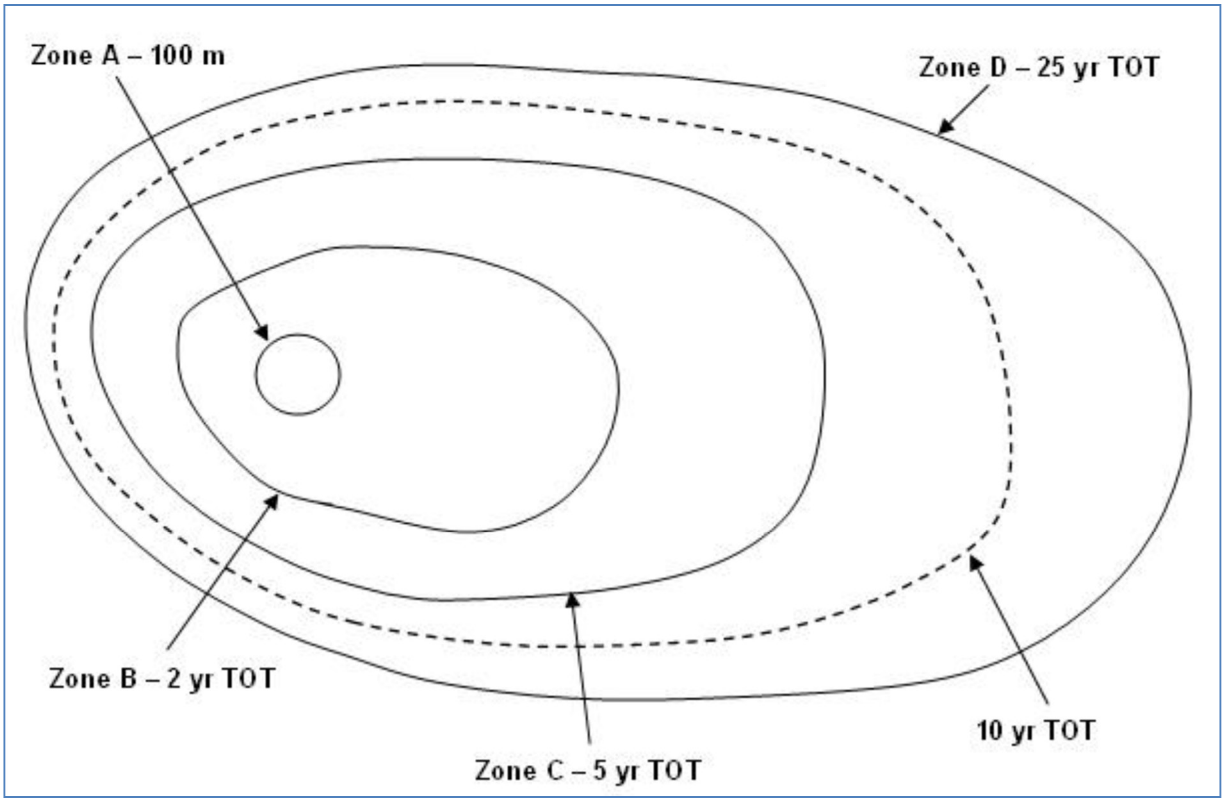
Pollutants can sometimes seep into the ground and contaminate the water in the well. Wellhead protection is a way to prevent municipal drinking water from becoming polluted because it requires landowners to manage activities that could become potential sources of contamination in the area supplying water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

4.1.3.1 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 4.1*.

Figure 4.1: 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.

Wells Influenced by Surface Water

Some wells are influenced by surface water. In these circumstances there is generally incomplete or undependable subsurface filtration of surface water and infiltrating precipitation. The well is said to provide Groundwater under the Direct Influence of Surface Water (GUDI). This can render the supply wells vulnerable to microbiological contamination from surface water sources. Additionally, the interaction between surface water and groundwater could decrease the time of travel of water to the well when compared to the time it would take water to travel to the well if the raw water supply for the well was not under the direct influence of surface water. If a well is known to be GUDI, additional effort is required to delineate the vulnerable area to account for the surface water impact. The additional vulnerable areas are known as WHPA-E (surface water in the immediate vicinity) and WHPA-F (additional contributing surface water).

4.1.3.2 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 4.5*.

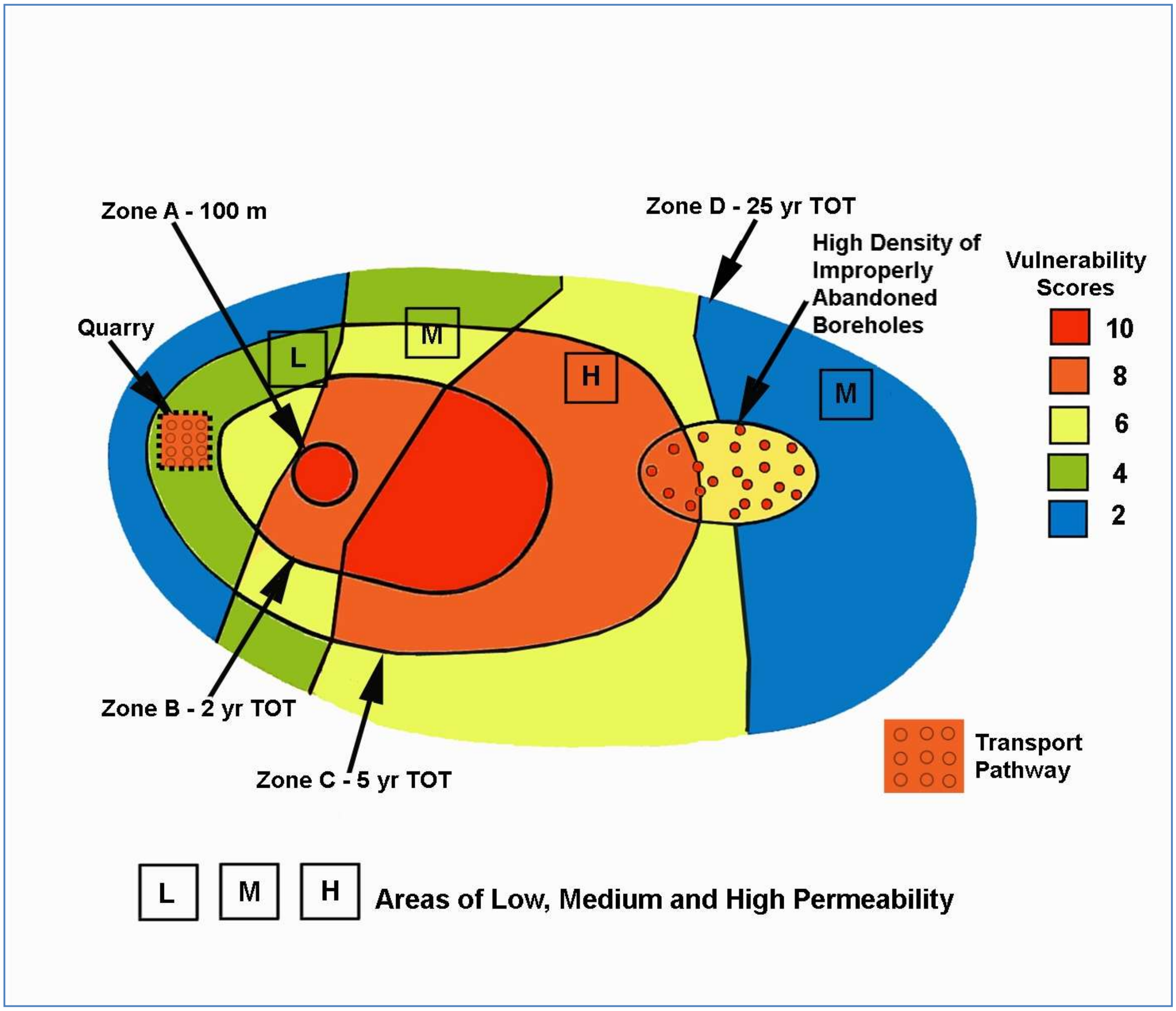
Table 4.5: Prescribed Wellhead Protection Vulnerability Scores (SWAT Approach)

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

4.1.3.3 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 4.2*.

Figure 4.2: Illustration of Vulnerability Scoring, considering Area Vulnerability and Transport Pathways



4.1.3.4 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* 0.

4.1.4 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 South Nation Source Protection Area, there are eight municipal water treatment plants that draw water from surface water:

1. Prescott (Town of Prescott)
2. Cardinal (Township of Edwardsburgh/Cardinal)
3. Morrisburg (Township of South Dundas)
4. Rockland (City of Clarence-Rockland)
5. Wendover (Township of Alfred-Plantagenet)
6. Lefaivre (Township of Alfred-Plantagenet)
7. Hawkesbury (Town of Hawkesbury)
8. Casselman (Village of Casselman)

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.

4.1.4.1 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

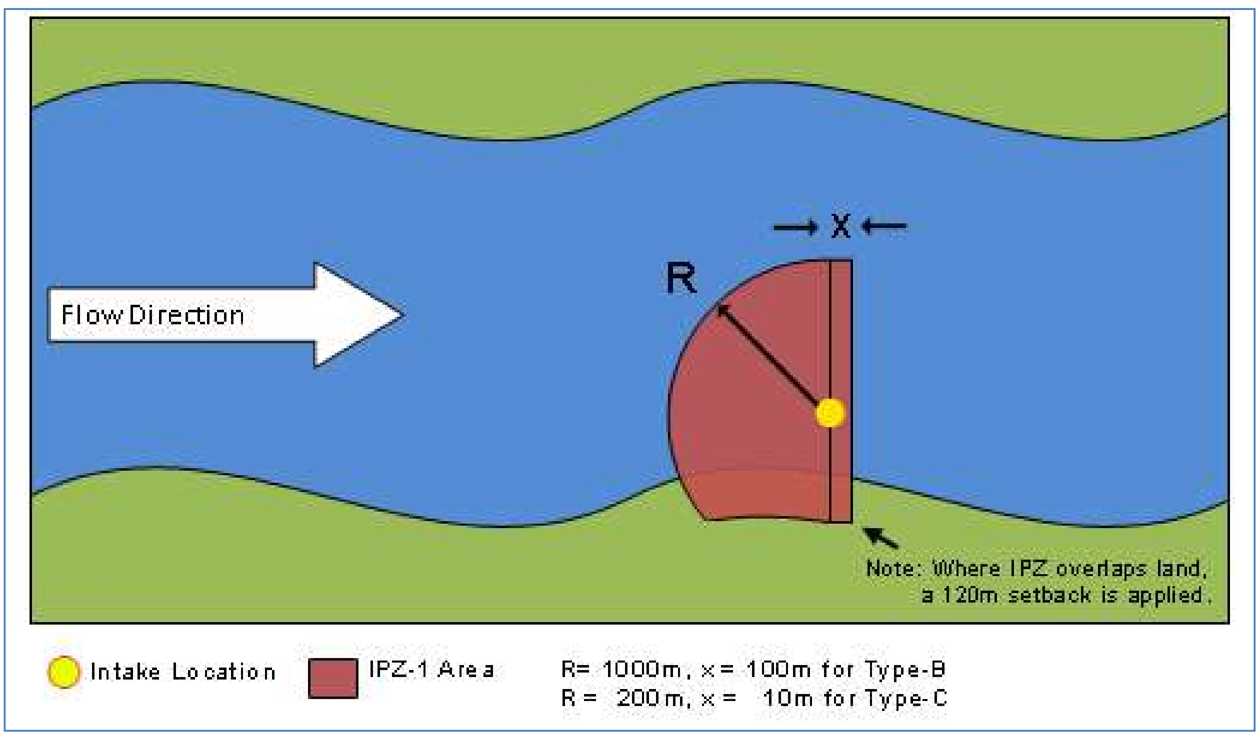
Intake Protection Zone 1

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 4.6*.

Table 4.6: 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 meters from the center point of the intake opening.
Type B	A semi-circle with a radius of 1000 meters extending upstream from the center point of the intake, and a rectangle with a length of 2000 meters and a width of 100 meters extending downstream from the center point of the intake. The zone may be modified based on local hydrodynamic conditions.
Type C	A semi-circle with a radius of 200 meters extending upstream from the centre point of the intake and a rectangle with a length of 400 meters and a width of 10 meters extending downstream from the center point. The zone may be modified based on local hydrodynamic conditions.

Figure 4.3: Default Geometry for Intake Protection Zone 1, Type-B and Type-C Systems



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.

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 wind storm, 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.

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.

4.1.4.2 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 in the product of these two factors is a representative measure of the drinking water source's susceptibility to contamination.

Equation 4.1: Vulnerability Score

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

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 4.7*.

Table 4.7: 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	

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 4.8*.

Table 4.8: 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			
Type B intake							X	X	X	
Type C intake									X	X
Type D intake								X	X	X

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 4.9*. Knowing the range of possible vulnerability scores is useful in assessing the assigned score of one intake relative to another intake.

Table 4.9: Possible Vulnerability Scores for Intake Protection Zones

Intake Type	Vulnerable Area		
	IPZ-1	IPZ-2	IPZ-3
Type A intake	5, 6 or 7	3.5 to 6.3	n.a.
Type B intake	7, 8 or 9	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

4.1.4.3 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* 0.

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 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 in; 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 19 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.

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.

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

An identified activity will be classified as Significant, Moderate or Low drinking water threat if certain circumstances are met. "Tables of Drinking Water Threats" (*the Tables*) is a reference that has been produced by the Province, and contains lists of circumstances where a prescribed activity is considered a threat. *The Tables* have been prepared through an identification of the various drinking water contaminants, and considers quantity, life cycle of a contaminant, toxicity and the likelihood of its release. *The Tables* make reference to 1943 circumstances where activities are drinking water threats due to chemicals (including 50 references to DNAPLs); and 28 circumstances where activities are drinking water threats due to pathogens. *The Tables* also consider the vulnerable area classification and vulnerability score where the activity is occurring.

For simplicity in reporting, *the Tables* have been divided into 76 subsets for particular settings. The "Number", "Name" and "Description" of the Provincial Tables of Circumstances are shown in *Table 4.10*.

Table 4.10: Provincial Tables of Circumstances

Table Number	Table Name	Table Description
1	CW10S	Chemicals in a WHPA with a vulnerability score of 10 where threats are significant
2	CW8S	Chemicals in a WHPA with a vulnerability score of 8 where threats are significant
3	CW10M	Chemicals in a WHPA with a vulnerability score of 10 where threats are moderate
4	CW8M	Chemicals in a WHPA with a vulnerability score of 8 where threats are moderate
5	CW6M	Chemicals in a WHPA with a vulnerability score of 6 where threats are moderate
6	CW10L	Chemicals in a WHPA with a vulnerability score of 10 where threats are low
7	CW8L	Chemicals in a WHPA with a vulnerability score of 8 where threats are low
8	CW6L	Chemicals in a WHPA with a vulnerability score of 6 where threats are low
9	DWAS	DNAPLS in WHPA-A, B, C, C1, with any vulnerability where threats are significant
10	DW6M	DNAPLS in WHPA-D with a vulnerability of 6 where threats are moderate

Table Number	Table Name	Table Description
11	DW6L	DNAPLS in WHPA-D with a vulnerability of 6 where threats are low
12	PW10S	Pathogens in WHPA-A, B with a vulnerability of 10 where threats are significant
13	PW10M	Pathogens in WHPA-A, B with a vulnerability of 10 where threats are moderate
14	PW8M	Pathogens in WHPA-A, B with a vulnerability of 8 where threats are moderate
15	PW8L	Pathogens in WHPA-A, B with a vulnerability of 8 where threats are low
16	PW6L	Pathogens in WHPA-A, B with a vulnerability of 6 where threats are low
17	CSGRAHVA6M	Chemicals in an SGRA or HVA with a vulnerability score of 6 where threats are moderate
18	CSGRAHVA6L	Chemicals in an SGRA or HVA with a vulnerability score of 6 where threats are low
19	CIPZ10S	Chemicals in an IPZ with a vulnerability of 10 where threats are significant
20	CIPZWE9S	Chemicals in an IPZ or WHPA E where the vulnerability score is 9 where threats are significant
21	CIPZWE8.1S	Chemicals in an IPZ or WHPA E where the vulnerability score is 8.1 where threats are significant
22	CIPZWE8S	Chemicals in an IPZ or WHPA E where the vulnerability score is 8 where threats are significant
23	CIPZ10M	Chemicals in an IPZ with a vulnerability of 10 where threats are moderate
24	CIPZWE9M	Chemicals in an IPZ or WHPA E where the vulnerability score is 9 where threats are moderate
25	CIPZWE8.1M	Chemicals in an IPZ or WHPA E where the vulnerability score is 8.1 where threats are moderate
26	CIPZWE8M	Chemicals in an IPZ or WHPA E where the vulnerability score is 8 where threats are moderate
27	CIPZWE7.2M	Chemicals in an IPZ or WHPA E where the vulnerability score is 7.2 where threats are moderate
28	CIPZWE7M	Chemicals in an IPZ or WHPA E where the vulnerability score is 7 where threats are moderate
29	CIPZWE6.4M	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.4 where threats are moderate
30	CIPZWE6.3M	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.3 where threats are moderate
31	CIPZWE10L	Chemicals in an IPZ with a vulnerability of 10 where threats are low
32	CIPZWE9L	Chemicals in an IPZ or WHPA E where the vulnerability score is 9 where threats are low
33	CIPZWE8.1L	Chemicals in an IPZ or WHPA E where the vulnerability score is 8.1 where threats are low
34	CIPZWE8L	Chemicals in an IPZ or WHPA E where the vulnerability score is 8 where threats are low
35	CIPZWE7.2L	Chemicals in an IPZ or WHPA E where the vulnerability score is 7.2 where threats are low
36	CIPZWE7L	Chemicals in an IPZ or WHPA E where the vulnerability score is 7 where threats are low
37	CIPZWE6.4L	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.4 where threats are low
38	CIPZWE6.3L	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.3 where threats are low
39	CIPZWE5.6L	Chemicals in an IPZ or WHPA E where the vulnerability score is 5.6 where threats are low
40	CIPZWE5.4L	Chemicals in an IPZ or WHPA E where the vulnerability score is 5.4 where threats are low
41	CIPZWE4.9L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.9 where threats are low
42	CIPZWE4.8L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.8 where threats are low
43	CIPZWE4.5L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.5 where threats are low
44	CIPZWE4.2L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.2 where threats are low
45	PIPZ10S	Pathogens in an IPZ with a vulnerability of 10 where threats are significant
46	PIPZWE9S	Pathogens in an IPZ or WHPA E with a vulnerability of 9 where threats are significant

Table Number	Table Name	Table Description
47	PIPZWE8.1S	Pathogens in an IPZ or WHPA E with a vulnerability of 8.1 where threats are significant
48	PIPZWE8S	Pathogens in an IPZ or WHPA E with a vulnerability of 8 where threats are significant
49	PIPZWE10M	Pathogens in an IPZ with a vulnerability of 10 where threats are moderate
50	PIPZWE9M	Pathogens in an IPZ or WHPA E with a vulnerability of 9 where threats are moderate
51	PIPZWE8.1M	Pathogens in an IPZ or WHPA E with a vulnerability of 8.1 where threats are moderate
52	PIPZWE8M	Pathogens in an IPZ or WHPA E with a vulnerability of 8 where threats are moderate
53	PIPZWE7.2M	Pathogens in an IPZ or WHPA E with a vulnerability of 7.2 where threats are moderate
54	PIPZWE7M	Pathogens in an IPZ or WHPA E with a vulnerability of 7 where threats are moderate
55	PIPZWE6.4M	Pathogens in an IPZ or WHPA E with a vulnerability of 6.4 where threats are moderate
56	PIPZWE6.3M	Pathogens in an IPZ or WHPA E with a vulnerability of 6.3 where threats are moderate
57	PIPZ6M	Pathogens in an IPZ with a vulnerability of 6 where threats are moderate
58	PIPZ10L	Pathogens in an IPZ with a vulnerability of 10 where threats are low
59	PIPZWE9L	Pathogens in an IPZ or WHPA E with a vulnerability of 9 where threats are low
60	PIPZWE8.1L	Pathogens in an IPZ or WHPA E with a vulnerability of 8.1 where threats are low
61	PIPZWE8L	Pathogens in an IPZ or WHPA E with a vulnerability of 8 where threats are low
62	PIPZWE7.2L	Pathogens in an IPZ or WHPA E with a vulnerability of 7.2 where threats are low
63	PIPZWE7L	Pathogens in an IPZ or WHPA E with a vulnerability of 7 where threats are low
64	PIPZWE6.4L	Pathogens in an IPZ or WHPA E with a vulnerability of 6.4 where threats are low
65	PIPZWE6.3L	Pathogens in an IPZ or WHPA E with a vulnerability of 6.3 where threats are low
66	PIPZ6L	Pathogens in an IPZ with a vulnerability of 6 where threats are low
67	PIPZWE5.6L	Pathogens in an IPZ with a vulnerability of 6 where threats are low
68	PIPZWE5.4L	Pathogens in an IPZ or WHPA E with a vulnerability of 5.4 where threats are low
69	PIPZ5L	Pathogens in an IPZ with a vulnerability of 5 where threats are low
70	PIPZWE4.9L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.9 where threats are low
71	PIPZWE4.8L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.8 where threats are low
72	PIPZWE4.5L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.5 where threats are low
73	PIPZWE4.2L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.2 where threats are low
74	CIPZWEL5	Chemicals in an IPZ or WHPA E where the vulnerability score is 5 where threats are low
75	CIPZWEM6	Chemicals in an IPZ or WHPA E where the vulnerability score is 6 where threats are moderate
76	CIPZWEL6	Chemicals in an IPZ or WHPA E where the vulnerability score is 6 where threats are low

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 includes 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, HVA or SGRA with a score of 6 or higher.

The thresholds defined in order 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 satellite imagery. Improperly classified properties were re-classified to an appropriate property code within the IPZs and WHPAs. The one exception to this manual verification of property codes was for the Casselman IPZ, which was too large of an area and therefore impractical to include with this approach.

The percent managed lands have been mapped and categorized for each assessed drinking water system. The results are presented in *Section5*. The percent managed lands in the Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs) is between 40% and 80%, which indicates a moderate potential for nutrient application to cause contamination on a regional average. HVAs and SGRAs with vulnerability scores of 2 and 4 are below the threshold for consideration.

A regional assessment of Managed Lands is shown in *Table 4.11*.

Table 4.11: Regional Assessment of Managed Lands, South Nation Source Protection Area

Vulnerable Area	Vulnerability Score	Percent Managed Land	Area (km^2)
HVA	6	40% to 80%	3,502.4
SGRA	6	40% to 80%	1,712.7

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 in order 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 *Section5*. The livestock density in Highly Vulnerable Areas (HVAs) and Significant Groundwater Recharge Areas (SGRAs) was <0.5 NU/acre, which indicates a low potential for nutrient application exceeding crop requirements on a regional average. HVAs and SGRAs with vulnerability scores of 2 and 4 are below the threshold for consideration.

A regional assessment of Livestock Density is shown in *Table 4.12*.

Table 4.12: Regional Assessment of Livestock Density, South Nation Source Protection Area

Vulnerable Area	Vulnerability Score	Livestock Density (NU/Acre)	Area (km^2)
HVA	6	<0.5	3,502.4
SGRA	6	<0.5	1,712.7

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 4.13*, *Table 4.14*, *Table 4.15* and *Table 4.16*.

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 4.13: 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 4.14: Potential Threat Areas depending on the nature of the contaminant, SGRAs

Vulnerable Area	Vulnerability Score	Chemical Threats			Pathogen Threats			DNAPL Threats		
		Sig.	Mod.	Low	Sig.	Mod.	Low	Sig.	Mod.	Low
SGRA	6		X	X					X	X
SGRA	4									
SGRA	2									

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

Table 4.15: 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 4.16: 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 South Nation Source Protection Area, this approach is limited to surface water intakes on the St. Lawrence River and Ottawa 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.

5 Assessment of Drinking Water Systems

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

1. Vars (City of Ottawa), 2 groundwater wells
2. Limoges (The Nation Municipality), 2 groundwater wells
3. Shadow Ridge, Greely (City of Ottawa), 1 groundwater well
4. Crysler (Township of North Stormont), 2 groundwater wells
5. Moose Creek (Township of North Stormont), 3 groundwater wells
6. Finch (Township of North Stormont), 2 groundwater wells
7. Winchester (Township of North Dundas), 6 groundwater wells
8. Chesterville (Township of North Dundas), 2 groundwater wells
9. Newington (Township of South Stormont), 2 groundwater wells
10. Bennett Street, Spencerville (Township of Edwardsburgh/Cardinal), 1 groundwater well
11. Prescott (Town of Prescott), 1 surface water intake
12. Cardinal (Township of Edwardsburgh/Cardinal), 1 surface water intake
13. Morrisburg (Township of South Dundas), 1 surface water intake
14. Rockland (City of Clarence-Rockland), 1 surface water intake
15. Wendover (Township of Alfred-Plantagenet), 1 surface water intake
16. Lefaivre (Township of Alfred-Plantagenet), 1 surface water intake
17. Hawkesbury (Town of Hawkesbury), 1 surface water intake
18. Casselman (Village of Casselman), 1 surface water intake

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

5.1 Vars

The village of Vars is located at the eastern extent of the City of Ottawa and the village of Limoges is within the Nation Municipality. The well fields for Vars and Limoges are situated between the two villages, and are located approximately 1.3 km apart. The study area for the Groundwater Vulnerability Analysis is located in the South Nation Watershed, within the Ottawa River Basin.

The Vars and Limoges municipal water supplies are part of the Vars–Winchester esker aquifer, from which the communities of Vars, Limoges, Winchester and Chesterville draw drinking water supplying approximately 16,000 local residents. Rivers traverse and incise into the esker, including the Castor River (located south of the well fields). Geophysics collected along the course of the Castor River imaged the esker beneath the river.

The municipal groundwater supply wells for Vars consist of Well No. 1 and Well No. 2, both 500 mm diameter drilled production wells. Well No. 1 is screened between a depth of 19 m and 22 m and exploits the Esker deposits. Well No. 2 is screened between a depth of 19 and 24 m; this second well exploits the same sand and gravel deposits. The maximum daily permitted pumping rate is 2,300 m³/day per well.

The site location is shown on *Map 5.1.1*. Drinking water system information is presented in *Table5.1.1*.

Table5.1.1: Drinking Water System Information, Vars

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	210002263
Drinking Water System Name	Vars Well System
Owner	The City of Ottawa
Operating Authority	The City of Ottawa
Source Water Type	Groundwater
Number of Wells	2
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	1: 474953 East, 5022389 North (UTM NAD-83, Zone 18) 2: 474942 East, 5022417 North (UTM NAD-83, Zone 18)
Location of Monitoring Wells	
Area served by System	Village of Vars
Number of Users (approx. residents)	800
Minimum Daily Taking	
Average Daily Taking	228 m³/day
Maximum Daily Taking	1,180 m³/day

WHPA Delineation Pumping Rate	584 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 areas WHPA-E and WHPA-F, 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 5.1.2*.

Table 5.1.2: Total Area by Vulnerable Area, Vars

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.7	< 1%
WHPA-B	52.8	10%
WHPA-C	78.3	15%
WHPA-D[1]	398.6	75%
Total	**533.4**	**100 %**

Note: 1) Due to its proximity to the Limoges Well Supply, the WHPA-D area is a shared area between the two drinking water systems

Due to the proximity of the Limoges Well Supply, the WHPA-D area for the Vars Well supply is shared with the WHPA-D area of the Limoges Well. It is not possible to isolate the WHPA-D for Vars, as the operation of Limoges affects the groundwater flow towards the Vars well.

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 takes into account 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.

Both the Vars and Limoges water supply wells are completed within coarse-textured Esker deposits. The surficial geology in this area consists of the linear Esker feature which can exceed thicknesses of 15 m. The Esker is exposed at surface in isolated pockets, but more often is overlain by the Basin Mud, which varies in thickness and can attain over 30 metres. Underlying the Esker deposits, and flanking the Esker to either side is a Sandy-Silt Till, the Sandy-Silt Till also underlies the Basin Mud. A discontinuous Sub-Till Sediment deposit is present between the Basin Mud and the underlying bedrock.

An elongated esker extends from Vars and Limoges down to the south towards Chesterville. Esker deposits are expected to consist of a gravelly central ridge (core) blanketed by a sandy carapace. However, the geometry and connectivity of the existing gravel deposits is not well understood.

The geologic stratigraphy at the municipal wells, as documented in the well record, comprises alternating layers of sand and gravel. In Well #1, a clay unit, about 1.5 m thick, was encountered at a depth of about 4 m. Above and below this clay layer was sand and gravel, the final depth of the well is about 23 m. The stratigraphy at Well #2, located about 32 m north of Well #1, is again mostly sand and gravel, with the exception of a layer described as a till between 3 and 4.6 m depth. The total depth of the well is 24.5 m. Both wells are interpreted to be located within the Esker.

SWAT assessment is shown on *Map 5.1.3*.

WHPA vulnerability scoring is shown on *Map 5.1.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.1.3*.

Table 5.1.3: Distribution of Vulnerability Scores, Vars

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-A	3.7	3.7	*n.a.*	*n.a.*	*n.a.*	*n.a.*
WHPA-B	52.8	2.7	50.1	0	*n.a.*	*n.a.*
WHPA-C	78.3	*n.a.*	0	61.9	*n.a.*	16.4
WHPA-D[1]	398.6	*n.a.*	*n.a.*	0	157.8	240.9
Total	**533.4**	**6.4**	**50.1**	**61.9**	**157.8**	**257.3**

Note: 1) Due to its proximity to the Limoges Well Supply, the WHPA-D area is a shared area between the two drinking water systems

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.

The Vars wells are completed in the sand and gravel esker aquifer. Groundwater supplying both the Vars wells flows from the Esker deposits, the Sub-Till Sediment and the shallow bedrock. The vulnerability of these aquifers is moderate to low given the presence of a protective layer. Transport pathways of greatest concern are wells that penetrate the aquifer and can act as conduits for contaminants. No noteworthy transport pathways or cluster s of pathways were identified, and thus, the vulnerability scores were not adjusted.

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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.1.4*, *Table 5.1.5*and *Table 5.1.6*.

The applicable circumstance tables are also referenced visually on *Map 5.1.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.1.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Vars

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-C	6	*Below threshold*	5 (CW6M)	8 (CW6L)
WHPA-C	2	*Below threshold*	*Below threshold*	*Below threshold*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.1.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Vars

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	**Moderate**	**Low**
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	8	*None*	14 (PW8M)	15 (PW8L)
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.1.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Vars

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	**Moderate**	**Low**
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
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 5.1.7*. The vulnerability score for WHPA-D and a portion of WHPA-C is 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, that area is not considered for this evaluation.

Table 5.1.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Vars

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	3	0	1	1	33%
WHPA-B	53	30	0	30	57%
WHPA-C	62	15	0	15	24%

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 5.1.8*. The vulnerability score for WHPA-D and a portion of WHPA-C is 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, that area is not considered for this evaluation.

Table 5.1.8: Livestock Density Assessment, Vars

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0	0.10		
8		0.10	n.a.	
6		0	0.10	n.a.

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 5.1.9*. The area vulnerability score for WHPA-D and a portion of WHPA-C is less than the vulnerability score 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 5.1.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Vars

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
WHPA-A	0	3.7	0	0
WHPA-B	22.3	30.5	0	0
WHPA-C	60.9	17.5	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

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 6activities that are or would be drinking water quality threats have been counted at 4 locations.

Specific activities and location counts are listed in *Table 5.1.10*.

Table 5.1.10: Significant Drinking Water Threat Activities, Vars

Activity	Sub Threat, if Applicable	Count
The handling and storage of fuel.		2
The storage of agricultural source material.		1
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.	Agricultural Source Material (ASM) Generation	3
Total – All Activities		**6**

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 5.1.11*. 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 5.1.11: Key Information Sources, Vars

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Vars Well Supply – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Vars and Limoges Water Supply.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Vars and Limoges Water Supply.*	Technical Study	SWAT Assessment, 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

Section	**Source(s)**	**Type**	**Analysis Method(s)**
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. *Groundwater Threats and Issues Inventory, Greely, Vars and Limoges.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Groundwater Threats and Issues Inventory, Greely, Vars and Limoges.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.1.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. SAAT uncertainty considers the accuracy of assessing the impermeable nature of the clay layer. This layer has varying thickness, where the clay is thinnest it appears there could be some vertical flow of groundwater. As the exact thickness is not known at all locations, uncertainty is assessed at "high”. Since the SAAT approach had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in

WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.1.12*.

Table 5.1.12: Summary of Uncertainty Analyses, Vars

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	High	High	Low	Low

5.2 Limoges

The village of Vars is located at the eastern extent of the City of Ottawa and the village of Limoges is within the Nation Municipality. The well fields for Vars and Limoges are situated between the two villages, and are located approximately 1.3 km apart. The study area for the Groundwater Vulnerability Analysis, is located in the South Nation Watershed, within the Ottawa River Basin.

The Vars and Limoges municipal water supplies are part of the Vars–Winchester esker aquifer, from which the communities of Vars, Limoges, Winchester and Chesterville draw drinking water supplying approximately 16,000 local residents. Rivers traverse and incise into the esker, including the Castor River (located south of the well fields). Geophysics collected along the course of the Castor River imaged the esker beneath the river.

The drinking water system for Limoges is located about 4 km west of the Village of Limoges at 2460 Russland Road. The system consists of two production wells both located on the same property. Well #1 was drilled in 1994 and has a depth of about 24.5 m. Well #2 was drilled in 1998 and has a depth of 21.5 m. The well is housed in a precast concrete chamber. This second well is used primarily as the standby well.

The site location is shown on *Map 5.2.1*. Drinking water system information is presented in *Table5.2.1*.

Table5.2.1: Drinking Water System Information, Limoges

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	260006841
Drinking Water System Name	Limoges Well Supply
Owner	The Nation Municipality
Operating Authority	SIMO
Source Water Type	Groundwater
Number of Wells	2
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	Not confirmed
Coordinates of Well	1: 475425.0 Easting, 5021088.0 Northing; NAD-83. Zone 18 2: 475424.5 Easting, 5021087.9 Northing; NAD-83. Zone 18
Location of Monitoring Wells	
Area served by System	Village of Limoges
Number of Users (approx. residents)	3,300
Minimum Daily Taking	
Average Daily Taking	615 m^3/day
Maximum Daily Taking	779 m^3/day

WHPA Delineation Pumping Rate	783 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 been identified as being near a surface water body; however, it has not formally been studied as under the direct influence (GUDI). Areas WHPA-E and WHPA-F, as defined by *the Rules* were not delineated. An updated Assessment Report would be required if a GUDI study was undertaken and the results indicated the groundwater source was influenced by surface water.

The various WHPAs for this drinking water system are shown on *Map 5.2.2*. The respective area calculations are summarized in *Table 5.2.2*.

Table 5.2.2: Total Area by Vulnerable Area, Limoges

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	<1%
WHPA-B	33.3	6%
WHPA-C	159.8	27%
WHPA-D[1]	398.6	67%
Total	**594.8**	**100 %**

Note: 1) Due to its proximity to the Vars Well Supply, the WHPA-D area is a shared area between the two drinking water systems

Due to the proximity of the Vars Well Supply, the WHPA-D area for the Limoges Well supply is shared with the WHPA-D area of the Vars Wells. It is not possible to isolate the WHPA-D for Limoges, as the operation of Vars affects the groundwater flow towards the Limoges well.

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 takes into account 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.

Both the Limoges and Vars water supply wells are completed within coarse-textured Esker deposits. The surficial geology in this area consists of the linear Esker feature which can exceed thicknesses of 15 m. The Esker is exposed at surface in isolated pockets, but more often is overlain by the Basin Mud, which varies in thickness and can attain over 30 metres. Underlying the Esker deposits, and flanking the Esker to either side is a Sandy-Silt Till, the Sandy-Silt Till also underlies the Basin Mud. A discontinuous Sub-Till Sediment deposit is present between the Basin Mud and the underlying bedrock.

An elongated esker extends from Vars and Limoges down to the south towards Chesterville. Esker deposits are expected to consist of a gravelly central ridge (core) blanketed by a sandy carapace. However, the geometry and connectivity of the existing gravel deposits is not well understood.

The water well records for both production wells (Well # 1 and # 2) indicate that, at this location, there is a thin layer of clay overlying an interbedded sand and gravel deposit. Both wells are between 20 and 25 m deep, and both intersected continuous sand and gravel below a depth of 4 m. These wells are assumed to penetrate the buried esker deposit.

SWAT assessment is shown on *Map 5.2.3*.

WHPA vulnerability scoring is shown on *Map 5.2.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.2.3*.

Table 5.2.3: Distribution of Vulnerability Scores, Limoges

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	33.3	0	9.4	23.9	*n.a.*	*n.a.*
WHPA-C	159.8	*n.a.*	0	21.6	*n.a.*	138.2
WHPA-D	398.6	*n.a.*	*n.a.*	0	157.8	240.9
Total	**594.8**	**3.1**	**9.4**	**45.5**	**157.8**	**379.1**

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.

The Limoges wells are completed in the sand and gravel esker aquifer. Groundwater supplying both the Limoges wells flows from the Esker deposits, the Sub-Till Sediment and the shallow bedrock. The vulnerability of these aquifers is moderate to low given the presence of a protective layer. Transport pathways of greatest concern are wells that penetrate the aquifer and can act as conduits for contaminants. No noteworthy transport pathways or clusters of pathways were identified, and thus, the vulnerability scores were not adjusted.

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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.2.4*, *Table 5.2.5* and *Table 5.2.6*.

The applicable circumstance tables are also referenced visually on *Map 5.2.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.2.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Limoges

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-B	6	*Below threshold*	5 (CW6M)	8 (CW6L)
WHPA-C	6	*Below threshold*	5 (CW6M)	8 (CW6L)
WHPA-C	2	*Below threshold*	*Below threshold*	*Below threshold*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.2.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Limoges

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	8	*None*	14 (PW8M)	15 (PW8L)
WHPA-B	6	*Below threshold*	*None*	16 (PW6L)
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.2.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Limoges

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*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 5.2.6* and is tabulated in *Table 5.2.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.2.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Limoges

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	1	1	34%
WHPA-B	33.3	0	4	4	12%
WHPA-C	159.8	4	2	6	4%

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 5.1.7* and is tabulated in *Table 5.2.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.2.8: Livestock Density Assessment, Limoges

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0	n.a.		
8		0	n.a.	
6		0	0.10	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 5.2.8* and tabulated in *Table 5.2.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.2.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Limoges

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
WHPA-A	0	3.1	0	0
WHPA-B	1.6	28.3	3.5	0
WHPA-C	16.0	66.4	77.4	0

5.2.3.6 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.

5.2.3.7 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

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 1 significant threat has been counted at 1 location.

Specific activities and location counts are listed in *Table 5.2.10*.

Table 5.2.10: Significant Drinking Water Threat Activities, Limoges

Activity	Sub Threat, if Applicable	Count
The handling and storage of fuel.		1
Total – All Activities		**1**

5.2.4 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.

5.2.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.2.11*. 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 5.2.11: Key Information Sources, Limoges

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2010. *Limoges Well Supply – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Vars and Limoges Water Supply.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Vars and Limoges Water Supply.*	Technical Study	SWAT Assessment, 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

Section	Source(s)	Type	Analysis Method(s)
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. *Groundwater Threats and Issues Inventory, Greely, Vars and Limoges.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Groundwater Threats and Issues Inventory, Greely, Vars and Limoges.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.2.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. SAAT uncertainty considers the accuracy of assessing the impermeable nature of the clay layer. This layer has varying thickness, where the clay is thinnest it appears there could be some vertical flow of groundwater. As the exact thickness is not known at all locations, uncertainty is assessed at "high". Since the SAAT approach had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in

WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.2.12*.

Table 5.2.12: Summary of Uncertainty Analyses, Limoges

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	High	High	Low	Low

5.3 Shadow Ridge, Greely

The Shadow Ridge Subdivision is located in the Village of Greely. The Village is located outside the serviced area of the City of Ottawa and therefore developments are usually designed with private services. The Shadow Ridge Estates has a communal water supply system that consists of two groundwater wells. These wells are located in the southeast portion of the development and are spaced approximately 10 m apart. The wells are completed to depths of 18.3m and 19 m in a very permeable sand and gravel unit. The estimated pumping rate for the wells is 748 m³/day. This development will eventually serve an estimated population of 2078 persons. As of 2009, approximately 30 housing units were planned. The site location is shown on *Map 5.3.1*. Drinking water system information is presented in *Table5.3.1*.

Table5.3.1: Drinking Water System Information, Shadow Ridge, Greely

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	260089635
Drinking Water System Name	SHADOW RIDGE WELL SUPPLY
Owner	City of Ottawa
Operating Authority	City of Ottawa
Source Water Type	Groundwater
Number of Wells	2
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	#1: 455891 Easting, 5010106 Northing (NAD-83, Zone-18) #2: 455903 Easting, 5010109 Northing (NAD-83, Zone-18)
Location of Monitoring Wells	
Area served by System	Shadow Ridge Subdivision, Greely
Number of Users (approx. residents)	2,078 (planned); 30 homes currently serviced
Minimum Daily Taking	
Average Daily Taking	17 m³/day
Maximum Daily Taking	133 m³/day
WHPA Delineation Pumping Rate	1,388 m³/day

5.3.1 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 areas WHPA-E and WHPA-F, as defined by *the Rules* do not apply.

The various WHPAs for this drinking water system are shown on *Map 5.3.2*. The respective area calculations are summarized in *Table 5.3.2*.

Table 5.3.2: Total Area by Vulnerable Area, Shadow Ridge, Greely

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	1%
WHPA-B	91.2	42%
WHPA-C	34.2	16%
WHPA-D	90.9	41%
Total	**219.4**	**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.

5.3.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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 that the sand and gravel aquifer is unconfined and therefore the calculation of vertical travel times yielded no vertical flux above the aquifer within the area delineated for the WHPA. The resulting SWAT is therefore the same as the time of travel zones used for WHPA delineation. This implies that aquifer vulnerability is high.

SWAT assessment is shown on *Map 5.3.3*.

WHPA vulnerability scoring is shown on *Map 5.3.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.3.3*.

Table 5.3.3: Distribution of Vulnerability Scores, Shadow Ridge, Greely

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	91.2	91.2	0	0	*n.a.*	*n.a.*
WHPA-C	34.2	*n.a.*	34.2	0	*n.a.*	0.0
WHPA-D	90.9	*n.a.*	*n.a.*	0	90.9	0.0
Total	**219.4**	**94.3**	**34.2**	**0**	**90.9**	**0.0**

5.3.2.1 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.

The aquifer for the Shadow Ridge Subdivision is an unconfined, highly permeable sand and gravel deposit. There is no natural protective layer above this aquifer (such as a till or clay layer) to isolate the aquifer from contamination. Any transport pathways therefore would not change the vulnerability scoring for these WHPA’s as the intrinsic vulnerability is already at its highest for the respective WHPA’s. Though the vulnerability score would not change, transport pathways are still present within the Shadow Ridge WHPA’s and could promote migration of contaminants. Of greatest concern are wells as they penetrate the aquifer and can act as conduits.

There are many domestic wells situated within the limits of the WHPA. Depending on the integrity of the well construction, any of these wells could provide a conduit for downward migration of contaminants into the aquifer. Excavations are areas where surface vegetation is removed or altered and transport pathways may exist. There is extensive construction within the 2-yr WHPA, creating large areas with no vegetation or soil. These areas of construction would be considered a transport pathway.

5.3.3 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.

5.3.3.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.3.3.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.3.4*, *Table 5.3.5* and *Table 5.3.6*.

The applicable circumstance tables are also referenced visually on *Map 5.3.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.3.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Shadow Ridge, Greely

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.3.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Shadow Ridge, Greely

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.3.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Shadow Ridge, Greely

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.3.3.3 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 5.3.6* and is tabulated in *Table 5.3.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.3.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Shadow Ridge, Greely

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	3	0	1	1	33%
WHPA-B	91	6	26	32	35%
WHPA-C	34	0	18	18	53%

5.3.3.4 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 5.3.7* and is tabulated in *Table 5.3.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.3.8: Livestock Density Assessment, Shadow Ridge, Greely

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0	0.10		
8		0.10	n.a.	
6		n.a.	n.a.	n.a.

5.3.3.5 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 5.3.8* and tabulated in *Table 5.3.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.3.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Shadow Ridge, Greely

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
WHPA-A	0	3.1	0	0
WHPA-B	0	35.1	56.2	0
WHPA-C	0	8.7	25.6	0

5.3.3.6 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.

5.3.3.7 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.

5.3.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 287 activities that are or would be drinking water quality threats have been counted at 145 locations.

Specific activities and location counts are listed in *Table 5.3.10*.

Table 5.3.10: Significant Drinking Water Threat Activities, Shadow Ridge, Greely

Activity	Sub Threat, if Applicable	Current Count
The application of agricultural source material to land.		5
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Septic System	138
The handling and storage of commercial fertilizer.		2
The handling and storage of fuel.		140
The handling and storage of pesticide.		2
Total – All Activities		**287**

5.3.4 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.

5.3.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.3.11*. 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 5.3.11: Key Information Sources, Shadow Ridge, Greely

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Shadow Ridge Well Supply – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analysis, Shadow Ridge Subdivision.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analysis, Shadow Ridge Subdivision.*	Technical Study	SWAT Assessment, 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

Section	Source(s)	Type	Analysis Method(s)
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. *Groundwater Threats and Issues Inventory, Greely, Vars and Limoges.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Groundwater Threats and Issues Inventory, Greely, Vars and Limoges.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.3.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. There is no low permeability layer overlying the aquifer, there was no additional SAAT calculation and therefore uncertainty is low. Although the SWAT approach had low uncertainty, the WHPA delineation 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.3.12*.

Table 5.3.12: Summary of Uncertainty Analyses, Shadow Ridge, Greely

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	Low	Low	Low
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	High	High	Low	Low

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5.5 Crysler

The Crysler drinking water system services the Village of Crysler, which is located approximately 60 km southeast of Ottawa. The Crysler groundwater wells are owned by the Township of North Stormont, operated by the Ontario Clean Water Agency (OCWA), and supply approximately 600 residents with potable water. The well field is located 5 km northeast of Crysler. Well #1 was installed in 1993 by Olympic Drilling Company Ltd, and was completed with a 250 mm diameter stainless steel casing and wire wrap screen to a depth of 12.2 m below ground. The well screen is approximately 3 m in length. The standby well, Well #2, was installed by Olympic Drilling Company Ltd in 1986. The well was drilled to a depth of 13.4 m below the ground surface in which 200 mm and 250 mm diameter stainless steel casings were installed to a depth of approximately 8.4 m below ground.

The site location is shown on *Map 5.5.1*. Drinking water system information is presented in *Table5.5.1*.

Table5.5.1: Drinking Water System Information, Crysler

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	220008649
Drinking Water System Name	Crysler Well Supply
Owner	North Stormont, The Corporation of the Township of
Operating Authority	Ontario Clean Water Agency (OCWA)
Source Water Type	Groundwater
Number of Wells	2
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	Yes, with effective in-situ filtration
Coordinates of Well	#1: 492520 East, 5009054 North (UTM NAD-83, Zone 18) #2: 492544 East, 5009035 North(UTM NAD-83, Zone 18)
Location of Monitoring Wells	
Area served by System	Village of Crysler
Number of Users (approx. residents)	600
Minimum Daily Taking	180 m^3/day
Average Daily Taking	260 m^3/day
Maximum Daily Taking	1,685 m^3/day
WHPA Delineation Pumping Rate	621 m^3/day

5.5.1 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).

Due to the absence of an overlying confining layer (such as basin mud), both supply wells have been classified as GUDI (groundwater under direct influence of surface water) wells with effective insitu filtration. WHPA-E and WHPA-F were not calculated for these systems..

The various WHPAs for this drinking water system are shown on *Map 5.5.2*. The respective area calculations are summarized in *Table 5.5.2*.

Table 5.5.2: Total Area by Vulnerable Area, Crysler

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	1%
WHPA-B	77.9	15%
WHPA-C	178.2	35%
WHPA-D	246.7	49%
Total	**505.9**	**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.

5.5.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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.

At the location of the Crysler municipal well, the well is completed within the esker deposits and there is no protective layer (e.g. clay) overlying the aquifer. The groundwater model results showed the groundwater that entered the Crysler wells travelled through the shallow bedrock and then into the more permeable esker deposits. There is very little clay in this vicinity, either overlying the esker or bedrock, and therefore it is considered there is no effective aquitard above the aquifer

SWAT assessment is shown on *Map 5.5.3*.

The value of the groundwater vulnerability is 10 at the well head (WHPA-A), and is also 10 in WHPA-B, due to the infiltration through the permeable esker, till and bedrock. WHPA-C has a vulnerability score of 8 and WHPA-D has a score of 4.

WHPA vulnerability scoring is shown on *Map 5.5.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.5.3*.

Table 5.5.3: Distribution of Vulnerability Scores, Crysler

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	77.9	77.9	0	0	*n.a.*	*n.a.*
WHPA-C	178.2	*n.a.*	178.2	0	*n.a.*	0
WHPA-D	246.7	*n.a.*	*n.a.*	0	246.7	0
Total	**505.9**	**81.0**	**178.2**	**0**	**246.7**	**0**

5.5.2.1 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.

The Crysler well is completed in the sand and gravel aquifer with no effective protective aquitard layer (e.g. clay) to protect the aquifer. As a result, the WHPA scores are already the highest possible score for each WHPA and any transport pathways therefore would not change the vulnerability scoring for these WHPAs. Though the vulnerability score would not change, transport pathways are still present within the Crysler WHPAs and could promote migration of contaminants. There are private wells located within the WHPA areas. The private wells represent a conduit to possible groundwater impact. Private wells that are no longer in use should be properly decommissioned to limit the number of transport pathways to the aquifer.

The intrinsic vulnerability was considered to be high in the WHPA-B, -C and –D. The presence of transport pathways therefore would not alter the vulnerability scoring for the Crysler WHPAs. The uncertainty related to transport pathways is low as the scoring does not change.

5.5.3 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.

5.5.3.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.5.3.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.5.4*, *Table 5.5.5* and *Table 5.5.6*.

The applicable circumstance tables are also referenced visually on *Map 5.5.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.5.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Crysler

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.5.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Crysler

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.5.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Crysler

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.5.3.3 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 5.5.6* and is tabulated in *Table 5.5.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.5.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Crysler

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	3	0	0	0	0 %
WHPA-B	78	63	0	63	81 %
WHPA-C	178	142	0	142	80 %

5.5.3.4 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 5.5.7* and is tabulated in *Table 5.5.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.5.8: Livestock Density Assessment, Crysler

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.38	0.38		
8			0.38	

5.5.3.5 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 5.5.8* and tabulated in *Table 5.5.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.5.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Crysler

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
WHPA-A	0	3.1	0	0
WHPA-B	9.6	68.4	0	0
WHPA-C	53.7	124.5	0	0

5.5.3.6 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.

5.5.3.7 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.

5.5.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 44 activities that are or would be drinking water quality threats have been counted at 9 locations.

Specific activities and location counts are listed in *Table 5.5.10*.

Table 5.5.10: Significant Drinking Water Threat Activities, Crysler

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		8
The application of commercial fertilizer to land.		8
The application of non-agricultural source material to land.		8
The application of pesticide to land.		8
The handling and storage of a dense non-aqueous phase liquid.		1
The handling and storage of commercial fertilizer.		2
The handling and storage of fuel.		3
The handling and storage of pesticide.		2
The storage of agricultural source material.		2
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.	Agricultural Source Material (ASM) Generation	2
Total – All Activities		**44**

5.5.4 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.

5.5.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.5.11*. 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 5.5.11: Key Information Sources, Crysler

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Crysler Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	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 Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.5.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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.

There was site specific data available for the development of the numerical groundwater model for the Crysler municipal supply well; however the primary data source was the MOE well records, and these data had relatively low density within the model domain.

The uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. Due to the presence of the esker, the shape of the WHPA is dependent on the relative conductivity in the bedrock, esker and other overburden materials as well as the geometry of these different layers. The WHPA Delineation in this case has high uncertainty. There is no effective low permeability layer above the aquifer and therefore there is no additional SAAT calculation. Uncertainty for the SAAT is low.

Since the WHPA delineation had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.5.12*.

Table 5.5.12: Summary of Uncertainty Analyses, Crysler

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	High
Surface to Aquifer Advection Time	n/a	Low	Low	Low
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	High	High	Low	Low

5.6 Moose Creek

The Moose Creek groundwater drinking water system services the Village of Moose Creek, which is located approximately 80 km southeast of Ottawa. The Moose Creek production wells are owned by the Township of North Stormont, operated by the Ontario Clean Water Agency (OCWA), and supply about 300 residents with potable water. The well field is located within the village of Moose Creek. There are three production wells, Well 1R, Well 2 and Well 3.

The site location is shown on *Map 5.6.1*. Drinking water system information is presented in *Table5.6.1*.

Table5.6.1: Drinking Water System Information, Moose Creek

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	220008033
Drinking Water System Name	Moose Creek Well Supply
Owner	North Stormont, The Corporation of the Township of
Operating Authority	Ontario Clean Water Agency (OCWA)
Source Water Type	Groundwater
Number of Wells	3
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	1R: 502764 East, 5010767 North (UTM NAD-83, Zone 18) 2 : 502855 East, 5010651 North (UTM NAD-83, Zone 18) 3 : 502916 East, 5010688 North (UTM NAD-83, Zone 18)
Location of Monitoring Wells	
Area served by System	Village of Moose Creek
Number of Users (approx. residents)	300
Minimum Daily Taking	151 m^3/day
Average Daily Taking	180 m^3/day
Maximum Daily Taking	896 m^3/day
WHPA Delineation Pumping Rate	421 m^3/day

5.6.1 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).

It is not know whether a GUDI (groundwater under direct influence) assessment has been completed at the Moose Creek municipal well field. In 2002, the Ministry of the Environment concluded it was not based on raw water quality data and the fact that the wells are deep (over 30 meters). WHPA-E and WHPA-F were not calculated for this well field.

The various WHPAs for this drinking water system are shown on *Map 5.6.2*. The respective area calculations are summarized in *Table 5.6.2*.

Table 5.6.2: Total Area by Vulnerable Area, Moose Creek

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	7.2	< 1%
WHPA-B	249.4	26%
WHPA-C	155.4	16%
WHPA-D	552.3	57%
Total	**964.3**	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.

5.6.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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 Moose Creek wells were completed in bedrock, and an overlying sand deposit. The WHPA for Moose Creek extends in different directions. The Moose Creek well field is located in a topographic low. The groundwater model results show groundwater flows to the wells is from the topographically high areas around the well field. Groundwater flows through the sands overlying the bedrock and the bedrock to arrive at the well. Groundwater flow through the surficial tills appears to be minimal. Till overlies the sand and bedrock aquifer in the area. However, the thickness of the till varies. Where the till is thick it appears to be an effective protective layer for the sand and bedrock aquifer, resulting in low vulnerability scores. Areas with a thin layer or no till resulted in higher vulnerability scores.

SWAT assessment is shown on *Map 5.6.3*.

The value of the vulnerability score is 10 at the well head (WHPA-A). Groundwater vulnerability scores in WHPA-B were between 6 and 10. Vulnerability in WHPA-C was between 4 and 8 and vulnerability scores within WHPA-D were either 2 or 4.

WHPA vulnerability scoring is shown on *Map 5.6.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.6.3*.

Table 5.6.3: Distribution of Vulnerability Scores, Moose Creek

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-A	7.2	7.2	*n.a.*	*n.a.*	*n.a.*	*n.a.*
WHPA-B	249.4	178.7	44.5	26.2	*n.a.*	*n.a.*
WHPA-C	155.4	*n.a.*	129.2	23.3	*n.a.*	2.9
WHPA-D	552.3	*n.a.*	*n.a.*	0	405.4	146.9
Total	**964.3**	**185.9**	**173.7**	**49.5**	**405.4**	**149.8**

5.6.2.1 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.

There are some areas where there is a confining layer over the WHPA for Moose Creek. There are very few wells completed within the WHPA for Moose Creek, and most of these wells were supervised by consultants. No transport pathways were identified for these WHPAs.

5.6.3 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.

5.6.3.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.6.3.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.6.4*, *Table 5.6.5* and *Table 5.6.6*.

The applicable circumstance tables are also referenced visually on *Map 5.6.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.6.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Moose Creek

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	**Moderate**	**Low**
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-B	6	*Below threshold*	5 (CW6M)	8 (CW6L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-C	6	*Below threshold*	5 (CW6M)	8 (CW6L)
WHPA-C	4	*Below threshold*	*Below threshold*	*Below threshold*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.6.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Moose Creek

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	**Moderate**	**Low**
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	8	*None*	14 (PW8M)	15 (PW8L)
WHPA-B	6	*Below threshold*	*None*	16 (PW6L)
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.6.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Moose Creek

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	**Moderate**	**Low**
WHPA-A	All Scores	9 (DWAS)	*None*	*None*

WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.6.3.3 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 5.6.6* and is tabulated in *Table 5.6.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.6.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Moose Creek

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	7	0.3	0	0.3	4%
WHPA-B	250	184	0	184	73%
WHPA-C	155	86	0	86	55%

5.6.3.4 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 5.6.7* and is tabulated in *Table 5.6.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.6.8: Livestock Density Assessment, Moose Creek

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.06	0.06		
8		0.06	0.06	
6		0.06	0.06	n.a.

5.6.3.5 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 5.6.8* and tabulated in *Table 5.6.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.6.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Moose Creek

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
WHPA-A	0	7.2	0	0
WHPA-B	13.5	232.6	3.3	0
WHPA-C	69.6	77.4	5.5	0

5.6.3.6 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.

5.6.3.7 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.

5.6.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 30 activities that are or would be drinking water quality threats have been counted at 18 locations.

Specific activities and location counts are listed in *Table 5.6.10*.

Table 5.6.10: Significant Drinking Water Threat Activities, Moose Creek

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		7
The application of pesticide to land.		7
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Septic System or Holding Tank	11
The handling and storage of a dense non-aqueous phase liquid.		1
The handling and storage of commercial fertilizer.		1
The handling and storage of fuel.		2
The handling and storage of pesticide.		1
Total – All Activities		**30**

5.6.4 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.

5.6.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.6.11*. 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 5.6.11: Key Information Sources, Moose Creek

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Moose Creek Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	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 Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.6.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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.

There was site specific data available for the development of the numerical groundwater model for the Moose Creek municipal supply well; however the primary data source was the MOE well records, and these data had relatively low density within the model domain. This information supports the relative uncertainty attributed to this assessment.

The uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. There are three wells that comprise the Moose Creek Well Field. Each well is completed at a different depth and thereby intersecting different geologic layers. Groundwater flow converges from three directions at the well field. Uncertainty of the general shape and direction is high resulting from different flow path possibilities depending on the contrasting hydraulic conductivity of the different overburden and bedrock layers. There is a low permeability layer overlying the eastern lobe of the WHPA, SAAT calculations were completed in this region.

Since the delineation of WHPA zones had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in

WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.6.12*.

Table 5.6.12: Summary of Uncertainty Analyses, Moose Creek

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	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	High	High	Low	Low

5.7 Finch

The Village of Finch is located approximately 70 km southeast of Ottawa. The Finch production wells are owned by the Township of North Stormont, operated by the Ontario Clean Water Agency (OCWA), and supply about 440 residents with potable water. The well field is located in the northwest area of Finch. There are two production wells, both were installed in 1972. Both wells are completed in limestone between the depths of 8.5 to 57 m below ground. The wells are cased to 8.5 m below ground and are open boreholes below 8.5 m depth.

The site location is shown on *Map 5.7.1*. Drinking water system information is presented in *Table5.7.1*.

Table5.7.1: Drinking Water System Information, Finch

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	210003912
Drinking Water System Name	Finch Well Supply
Owner	North Stormont, The Corporation of the Township of
Operating Authority	Ontario Clean Water Agency (OCWA)
Source Water Type	Groundwater
Number of Wells	2
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	NAD 83, Zone 18: Easting, 493022; Northing,4998973;
Location of Monitoring Wells	
Area served by System	Village of Finch
Number of Users (approx. residents)	440
Minimum Daily Taking	240 m^3/day
Average Daily Taking	240 m^3/day
Maximum Daily Taking	778 m^3/day
WHPA Delineation Pumping Rate	947.5 m^3/day

5.7.1 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).

A formal hydrogeological study has not been completed on these wells but they are interpreted not to be under the direct influence of surface water (GUDI) based on Drinking Water Inspection Reports. Therefore, WHPA-E and WHPA-F were not calculated for these systems.

The various WHPAs for this drinking water system are shown on *Map 5.7.2*. The respective area calculations are summarized in *Table 5.7.2*.

Table 5.7.2: Total Area by Vulnerable Area, Finch

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	0%
WHPA-B	206.7	31%
WHPA-C	140.5	21%
WHPA-D	320.6	48%
Total	**670.9**	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.

5.7.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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 Finch wells are completed in a bedrock aquifer. The groundwater modeling shows groundwater primarily flows through the bedrock to the wells although groundwater also flows through the sand and gravel unit overlying the bedrock. Also the model showed there was some infiltration through the surficial till. The thickness of the till increases to the southeast, resulting in a lower vulnerability.

SWAT assessment is shown on *Map 5.7.3*.

The value of the groundwater vulnerability is 10 at the well head (WHPA-A), and is also 10 in WHPA-B, due to the infiltration through the relatively thinner till layer in this area. WHPA-C has a vulnerability score of 8, and WHPA-D has a score of 4.

WHPA vulnerability scoring is shown on *Map 5.7.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.7.3*.

Table 5.7.3: Distribution of Vulnerability Scores, Finch

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	206.7	206.7	0	0	*n.a.*	*n.a.*
WHPA-C	140.5	*n.a.*	140.5	0	*n.a.*	0
WHPA-D	320.6	*n.a.*	*n.a.*	0	320.6	0
Total	**670.9**	**209.8**	**140.5**	**0**	**320.6**	**0**

5.7.2.1 Transport Pathways

The Finch wells are completed in bedrock, but do not have an overlying aquitard to protect the bedrock aquifer. As a result, the WHPA scores are already the highest possible score for each WHPA and any transport pathways therefore would not change the vulnerability scoring for these WHPAs. Though the vulnerability score would not change, transport pathways are still present within the Finch WHPAs and could promote migration of contaminants. There are private wells located within the WHPA areas. The private wells represent a conduit to possible groundwater impact. Private wells that are no longer in use should be properly decommissioned to limit the number of transport pathways to the aquifer.

The intrinsic vulnerability was considered to be high in the WHPA-B, -C and –D. The presence of transport pathways therefore would not alter the vulnerability scoring for the Finch WHPAs. The uncertainty related to transport pathways is low as the scoring does not change.

5.7.3 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.

5.7.3.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.7.3.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.7.4*, *Table 5.7.5*and *Table 5.7.6*.

The applicable circumstance tables are also referenced visually on *Map 5.7.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.7.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Finch

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.7.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Finch

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.7.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Finch

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.7.3.3 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 5.7.6* and is tabulated in *Table 5.7.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.7.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Finch

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	1.5	0	1.5	51 %
WHPA-B	206.7	143	0	143	69 %
WHPA-C	140.5	91	0	91	65 %

5.7.3.4 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 5.7.7* and is tabulated in *Table 5.7.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.7.8: Livestock Density Assessment, Finch

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.16	0.16		
8			0.16	

5.7.3.5 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 5.7.8* and tabulated in *Table 5.7.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.7.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Finch

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
WHPA-A	0	0	3.1	0
WHPA-B	0	90.5	116.2	0
WHPA-C	1.7	119.0	19.7	0

5.7.3.6 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.

5.7.3.7 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.

5.7.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 67activities that are or would be drinking water quality threats have been counted at 34 locations.

Specific activities and location counts are listed in *Table 5.7.10*.

Table 5.7.10: Significant Drinking Water Threat Activities, Finch

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		11
The application of pesticide to land.		10
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Septic System or Holding Tank	14
The handling and storage of a dense non-aqueous phase liquid.		6
The handling and storage of an organic solvent.		4
The handling and storage of commercial fertilizer.		4
The handling and storage of fuel.		9
The handling and storage of pesticide.		3
The storage of agricultural source material.		3
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.	Agricultural Source Material (ASM) Generation	3
Total – All Activities		**67**

5.7.4 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.

5.7.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.7.11*. 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 5.7.11: Key Information Sources, Finch

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Finch Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Analyses, Crysler, Finch and Moose Creek Water Supplies.*	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 Analyses, Crysler, Finch and Moose Creek Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.7.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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”.

There was site specific data available for the development of the numerical groundwater model for the Finch municipal supply well; however the primary data source was the MOE well records, and these data had relatively low density within the model domain. This information supports the relative uncertainty attributed to this assessment. 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 uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. The geology south west of the Finch well is relatively regular and therefore the uncertainty of the shape and direction of the WHPA is considered low. It was assumed there was no effective impermeable layer overlying the bedrock aquifer. There is a continuous till; however the thickness varies from a few meters to a maximum of 10 meters, and parts are unsaturated. Given there was no additional SAAT assessment, the uncertainty was considered low.

Despite low uncertainty on the SAAT calculation and general shape of the WHPA, the extent of the WHPA had high uncertainty and 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

Uncertainty in the vulnerability scoring is a function of both the uncertainty of the WHPA, the time of travel calculation and the uncertainty associated with the SWAT calculation. The overall uncertainty resulting from the combination of these assessments is considered to be high.

The enumeration of threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances.

A summary of uncertainty is listed in *Table 5.7.12*.

Table 5.7.12: Summary of Uncertainty Analyses, Finch

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	Low	Low	Low
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	High	High	Low	Low

5.8 Winchester

Municipal water for Winchester is blended from up to four well fields comprising ~~six~~ eight well heads. The Winchester production wells are owned by the Township of North Dundas and operated by the Ontario Clean Water Agency (OCWA). The drinking water system is comprised of ~~four~~ five distinct well fields (#1, #5, #6 ~~and~~ , #7 and #8). Wells at three of the Winchester well fields (#1, #5 and #6) are completed in bedrock, the wells at the fourth location (Well Field #7) are completed within esker deposits. Well #1 was drilled in 1958 to a depth of 310 feet (94m); subsequent testing indicated lower water quality at depth and therefore a packer was installed at a depth of 190 ft (58 m) and as a result groundwater extraction occurs only from the shallower part of the well above the packer. Well #5 was drilled in 1972 to a depth of 92 feet (28 m). Well #6 was drilled in 1982 to a depth of 52 ft (16 m), the casing extends to a depth of 24.5 ft (7.5 m). Three separate wells were drilled at location of Well Field #7, all completed within sand and gravel esker deposits. The first well, Well 7a, was drilled in 1994, second well, Well 7b, was drilled in 1996 to a depth of 14.5 m and a few months later a third well (7c) was drilled to a depth of 15 m. Well 7c is only operated in conjunction with one of the other wells, or during maintenance, due to is relatively higher concentration of manganese. Two separate wells were drilled at the location of Well Field #8. Similar to Well Field #7, both wells in Well Field #8 were completed within sand and gravel esker deposits.

The site location is shown on *Map 5.8.1*. Drinking water system information is presented in *Table5.8.1*.

Table5.8.1: Drinking Water System Information, Winchester

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	210000586
Drinking Water System Name	Winchester Waterworks
Owner	Township of North Dundas
Operating Authority	OCWA
Source Water Type	Groundwater
Number of Wells	~~6~~ 8 wells, (~~4~~ 5 well fields)
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	1 : 472834 Easting, 4992119 Northing (NAD-83, Zone-18) 5 : 470322 Easting, 4992931 Northing (NAD-83, Zone-18) 6 : 467211 Easting, 4992425 Northing (NAD-83, Zone-18) 7a: 476602 Easting, 5000426 Northing (NAD-83, Zone-18) 7b: 476609 Easting, 5000483 Northing (NAD-83, Zone-18) 7c: 476617 Easting, 5000489 Northing (NAD-83, Zone-18) 8a: 476579 Easting, 4999482 Northing (NAD-83, Zone-18) 8b: 476605 Easting, 4999498 Northing (NAD-83, Zone-18)
Location of Monitoring Wells	

Area served by System	Village of Winchester
Number of Users (approx. residents)	2,300
Minimum Daily Taking	
Average Daily Taking	~~1,241~~2,261 m³/day (combined taking of all wells)
Maximum Daily Taking	~~3,785~~5,513 m³/day
WHPA Delineation Pumping Rate	~~3,249~~ 4,977 m³/day

5.8.1 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 areas WHPA-E~~ and WHPA-F~~, as defined by *the Rules* do not apply.

The various WHPAs for this drinking water system are shown on *Map 5.8.2*. The respective area calculations are summarized in *Table 5.8.2*.

Table 5.8.2: Total Area by Vulnerable Area, Winchester

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	~~13.9~~16.2	1%
WHPA-B	~~621.4~~512.8	~~23~~20%
WHPA-C	~~862.4~~674.5	~~33~~26%
WHPA-D	~~1,153.1~~1,337.1	~~44~~53%
Total	**~~2,650.8~~2,540.6**	**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.

5.8.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability for wells #1, #5 and #6. This method takes into account 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.

For wells #7 and #8, The vulnerability was calculated using the Aquifer Vulnerability Index (AVI) method. The AVI is a method for mapping the susceptibility of an aquifer to surficial contaminants and was based on both the refined conceptual model information (i.e., layers, hydraulic conductivity, etc.) and available geological information available from previous Golder and WSP investigations (Golder 1989, 1990, 1995; WSP 2024a, 2024b). The method also included geological mapping completed within the limits or vicinity of the Morewood Esker (GSC 2007) and interpreted buried channel connecting the southern end of the Morewood Esker and the north side of the Maple Ridge esker (Gorrell 1991). Geological information from the MECP Water Well Information System (WWIS) database and the previous assessment presented in WESA (2010) were also included in the AVI method.

Within the local area, the overburden ranges in depth from 0 m, in areas where bedrock outcrops at the ground surface, to almost 50 m, in a few regions within the area. Most of the region is blanketed with a layer of Basin Mud which overlies, in most locations, the Silty-Till Sediments; the Basin-Mud often fills in valleys of lower lying Silty-Till deposits.

Esker deposits are expected to consist of a gravelly central ridge (core) blanketed by a sandy carapace. The Vars-Winchester Esker is a north-south trending linear formation identified as Glaciofluvial deposits. The geometry and connectivity of the existing gravel deposits within the esker system is not yet well understood.

The municipal well field for Winchester includes ~~four~~ five separate locations, Well #1, #5, #6, #7 and #~~7~~8. The municipal wells at the first three locations are all completed in limestone bedrock. At locations #1 and #6 the bedrock is overlain by approximately 5 m of Silty-Till. At location #5, the bedrock is overlain by approximately 5 m of Basin Mud deposits. The Winchester Well Field #7, which includes three wells, and Well Field #8, which includes 2 wells, are all completed within the Morewood Esker deposits. The wells appear to be located at the eastern edge of the linear esker deposits. Based on drill logs of wells completed in the vicinity, the Esker deposits appear to be incised in the Silty-Till, though at some locations the esker sediments appear to lie directly on top of the bedrock.

~~SWAT~~ Vulnerability assessment is shown on *Map 5.8.3*.

WHPA vulnerability scoring is shown on *Map 5.8.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.8.3*.

Table 5.8.3: Distribution of Vulnerability Scores, Winchester

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-A	~~13.9~~16.2	~~13.9~~16.2	*n.a.*	*n.a.*	*n.a.*	*n.a.*
WHPA-B	~~621.4~~512.8	~~564.3~~446.3	~~57.1~~66.5	0	*n.a.*	*n.a.*
WHPA-C	~~862.4~~674.5	*n.a.*	~~693.1~~456.6	~~169.3~~217.9	*n.a.*	0
WHPA-D	~~1,153.1~~1,337.1	*n.a.*	*n.a.*	~~0~~138.7	~~909.2~~877.0	~~243.9~~321.4
Total	**~~2,650.8~~2,540.6**	**~~578.2~~462.5**	**~~750.2~~523.1**	**~~169.3~~356.6**	**~~909.2~~877.0**	**~~243.9~~321.4**

5.8.2.1 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.

The Winchester wells #1, 5 and 6 are completed in the bedrock and have some protection from the overlying Silty-Till and Basin Mud sediments. Winchester wells #7 and #8 ~~is~~ are completed in the Glaciofluvial sediments and have varying degrees of protection, the Glaciofluvial aquifer is most exposed closest to the municipal wells. Of concern is the presence of groundwater wells as they penetrate the overlying aquitard and can provide a direct conduit vertical contaminant migration. Another transport pathway of concern are open Pits. Pits are located where the natural sediments are coarse and therefore very permeable and hence the vulnerability to the aquifer is already high. The presence of a pit therefore could not increase the vulnerability scoring as it would already be "high", however it is important to recognize these activities as transport pathways.

5.8.3 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.

5.8.3.1 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 a~~Activities prescribed to be drinking water threats in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of O. Reg. 287/07 (General) were reviewed~~.~~

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

5.8.3.2 Circumstances

No local circumstances have been added to the Tables of drinking water threats 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 5.8.4, Table 5.8.5 and Table 5.8.6 can be used to determine which areas are vulnerable to chemical, pathogen and DNAPL threats. These are also referenced visually on Map 5.8.5~~The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.8.4*, *Table 5.8.5* and *Table 5.8.6*.~~

~~The applicable circumstance tables are also referenced visually on *Map 5.8.5*.~~

~~No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.~~

~~The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.~~

Table 5.8.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Winchester

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	~~1 (CW10S)~~Yes	Yes~~3 (CW10M)~~	Yes~~6 (CW10L)~~
WHPA-B	10	Yes~~1 (CW10S)~~	Yes~~3 (CW10M)~~	Yes~~6 (CW10L)~~
WHPA-B	8	Yes~~2 (CW8S)~~	Yes~~4 (CW8M)~~	Yes~~7 (CW8L)~~
WHPA-C	8	Yes~~2 (CW8S)~~	Yes~~4 (CW8M)~~	Yes~~7 (CW8L)~~
WHPA-C	6	*Below threshold*	Yes~~5 (CW6M)~~	Yes~~8 (CW6L)~~
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.8.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Winchester

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	Yes~~12 (PW10S)~~	Yes~~13 (PW10M)~~	*None*
WHPA-B	10	Yes~~12 (PW10S)~~	Yes~~13 (PW10M)~~	*None*
WHPA-B	8	*None*	Yes~~14 (PW8M)~~	Yes~~15 (PW8L)~~
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.8.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Winchester

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	Yes~~9 (DWAS)~~	*None*	*None*
WHPA-B	All Scores	Yes~~9 (DWAS)~~	*None*	*None*
WHPA-C	All Scores	Yes~~9 (DWAS)~~	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.8.3.3 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 5.8.6* and is tabulated in *Table 5.8.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.8.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Winchester

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	~~13.9~~16.2	~~3.7~~5.1	0	~~3.7~~5.1	~~27~~32%
WHPA-B	~~621.4~~512.8	~~499.3~~394.5	0	~~499.3~~394.5	~~80~~77%
WHPA-C	~~862.4~~674.1	~~741.1~~570.0	0	~~741.1~~656.5	~~86~~85%

5.8.3.4 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 5.8.7* and is tabulated in *Table 5.8.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.8.8: Livestock Density Assessment, Winchester

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.25	0.25		
8		0.25	0.25	
6		0.25	0.25	0.25
4				*Below threshold*
2			*Below threshold*	

5.8.3.5 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 5.8.8* and tabulated in *Table 5.8.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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. Note that the 1 km^2 grid method was used, as it was found to be more conservative than the vulnerable areas–based method.

Table 5.8.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Winchester

WHPA Score	Low Threat	Moderate Threat	Significant Threat
10	Less than 1%	1% to Less than 30%	30% or more
8	Less than 1%	1% to less than 30%	N/A
6	Less than 8%	N/A	N/A

5.8.3.6 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.

5.8.3.7 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.

5.8.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total ~~181~~ 145 activities that are or would be drinking water quality threats have been counted at 64 locations.

Specific activities and location counts are listed in *Table 5.8.10*.

Table 5.8.10: Significant Drinking Water Threat Activities, Winchester

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.	Application of agricultural source material (ASM) to land	22
The application of commercial fertilizer to land	Application of commercial fertilizer to land	2
The application of non-agricultural source material to land	Application of non-agricultural source material (NASM) to land	1
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard	Agricultural source material (ASM) generation - livestock grazing or pasturing	7
The storage of agricultural source material	Storage of agricultural source material (ASM)	3
The handling and storage of a dense non-aqueous phase liquid	Handling and storage of a dense non-aqueous phase liquid (DNAPL)	10
The handling and storage of an organic solvent	Handling and storage of an organic solvent	2
The handling and storage of fuel	Handling and storage of fuel	5

Activity	Sub Threat, if Applicable	Count
The application of pesticide to land	Application of pesticide to land	43
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Onsite sewage works	23
*The application of road salt **		*27*
Total – All Activities		**145**

*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.

~~Activity~~	~~Sub Threat, if Applicable~~	~~Count~~
~~The application of agricultural source material to land.~~		~~33~~
~~The application of non-agricultural source material to land.~~		~~21~~
~~The application of pesticide to land.~~		~~33~~
~~The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.~~	~~Septic System or Holding Tank~~	~~25~~
~~The handling and storage of a dense non-aqueous phase liquid.~~		~~18~~
~~The handling and storage of an organic solvent.~~		~~2~~
~~The handling and storage of commercial fertilizer.~~		~~6~~
~~The handling and storage of fuel.~~		~~21~~
~~The handling and storage of pesticide.~~		~~6~~
~~The storage of agricultural source material.~~		~~8~~
~~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.~~	~~Agricultural Source Material (ASM) Generation~~	~~8~~
~~**Total – All Activities**~~		~~**181**~~

5.8.4 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.

5.8.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.8.11*. 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 5.8.11: Key Information Sources, Winchester

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 South Nation Conservation Watershed*.	Report	Literature Review
	WSP Canada Inc. 2025. Source Water Protection Drinking Water Vulnerability and Threats Assessment Wellfield No. 7 and No. 8 – VERSION 2		
	Ontario Ministry of the Environment. 2009. *Winchester Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
	WSP Canada Inc. 2025. Source Water Protection Drinking Water Vulnerability and Threats Assessment Wellfield No. 7 and No. 8 – VERSION 2		
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	SWAT Assessment, Engineering Assessment
	WSP Canada Inc. 2025. Source Water Protection Drinking Water Vulnerability and Threats Assessment Wellfield No. 7 and No. 8 – VERSION 2		
Managed Lands	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	

Section	Source(s)	Type	Analysis Method(s)
	WSP Canada Inc. 2025. Source Water Protection Drinking Water Vulnerability and Threats Assessment Wellfield No. 7 and No. 8 – VERSION 2		Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	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
Water Quality Threats Assessment	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.8.4.2 *Uncertainty Analysis*

Uncertainty analyses have been carried out 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 uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation (or AVI score) and the identification of transport pathways.

Wells 1, 5 and 6 are all completed in the bedrock. The shape and direction of the WHPA is considered to have low uncertainty due to the assumed relative uniformity of the geology of the bedrock. Wells 7a, b and c and Wells 8a and 8b are all completed in the esker. The direction of groundwater flow is from the east and therefore even though the wells are completed in the esker, most of the water originates from the underlying bedrock aquifer.

Overlying each well field is till and a discontinuous clay deposit. The clay can, where present, provide a protective barrier to vertical flow, however the extent and thickness of the clay is approximated based on best available data. The uncertainty of the SAAT calculation is considered high in the areas where there may be a low permeability cover.

Since the SAAT approach had high uncertainty, the vulnerability scoring is assumed to have high uncertainty for wells #1, #5, and #6.

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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

For wells #7 and #8, AVI value is interpolated between the well locations to produce a complete spatial assessment of the intrinsic vulnerability of the aquifer. The AVI scores were converted into “low”, “medium” or “high” aquifer vulnerability values based on Technical Rule IV.1 (38) as follows:

- High Aquifer Vulnerability – AVI less than 30;
- Medium Aquifer Vulnerability – AVI between 30 and 80; and
- Low Aquifer Vulnerability – AVI greater than 80.

The resulting AVI map, presented in Map 5.8.3, shows that the area within the limits of WHPA-A is classified as having a “high” intrinsic vulnerability, WHPA-B and WHPA-C have both “high” and “medium” intrinsic vulnerability, while WHPA-D located within the extent of the sand carapace and surrounding buried channel are generally classified as having a “high”, “medium” and “low” intrinsic vulnerability. A “low” vulnerable area is mapped beyond the sand carapace and buried channel in WHPA-D.

A summary of uncertainty is listed in *Table 5.8.12*.

Table 5.8.12: Summary of Uncertainty Analyses, Winchester

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 / Low [1]
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	High	High	Low	Low

Notes: 1) Wells 1, 5, and 6 have High uncertainty, Wells 7 a, b and c have Low uncertainty for WHPA-D length. Wells 8 a and b have Low uncertainty.

5.9 Chesterville

Drinking water for the Village of Chesterville is owned by The Township of North Dundas and operated by the Ontario Clean Water Agency (OCWA). The Chesterville productions wells (#5 and #6) are located about 3.8 km west of the Village of Chesterville and 200 m north of Highway 43. Both wells are completed in the Glaciofluvial deposits of the Maple Ridge esker. Well # 5 was drilled in January 1989 to a depth of about 40 ft (12 m) into sand and gravel. Well No. 6 extends to a depth of 9.75 m.

The site location is shown on *Map 5.9.1*. Drinking water system information is presented in *Table5.9.1*.

Table5.9.1: Drinking Water System Information, Chesterville

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	210000728
Drinking Water System Name	Chesterville Waterworks
Owner	Township of North Dundas
Operating Authority	OCWA
Source Water Type	Groundwater
Number of Wells	2 (one production, one standby)
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	No
Coordinates of Well	477866 Easting, 4994078 Northing; NAD-83, Zone-18
Location of Monitoring Wells	
Area served by System	Village of Chesterville
Number of Users (approx. residents)	1,560
Minimum Daily Taking	
Average Daily Taking	1,006 m^3/day
Maximum Daily Taking	2,999 m^3/day
WHPA Delineation Pumping Rate	1,347 m^3/day

5.9.1 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 areas WHPA-E and WHPA-F, as defined by *the Rules* do not apply.

The various WHPAs for this drinking water system are shown on *Map 5.9.2*. The respective area calculations are summarized in *Table 5.9.2*.

Table 5.9.2: Total Area by Vulnerable Area, Chesterville

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	5.6	<1%
WHPA-B	226.4	20%
WHPA-C	217.8	19%
WHPA-D	695.1	61%
Total	**1,144.9**	**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.

5.9.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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.

Within the local area, the overburden ranges in depth from 0 m, in areas where bedrock outcrops at the ground surface, to almost 50 m, in a few regions within the area. Most of the region is blanketed with a layer of Basin Mud which overlies, in most locations, the Silty-Till Sediments; the Basin-Mud often fills in valleys of lower lying Silty-Till deposits.

Esker deposits are expected to consist of a gravelly central ridge (core) blanketed by a sandy carapace. The Vars-Winchester Esker is a north-south trending linear formation identified as Glaciofluvial deposits.

The geometry and connectivity of the existing gravel deposits within the esker system is not yet well understood.

Two wells currently comprise the Chesterville Well Field, #5 and #6. Both wells are completed in the Maple Ridge esker, located west of the Village of Chesterville, and at the southern extent of the Vars-Winchester esker system.

SWAT assessment is shown on *Map 5.9.3*.WHPA vulnerability scoring is shown on *Map 5.9.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.9.3*.

Table 5.9.3: Distribution of Vulnerability Scores, Chesterville

Vulnerable Area	Total Area (ha)	Area by Vulnerability Score (ha)				
		10	8	6	4	2
WHPA-A	5.6	5.6	*n.a.*	*n.a.*	*n.a.*	*n.a.*
WHPA-B	226.4	202.3	24.1	0	*n.a.*	*n.a.*
WHPA-C	217.8	*n.a.*	103.8	114.0	*n.a.*	0
WHPA-D	695.1	*n.a.*	*n.a.*	0	675.8	19.3
Total	**1,144.9**	**207.9**	**127.9**	**114.0**	**675.8**	**19.3**

5.9.2.1 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.

The Chesterville wells are completed in the Glaciofluvial sediments and have varying degrees of protection, the Glaciofluvial aquifer is most exposed closest to the municipal wells. Of concern is the presence of groundwater wells as they penetrate the overlying aquitard and can provide a direct conduit vertical contaminant migration. Another transport pathway of concern are open Pits. Pits are located where the natural sediments are coarse and therefore very permeable and hence the vulnerability to the aquifer is already high. The presence of a pit therefore could not increase the vulnerability scoring as it would already be “high”, however it is important to recognize these activities as transport pathways.

5.9.3 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.

5.9.3.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.9.3.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.9.4*, *Table 5.9.5* and *Table 5.9.6*.

The applicable circumstance tables are also referenced visually on *Map 5.9.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.9.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Chesterville

Vulnerable Area	**Vulnerability Score**	**Provincial Circumstance Table Number (Table Name)**		
		Significant	**Moderate**	**Low**
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-C	6	*Below threshold*	5 (CW6M)	8 (CW6L)
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.9.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Chesterville

Vulnerable Area	**Vulnerability Score**	**Provincial Circumstance Table Number (Table Name)**		
		Significant	**Moderate**	**Low**
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	8	*None*	14 (PW8M)	15 (PW8L)
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.9.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Chesterville

Vulnerable Area	**Vulnerability Score**	**Provincial Circumstance Table Number (Table Name)**		
		Significant	**Moderate**	**Low**
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.9.3.3 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 5.9.6* and is tabulated in *Table 5.9.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.9.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Chesterville

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
WHPA-A	5.6	0	0	0	0%
WHPA-B	226.4	166.4	0	166.4	73%
WHPA-C	217.8	104.5	0	104.5	48%

5.9.3.4 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 5.9.7* and is tabulated in *Table 5.9.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.9.8: Livestock Density Assessment, Chesterville

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.47	0.47		
8		0.47	0.47	
6		0.47	0.47	0.47

5.9.3.5 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 5.9.8* and tabulated in *Table 5.9.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.9.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Chesterville

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
WHPA-A	3.1	0	0	0
WHPA-B	163.7	65.2	0	0
WHPA-C	74.3	143.4	0	0

5.9.3.6 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.

5.9.3.7 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.

5.9.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 30 activities that are or would be drinking water quality threats have been counted at 11 locations.

Specific activities and location counts are listed in *Table 5.9.10*.

Table 5.9.10: Significant Drinking Water Threat Activities, Chesterville

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		9
The application of pesticide to land.		9
The handling and storage of a dense non-aqueous phase liquid.		2
The handling and storage of an organic solvent.		1
The handling and storage of commercial fertilizer.		1
The handling and storage of fuel.		3
The handling and storage of pesticide.		1
The storage of agricultural source material.		2
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.	Agricultural Source Material (ASM) Generation	2
Total – All Activities		**30**

5.9.4 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.

5.9.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.9.11*. 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 5.9.11: Key Information Sources, Chesterville

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Chesterville Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Analyses, Winchester and Chesterville Water Supplies.*	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 Analyses, Winchester and Chesterville Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.9.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. The shape and direction of the WHPA is of high uncertainty. The well is completed at the edge of the esker. Groundwater flow in the vicinity of the esker is not well documented, nor is the interaction between the esker and the bedrock. There is also uncertainty regarding flow within the esker deposits, some data suggests there is stratification within the esker resulting in vertical gradients within the esker complex. There is a low permeability formation overlying the aquifer to the west of the well, SAAT calculations were completed.

Since the WHPA delineation had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.9.12*.

Table 5.9.12: Summary of Uncertainty Analyses, Chesterville

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	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	High	High	Low	Low

5.10 Newington

The Village of Newington, located about 25 km northeast of Cornwall is supplied by a municipal; groundwater system. The municipal well field is located in Newington and consists of two groundwater wells. Well #1 is a dug well with a diameter of 3.8 m and is the primary production well. Well #1 (also called the Kraft well) is 5.2 m deep and is completed in the till and subtill sediments. The standby well, well #2 (also called the Fairgrounds well), is a drilled well completed in the limestone bedrock.

The site location is shown on *Map 5.10.1*. Drinking water system information is presented in *Table5.10.1.*

Table5.10.1: Drinking Water System Information, Newington

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	220008051
Drinking Water System Name	Newington Well Supply
Owner	South Stormont, The Corporation of the Township of
Operating Authority	Caneau Water and Sewage Operations Inc.
Source Water Type	Groundwater
Number of Wells	2
Number of Surface Water Intakes	0
Is Groundwater Under Direct Influence (GUDI) from Surface Water	Yes
Coordinates of Well	498574 East, 4996277 North (UTM NAD-83, Zone 18) 498873 East, 4996416 North (UTM NAD-83, Zone 18)
Location of Monitoring Wells	
Area served by System	Village of Newington
Number of Users (approx. residents)	260
Minimum Daily Taking	66 m^3/day
Average Daily Taking	79 m^3/day
Maximum Daily Taking	1392 m^3/day
WHPA Delineation Pumping Rate	165 m^3/day

5.10.1 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 directly influenced by a surface water body, and therefore WHPA-E was determined. WHPA-E is includes the area to either side of a surface water body that may contribute water to a stream that may impact the groundwater within the WHPA. The size of WHPA-E must be equal to or greater than the time that is sufficient to allow the operator of the system to respond to a spill or other event that may impair the quality of the water. As with the delineation of an IPZ-2, it was assumed a time of travel of 2 hours would be appropriate for delineation of the WHPA-E. A setback of 120 m is included along the entire length of the WHPA-E.

The various WHPAs for this drinking water system are shown on *Map 5.10.2*. The respective area calculations are summarized in *Table 5.10.2*.

Table 5.10.2: Total Area by Vulnerable Area, Newington

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	6.2	2%
WHPA-B	21.5	7%
WHPA-C	20.8	7%
WHPA-D	47.7	17%
WHPA-E	191.3	67%
Total	**287.5**	**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.

5.10.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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 Newington municipal supply well is completed in overburden till and subtill. The subtill is a coarse-grained, permeable aquifer. The groundwater model results showed the majority of water flows through the till and the subtill before entering the well. Only a small amount of water enters the wells from the bedrock. Groundwater flowing to the well appears to be locally recharged through the Till. The clay in the area surrounding the well is sparse and discontinuous, and does not protect the underlying aquifer.

SWAT assessment is shown on *Map 5.10.3*.

The Newington well draws water from a shallow aquifer, and the aquifer has minimal protection from an overlying clay layer. Therefore, the Newington vulnerability scores are high. The value of the groundwater vulnerability is 10 at the well head (WHPA-A), and is also 10 in WHPA-B, due to the groundwater infiltration through the till. WHPA-C has a vulnerability score of 8 and WHPA-D has a score of 4.

Scoring of the WHPA-E is to be done similarly to the IPZ-2 in Surface Water studies. Two factors are assessed, the Area Vulnerability Factor of the WHPA-E and the Source Vulnerability Factor of the municipal well. The resulting vulnerability was 7.2 for WHPA-E. A potential contaminant would first have to infiltrate from the surface water, through the unsaturated zone, into the underlying aquifer, and then flow horizontally to the well.

WHPA vulnerability scoring is shown on *Map 5.10.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.10.3*.

Table 5.10.3: Distribution of Vulnerability Scores, Newington

Vulnerable Area	Total Area (ha)		Area by Vulnerability Score (ha)				
		10	8	7.2	6	4	2
WHPA-A	6.2	6.2	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*
WHPA-B	21.5	21.5	0	*n.a*	0	*n.a.*	*n.a.*
WHPA-C	20.8	*n.a.*	20.8	*n.a*	0	*n.a.*	0
WHPA-D	47.7	*n.a.*	*n.a.*	*n.a*	0	47.7	0
WHPA-E	191.3	*n.a.*	*n.a.*	191.3	*n.a.*	*n.a.*	*n.a.*
Total	**287.5**	**27.7**	**20.8**	**191.3**	**0**	**47.7**	**0**

5.10.3 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.

The Newington well is completed in the sand and gravel aquifer with no effective protective aquitard layer overlying the aquifer and hence the aquifer is highly vulnerable to activities within the WHPA that might release contaminants. Any transport pathways therefore would not change the vulnerability scoring for these WHPA’s as the intrinsic vulnerability is already at its highest for the respective WHPA’s.

There are private wells located within the WHPA areas. The private wells represent a conduit to possible groundwater impact. Private wells that are no longer in use should be properly decommissioned to limit the number of transport pathways to the aquifer.

5.10.4 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.

5.10.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.10.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.10.4*, *Table 5.10.5* and *Table 5.10.6*.

The applicable circumstance tables are also referenced visually on *Map 5.10.5.* No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system. The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.10.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Newington

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*
WHPA-E	7.2	*Below threshold*	27 (CIPZWE7.2M)	35 (CIPZWE7.2L)

Table 5.10.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Newington

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			
WHPA-E	7.2	*Below threshold*	53 (PIPZWE7.2M)	62 (PIPZWE7.2L)

Table 5.10.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Newington

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	9 (DWAS)	*None*	*None*
WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*
WHPA-E	7.2	*Not Applicable*	*Not Applicable*	*Not Applicable*

5.10.4.3 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 5.10.6* and is tabulated in *Table 5.10.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.10.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Newington

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Percent Managed Land
WHPA-A	6	2.5	2.5	39 %
WHPA-B	22	13	13	61 %
WHPA-C	21	7.8	7.8	38 %
WHPA-E	191.3			39%

5.10.4.4 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 5.10.7* and is tabulated in *Table 5.10.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.10.8: Livestock Density Assessment, Newington

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-E
10	0.27	0.27		
8			0.27	
7.2			.	0.27

5.10.4.5 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 5.10.8* and tabulated in *Table 5.10.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.10.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Newington

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
WHPA-A	0	0	6.2	0
WHPA-B	0	0	21.5	0
WHPA-C	0	2	18.7	0
WHPA-E	48	138.4	4.9	0

5.10.4.6 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.

5.10.4.7 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.

5.10.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 65 activities that are or would be drinking water quality threats have been counted at 56 locations.

Specific activities and location counts are listed in *Table 5.10.10*.

Table 5.10.10: Significant Drinking Water Threat Activities, Newington

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material 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	52
The handling and storage of a dense non-aqueous phase liquid.		2
The handling and storage of fuel.		4
The storage of agricultural source material.		1
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.	Agricultural Source Material (ASM) Generation	1
Total – All Activities		**65**

5.10.5 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.

5.10.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.10.11*. 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 5.10.11: Key Information Sources, Newington

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

Section	Source(s)	Type	Analysis Method(s)
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2010. *Newington Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analysis, Newington Water Supply.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analysis, Newington Water Supply.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	WESA. 2010. *Groundwater Threats Assessment, Newington Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Assessment, Newington Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Assessment, Newington Water Supply.*	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
Water Quality Threats Assessment	WESA. 2010. *Groundwater Threats Assessment, Newington Water Supply.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.10.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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.

There was site specific data available for the development of the numerical groundwater model for the Newington municipal supply well; however most of this data was very localized to the waste disposal site property to the southeast. The primary data source was the MOE well records, and these data had relatively low density within the model domain.

The uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. The geology is relatively uniform within the region of the WHPA and therefore the shape and direction is of low uncertainty; however the extent of each WHPA has high uncertainty. There is no effective low permeability layer above the aquifer and therefore no additional SAAT calculations were completed.

Since the extent of each WHPA had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.10.12*.

Table 5.10.12: Summary of Uncertainty Analyses, Newington

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	Low	Low	Low
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	High	High	Low	Low

5.11 Bennett Street, Spencerville

The Village of Spencerville is located approximately 75 km south of Ottawa. Within the Village a groundwater supply system provides water to one 15-unit apartment building located on Bennett St. in Spencerville. The groundwater supply is provided by one groundwater well. The well is commonly called the Bennett St. well. The original well was drilled in 1975. A new 11 m deep well was drilled in 2003 is completed in bedrock. The well casing is 7 m deep and intersects the top 2 m of bedrock.

The site location is shown on *Map 5.11.1*. Drinking water system information is presented in *Table5.11.1*.

Table5.11.1: Drinking Water System Information, Bennett Street, Spencerville

Drinking Water System Type (MOE)	**Existing, Small Municipal Residential System**
Drinking Water System Number (MOE)	260006971
Drinking Water System Name	Bennett Street Well Supply
Owner	Leeds and Grenville, United Counties of
Operating Authority	Edwardsburg/Cardinal Environmental Services
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	33 Bennett St, Spencerville, Ontario
Location of Monitoring Wells	n/a
Area served by System	Apartment complex in Spencerville
Number of Users (approx. residents)	15
Minimum Daily Taking	3.7 m^3/day
Average Daily Taking	5.8 m^3/day
Maximum Daily Taking	7.1 m^3/day
WHPA Delineation Pumping Rate	6.9 m^3/day

5.11.1 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 areas WHPA-E and WHPA-F, as defined by *the Rules* do not apply.

The various WHPAs for this drinking water system are shown on *Map 5.11.2*. The respective area calculations are summarized in *Table 5.11.2*.

Table 5.11.2: Total Area by Vulnerable Area, Bennett Street, Spencerville

Vulnerable Area	Total Area (ha)	Percentage of Total Area
WHPA-A	3.1	19%
WHPA-B	5.5	34%
WHPA-C	6.3	38%
WHPA-D	1.5	9%
Total	**16.4**	**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.

5.11.2 Vulnerability Scoring

A Surface to Well Advection Time (SWAT) approach was used to assess the vulnerability. This method takes into account 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 Bennett St. well is drilled through overburden material including till and a permeable lower sediment, and completed in bedrock. The groundwater that supplies the Bennett St. well is from the bedrock groundwater system. The origin of the water flowing to the Bennett St. well appears to be from groundwater recharge to the bedrock located west of the well. The bedrock in the area west of the well is exposed at surface or is covered by a thin layer of overburden, and is not considered to be protected from contamination originating at the surface. In the area surrounding the well there is a significant layer of fine grained material, which lowers the vulnerability of the well.

SWAT assessment is shown on *Map 5.11.3*.

The value of the groundwater vulnerability is 10 at the well head (WHPA-A), and is also 10 in WHPA-B, due to the negligible protection for the bedrock aquifer. WHPA-C has a vulnerability score of 8 and WHPA-D has a score of 4, which are also high due to the thin veneer of overburden over the bedrock aquifer.

WHPA vulnerability scoring is shown on *Map 5.11.4*. A distribution of vulnerability scores by sub-area is presented in *Table 5.11.3*.

Table 5.11.3: Distribution of Vulnerability Scores, Bennett Street, Spencerville

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	5.5	5.5	0	0	*n.a.*	*n.a.*
WHPA-C	6.3	*n.a.*	6.3	0	*n.a.*	0
WHPA-D	1.5	*n.a.*	*n.a.*	0	1.5	0
Total	**16.4**	**8.8**	**6.3**	**0**	**1.5**	**0**

5.11.2.1 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.

There are consultant and domestic wells located immediately up gradient of the Bennett St. municipal supply well. These are all potential transport pathways. Additional potential transport pathways include: buried municipal services within the composite WHPA area; and basements of larger buildings, up-gradient of the municipal well.

The intrinsic vulnerability is high in all areas except in the immediate vicinity of the municipal well. Within 100 m of the municipal well, the vulnerability score is 10 (highest score). As the intrinsic vulnerability, or vulnerability score, is high everywhere the presence of any transport pathways would not increase the estimated vulnerability score.

5.11.3 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.

5.11.3.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.11.3.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats as well as threats from dense non-aqueous phase liquids (DNAPLs), which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.11.4*, *Table 5.11.5* and *Table 5.11.6*.

The applicable circumstance tables are also referenced visually on *Map 5.11.5.*

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

Table 5.11.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Bennett Street, Spencerville

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-B	10	1 (CW10S)	3 (CW10M)	6 (CW10L)
WHPA-C	8	2 (CW8S)	4 (CW8M)	7 (CW8L)
WHPA-D	4	*Below threshold*	*Below threshold*	*Below threshold*

Table 5.11.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Bennett Street, Spencerville

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-B	10	12 (PW10S)	13 (PW10M)	*None*
WHPA-C	All Scores	*Pathogens are not considered a threat within WHPA-C and WHPA-D*		
WHPA-D	All Scores			

Table 5.11.6: Applicable Provincial Tables of Circumstances for DNAPL Threats, Bennett Street, Spencerville

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
WHPA-A	All Scores	9 (DWAS)	*None*	*None*

WHPA-B	All Scores	9 (DWAS)	*None*	*None*
WHPA-C	All Scores	9 (DWAS)	*None*	*None*
WHPA-D	4, 2	*Below threshold*	*Below threshold*	*Below threshold*

5.11.3.3 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 5.11.6* and is tabulated in *Table 5.11.7*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.11.7: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Bennett Street, Spencerville

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Percent Managed Land
WHPA-A	3	1.1	0	36 %
WHPA-B	6	0.7	0	13 %
WHPA-C	6	0.3	0	4 %

5.11.3.4 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 5.11.7* and is tabulated in *Table 5.11.8*. The vulnerability score for WHPA-D is 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, that area is not considered for this evaluation.

Table 5.11.8: Livestock Density Assessment, Bennett Street, Spencerville

Vulnerability Score	Livestock Density of Agricultural Managed Land by Vulnerable Area(NU/acre)			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
10	0.05	0.05		
8			0.05	

5.11.3.5 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 5.11.8* and tabulated in *Table 5.11.9*. The area vulnerability score for WHPA-D is less than the vulnerability score 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 5.11.9: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Bennett Street, Spencerville

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on $1km^2$ grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
WHPA-A	0	2.2	0.9	0
WHPA-B	1.1	4.2	0.3	0
WHPA-C	4.1	.8	1.4	0

5.11.3.6 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.

5.11.3.7 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.

5.11.3.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 5 activities that are or would be drinking water quality threats have been counted at 3 locations.

Specific activities and location counts are listed in *Table 5.11.10*.

Table 5.11.10: Significant Drinking Water Threat Activities, Bennett Street, Spencerville

Activity	Sub Threat, if Applicable	Count
The application of pesticide to land.		1
The handling and storage of a dense non-aqueous phase liquid.		1
The handling and storage of fuel.		3
Total – All Activities		**5**

5.11.4 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.

5.11.4.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.11.11*. 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 5.11.11: Key Information Sources, Bennett Street, Spencerville

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2010. *Bennett Street Well Supply – Drinking Water Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA. 2010. *Groundwater Vulnerability Analysis, Bennett Street Water Supply.*	Technical Study	Hydrogeologic Modelling, Spatial Analysis
Vulnerability Scoring	WESA. 2010. *Groundwater Vulnerability Analysis, Bennett Street Water Supply.*	Technical Study	SWAT Assessment, Engineering Assessment
Managed Lands	WESA. 2010. *Groundwater Threats Assessment, Bennett Street Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Groundwater Threats Assessment, Bennett Street Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Groundwater Threats Assessment, Bennett Street 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, Bennett Street Water Supply.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.11.4.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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.

There was site specific data available for the development of the numerical groundwater model for the Bennett St. well; however most of this data was very localized to the waste disposal site property to the southeast. The primary data source was the MOE well records, and these data had relatively low density within the model domain.

The uncertainty relating to scoring of WHPAs is related to the uncertainty in WHPA delineation, SAAT calculation and the identification of transport pathways. The geology within the WHPA is generally uniform. Most of the groundwater comes from the bedrock. There is only a small region where there appears to be an effective low permeability layer, close to the well head. SAAT calculations were completed.

Since the extent of each WHPA had high uncertainty, 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the activity and applicable circumstances. Threats enumeration in WHPA-C and WHPA-D were considered low as there are few activities that constitute significant threats in these areas.

A summary of uncertainty is listed in *Table 5.11.12*.

Table 5.11.12: Summary of Uncertainty Analyses, Bennett Street, Spencerville

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	Low	Low	Low
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	High	High	Low	Low

5.12 Prescott

The Town of Prescott municipal water intake is located to the west of the Town limits at the foot of Sophia Street, in the St. Lawrence River. Raw water is drawn from approximately 2.3 m off the river bottom. The normal depth of water over the intake is estimated to be 5.5 m. The intake crib is approximately 105 m from the shore at the nearest location.

The Ontario Clean Water Agency operates the Prescott Water Treatment Plant. The plant has a design capacity of is 8200 m^3/d (95 L/s); and services a population of approximately 4,000 Treated drinking-water from the Prescott Water Treatment Plant is also supplied to a standalone distribution system owned and operated by the Township of Edwardsburgh/Cardinal and serves approximately 25 residences and 6 industrial/commercial establishments (estimated service population of 75).

The site location is shown on *Map 5.12.1*. Drinking water system information is presented in *Table5.12.1.*

Table5.12.1: Drinking Water System Information, Prescott

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	330002356
Drinking Water System Name	Prescott Water Treatment Plant
Owner	Town of Prescott
Operating Authority	Ontario Clean Water Agency
Source Water Type	Surface Water
Source Water	St. Lawrence River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	B
Coordinates of Intake	458781 Easting, 4950041 Northing (NAD 83, Zone-18)
Area served by System	Town of Prescott, plus small portion of Edwardsburgh/Cardinal
Number of Users (approx. residents)	3,900
Minimum Daily Taking	
Average Daily Taking	3,425 m^3/day
Maximum Daily Taking	7,487 m^3/day

5.12.1 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.

5.12.2 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 5.12.2*. The respective area calculations are summarized in *Table 5.12.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.12.2: Total Area by Vulnerable Area, Prescott

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	78.6	11 %
IPZ-2	646.3	89 %
Total	**724.9**	**100** %

5.12.2.1 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.

5.12.2.2 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 an in-stream portion representing the St. Lawrence River (computed with RMA model) and an up-tributary portion, Bradley's Creek (computed with Manning's Equation). Additional smaller subwatershed drainage features were considered (calculated by Moin's Index Flood

Method implemented in BASINS model). The stormsewershed associated with a nearby outfall (Sophia Street) was not included in IPZ-2 as discharges were found not to reach the intake (based on the hydrodynamics, RMA model). No tile drains were found to intersect the limits of IPZ-2.

5.12.3 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.

5.12.3.1 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.

The area vulnerability factor for IPZ-2 was set at 9 after considering:

- The ratio of land to water is low (28% land vs. 72% water);
- Land cover is predominantly agricultural with some urban and forest areas, there is low permeability and moderate slopes;
- There are many transportation corridors present (including Highways 2 and 401).

5.12.3.2 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 shallow (5.5 m below mean river level);
- The intake is located close to land (an offshore distance of approximately 100 m);
- There is no history of water quality concerns

5.12.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.12.3* and shown on *Map 5.12.3*.

Table 5.12.3: Vulnerability Scores, Prescott

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.8	8
IPZ-2	9	0.8	7.2

5.12.4 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.

5.12.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.12.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.12.4* and *Table 5.12.5*. The applicable circumstance tables are also referenced visually on *Map 5.12.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.12.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Prescott

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	8	22 (CIPZWE8S)	26 (CIPZWE8M)	34 (CIPZWE8L)
IPZ-2	7.2	*Below threshold*	27 (CIPZWE7.2M)	35 (CIPZWE7.2L)

Table 5.12.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Prescott

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	8	48 (PIPZWE8S)	52 (PIPZWE8M)	61 (PIPZWE8L)
IPZ-2	7.2	*Below threshold*	53 (PIPZWE7.2M)	62 (PIPZWE7.2L)

5.12.4.3 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 5.12.5* and is tabulated in *Table 5.12.6*.

Table 5.12.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Prescott

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	79	2	8	10	13%
IPZ-2	646	95	37	132	20%

5.12.4.4 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 5.12.6*and is tabulated in *Table 5.12.7*.

Table 5.12.7: Livestock Density Assessment, Prescott

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.10
IPZ-2	0.10

5.12.4.5 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 5.12.7* and tabulated in *Table 5.12.8.*

Table 5.12.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Prescott

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	37.6	0	41.0	0
IPZ-2	385.8	22.1	238.4	0

5.12.4.6 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.

5.12.4.7 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.

5.12.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 0 activities that are or would be drinking water quality threats have been counted at 0 locations.

Specific activities and location counts are listed in *Table 5.12.9*.

Table 5.12.9: Significant Drinking Water Threat Activities, Prescott

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

5.12.5 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.

5.12.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.12.10*. The information sources quoted below may contain additional expanded references.

Table 5.12.10: Key Information Sources, Prescott

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Prescott Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit

Section	Source(s)	Type	Analysis Method(s)
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Town of Prescott, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Town of Prescott, 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
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, Town of Prescott Municipal Drinking Water 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, Town of Prescott Municipal Drinking Water Intake, Assessment Report Input*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.12.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances. The IPZ-1 score is very close to the low threshold to trigger a significant threat. There are very few circumstances where a significant threat could exist in IPZ-1 therefore, the uncertainty is low.

A summary of uncertainty is listed in *Table 5.12.11*.

Table 5.12.11: Summary of Uncertainty Analyses, Prescott

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

5.13 Cardinal

The Village of Cardinal municipal water intake is located 55 meters south west of the water treatment plant, approximately 43 meters from the edge of the water, in the St. Lawrence River. The intake is located at a depth of approximately 5.2 m. The plant has a design capacity of is 3550 m3/d (41 L/s); and services a population of approximately 1,600.

The site location is shown on *Map 5.13.1*. Drinking water system information is presented in *Table5.13.1.*

Table5.13.1: Drinking Water System Information, Cardinal

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	220003582
Drinking Water System Name	Cardinal Water Treatment Plant
Owner	Township of Edwardsburgh/Cardinal
Operating Authority	Township of Edwardsburgh/Cardinal
Source Water Type	Surface Water
Source Water	St. Lawrence River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	B
Coordinates of Intake	469675 Easting, 4959079 Northing (NAD 83, Zone-18)
Area served by System	Village of Cardinal
Number of Users (approx. residents)	1,650
Minimum Daily Taking	
Average Daily Taking	900 m^3/day
Maximum Daily Taking	2,258 m^3/day

5.13.1 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.

5.13.2 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 5.13.2*. The respective area calculations are summarized in *Table 5.13.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.13.2: Total Area by Vulnerable Area, Cardinal

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	52.1	4%
IPZ-2	1,321.8	96%
Total	**1,373.9**	**100%**

5.13.2.1 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. There is a land barrier at the north-west boundary close to the shoreline. Surface runoff from the main land, is channeled along the canal and discharges downstream of the intake. The IPZ-1 area was modified to exclude areas which cannot affect the intake.

5.13.2.2 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 an in-stream portion representing the St. Lawrence River (computed with RMA model) and an up-tributary portion: Driver's Creek, Noname Creek and Baylane Creek (computed with Manning's Equation). Additional smaller subwatershed drainage features were considered (calculated by Moin's Index Flood Method implemented in BASINS model). There are no known sewer outfalls or tile drainage areas within the limits of IPZ-2.

5.13.3 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.

5.13.3.1 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.

The area vulnerability factor for IPZ-2 was set at 8 after considering:

- The ratio of land to water is low (13% land vs. 87% water);
- Land cover is predominantly agricultural and urban, there is low permeability and moderate slopes;
- There are no transport pathways present (storm sewers and tile drainage).

5.13.3.2 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 shallow (5 m below mean river level);
- The intake is located close to land (an offshore distance of approximately 40 m; however it is somewhat separated from the mainland via Gallop Canal);
- There is no history of water quality concerns.

5.13.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.13.3* and shown on *Map 5.13.3*.

Table 5.13.3: Vulnerability Scores, Cardinal

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.8	8
IPZ-2	8	0.8	6.4

5.13.4 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.

5.13.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.13.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.13.4* and *Table 5.13.5*. The applicable circumstance tables are also referenced visually on *Map 5.13.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.13.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Cardinal

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	8	22 (CIPZWE8S)	26 (CIPZWE8M)	34 (CIPZWE8L)
IPZ-2	6.4	Below threshold	29 (CIPZWE6.4M)	37 (CIPZWE6.4L)

Table 5.13.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Cardinal

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	8	48 (PIPZWE8S)	52 (PIPZWE8M)	61 (PIPZWE8L)
IPZ-2	6.4	Below threshold	55 (PIPZWE6.4M)	64 (PIPZWE6.4L)

5.13.4.3 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 5.13.5* and is tabulated in *Table 5.13.6*.

Table 5.13.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Cardinal

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	52	0	5	5	9%
IPZ-2	1,452	104	125	229	16%

5.13.4.4 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 5.13.6*and is tabulated in *Table 5.13.7*.

Table 5.13.7: Livestock Density Assessment, Cardinal

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0
IPZ-2	0.14

5.13.4.5 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 5.13.7* and tabulated in *Table 5.13.8.*

Table 5.13.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Cardinal

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	27.9	0	24.2	0
IPZ-2	765.0	180.7	274.0	0

5.13.4.6 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.

5.13.4.7 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.

5.13.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 0 activities that are or would be drinking water quality threats have been counted at 0 locations.

Specific activities and location counts are listed in *Table 5.13.9*.

Table 5.13.9: Significant Drinking Water Threat Activities, Cardinal

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

5.13.5 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.

5.13.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.13.10*. The information sources quoted below may contain additional expanded references.

Table 5.13.10: Key Information Sources, Cardinal

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Cardinal Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit

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 Edwardsburgh/Cardinal (Cardinal 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 Edwardsburgh/Cardinal (Cardinal 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
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 Edwardsburgh/Cardinal, Cardinal 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 Edwardsburgh/Cardinal, Cardinal Intake, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.13.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 enumeration of threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.13.11*.

Table 5.13.11: Summary of Uncertainty Analyses, Cardinal

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

5.14 Morrisburg

The Town of Morrisburg municipal water intake is located at the south end of Augusta Street toward the west of the town limits, in the St. Lawrence River. Raw water is drawn from approximately 2.75 m off the river bottom. The normal depth of water over the intake is estimated to be 8m. The intake crib is approximately 84 m from the shore.

CANEAU Water and Sewage Operations Inc. operates the Morrisburg Water Treatment Plant. The plant has a design capacity of 13,703 m^3/d (159 L/s). Treated water supplies a total population of approximately 3,700 in the Town of Morrisburg and the Town of Iroquois.

The site location is shown on *Map 5.14.1*. Drinking water system information is presented in *Table5.14.1.*

Table5.14.1: Drinking Water System Information, Morrisburg

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	220001012
Drinking Water System Name	SOUTH DUNDAS REGIONAL WATER TREATMENT PLANT
Owner	Township of South Dundas
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	485430 Easting, 4970875 Northing (NAD 83, Zone-18)
Area served by System	Village of Morrisburg and Village of Iroquois
Number of Users (approx. residents)	3,938
Minimum Daily Taking	
Average Daily Taking	3,248 m^3/day
Maximum Daily Taking	

5.14.1 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.

5.14.2 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 5.14.2*. The respective area calculations are summarized in *Table 5.14.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.14.2: Total Area by Vulnerable Area, Morrisburg

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	109.9	5 %
IPZ-2	2,170.8	95 %
Total	**2,280.7**	**100** %

5.14.2.1 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.

5.14.2.2 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 an in-stream portion representing the St. Lawrence River (computed with RMA model) and up-tributary portions for small tributaries (i.e., Strata's Bay Creek, Flagg Creek, Findlay, etc.) and creeks with upstream drainage area of 10 ha or larger (estimated based on the Manning Equation). The stormsewersheds associated with nearby outfalls (Old Canal Lane and Augusta Street) was not included in IPZ-2 as discharges were found not to reach the intake (based on the hydrodynamics, RMA model). Tile drained agricultural areas were also included where drain areas intersect the inland tributaries within a the 2-hour travel time to the intake.

5.14.3 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.

5.14.3.1 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.

The area vulnerability factor for IPZ-2 was set at 9 after considering:

- The ratio of land to water is moderate (40% land vs. 60% water);
- Land cover is predominantly agricultural with some urban and forested areas, there is low permeability and moderate slopes;
- There are many transport pathways present (extensive tile drainage).

5.14.3.2 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 (8 m below mean river level);
- The intake is located close to land (an offshore distance of approximately 84 m);

- There is no history of water quality concerns.

5.14.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.14.3* and shown on *Map 5.14.3*.

Table 5.14.3: Vulnerability Scores, Morrisburg

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.8	8
IPZ-2	9	0.8	7.2

5.14.4 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.

5.14.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.14.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.14.4* and *Table 5.14.5*. The applicable circumstance tables are also referenced visually on *Map 5.14.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.14.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Morrisburg

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	8	22 (CIPZWE8S)	26 (CIPZWE8M)	34 (CIPZWE8L)
IPZ-2	7.2	Below threshold	27 (CIPZWE7.2M)	35 (CIPZWE7.2L)

Table 5.14.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Morrisburg

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low

IPZ-1	8	48 (PIPZWE8S)	52 (PIPZWE8M)	61 (PIPZWE8L)
IPZ-2	7.2	Below threshold	53 (PIPZWE7.2M)	62 (PIPZWE7.2L)

5.14.4.3 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 5.14.5* and is tabulated in *Table 5.14.6*.

Table 5.14.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Morrisburg

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	113	0	10	10	9%
IPZ-2	2,416	512	175	687	28%

5.14.4.4 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 5.14.6*and is tabulated in *Table 5.14.7*.

Table 5.14.7: Livestock Density Assessment, Morrisburg

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0
IPZ-2	0.15

5.14.4.5 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 5.14.7* and tabulated in *Table 5.14.8.*

Table 5.14.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Morrisburg

Vulnerable Area	Area (ha) corresponding to impervious thresholds (based on 1km^2 grid)			
	1% or Less	More than 1% but not more than 8%	More than 8% but less than 80%	80% or Greater
IPZ-1	52.4	0	57.5	0
IPZ-2	1010.6	756.2	404.0	0

5.14.4.6 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.

5.14.4.7 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.

5.14.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 0 activities that are or would be drinking water quality threats have been counted at 0 locations.

Specific activities and location counts are listed in *Table 5.14.9*.

Table 5.14.9: Significant Drinking Water Threat Activities, Morrisburg

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

5.14.5 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.

5.14.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.14.10*. The information sources quoted below may contain additional expanded references.

Table 5.14.10: Key Information Sources, Morrisburg

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 South Nation Conservation Watershed*.	Report	Literature Review

Section	**Source(s)**	**Type**	**Analysis Method(s)**
	Ontario Ministry of the Environment. 2009. *South Dundas Regional Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Studies on the St. Lawrence River, Township of South Dundas, Morrisburg 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 Dundas, Morrisburg 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
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 Dundas, Morrisburg Intake, Assessment Report Input.*	Technical Study	Data Analyses

Section	Source(s)	Type	Analysis Method(s)
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 Dundas, Morrisburg Intake, Assessment Report Input.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.14.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.14.11*.

Table 5.14.11: Summary of Uncertainty Analyses, Morrisburg

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

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

5.15 Rockland

The City of Clarence-Rockland is located in Eastern Ontario, about 40 kilometres east of the City of Ottawa. The municipal intake is located in the Ottawa River at a depth of 9.1m and 65m off shore near the City of Clarence-Rockland. In addition to Rockland, this surface water treatment facility also supplies the municipal water to Hammond, Bourget, Saint Pascal de Baylon, Cheney and Clarence Creek. A total population of 13,500 is estimated to be serviced by the City of Clarence-Rockland drinking water system.

The site location is shown on *Map 5.15.1*. Drinking water system information is presented in *Table5.15.1.*

Table5.15.1: Drinking Water System Information, Rockland

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	210000639
Drinking Water System Name	ROCKLAND WATER TREATMENT PLANT
Owner	CLARENCE-ROCKLAND, THE CORPORATION OF THE CITY OF
Operating Authority	Ontario Clean Water Agency
Source Water Type	Surface Water
Source Water	Ottawa River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	C
Coordinates of Intake	476606 Easting, 5044863 Northing (NAD 83, Zone-18)
Area served by System	Rockland, Hammond, Bourget, St Pascal de Bayon, Cheney, Clarence Creek
Number of Users (approx. residents)	13,500
Minimum Daily Taking	
Average Daily Taking	2,798 m^3/day
Maximum Daily Taking	6,641 m^3/day

5.15.1 Intake Classification

The intake is located in the Ottawa River, and neither the direction nor the velocity of the flow of the water at the intake is affected by a water impoundment structure. The Ottawa River is not considered a connecting channel. For these reasons, the intake is classified as type C.

5.15.2 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 5.15.2*. The respective area calculations are summarized in *Table 5.15.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.15.2: Total Area by Vulnerable Area, Rockland

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	20.3	2%
IPZ-2	1,066.5	98%
Total	**1,086.8**	**100.0** %

5.15.2.1 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 200 metres extending upstream from the center point of intake and a rectangle with a length of 400 metres and a width of 10 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 Ottawa River.

As there are no Regulation Limits along the Ottawa 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.

5.15.2.2 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, HEC-RAS with 2-year flow);
- 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 Ottawa 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 Ottawa River (via HEC-RAS model and wind vectors) and an up-tributary portion representing 14 tributaries (via time of concentration calculations). Contributing drainage areas including anthropogenic transport pathways (e.g. ditches, roads, channels) were accounted for through up-tributary hydraulic calculations.

During the bank-full flow condition (i.e. 2 year flow), there is an interprovincial contribution to the IPZ-2 from Quebec. The limit to IPZ-2 has been clipped to the interprovincial border for the purpose of this assessment.

Acoustic Doppler Current Profiler (ADCP) technology was used to assess the Ottawa River current's directions and velocity in the vicinity of the Clarence-Rockland intake. The ADCP results indicated backflow conditions and potential eddies in the vicinity of the Clarence-Rockland intake. Hence, the IPZ-2 was extended downstream to account for possible backflows.

5.15.3 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.

5.15.3.1 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.

The area vulnerability factor for IPZ-2 was set at 8 after considering:

- The ratio of land to water is moderate (54% land vs. 46% water);
- Land cover is predominantly agricultural and urban, there is moderate permeability and slight slopes;
- There are many transport pathways present (storm sewers and tile drainage).

Although the intake protection zone boundaries have been clipped at the Ontario-Quebec border for the purpose of this assessment, conditions on the Quebec side which influence the area vulnerability factor were considered.

5.15.3.2 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 0.9 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 0.9 after considering:

- The intake is relatively deep (9 m below mean river level);
- The intake is located fairly close to land (an offshore distance of approximately 65 m);
- There is no history of water quality concerns.

5.15.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.15.3* and shown on and shown on *Map 5.15.3*.

Table 5.15.3: Vulnerability Scores, Rockland

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.9	9
IPZ-2	8	0.9	7.2

5.15.4 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.

5.15.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.15.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.15.4* and *Table 5.15.5*. The applicable circumstance tables are also referenced visually on *Map 5.15.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.15.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Rockland

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	9	20 (CIPZWE9S)	24 (CIPZWE9M)	32 (CIPZWE9L)
IPZ-2	7.2	*Below threshold*	27 (CIPZWE7.2M)	35 (CIPZWE7.2L)

Table 5.15.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Rockland

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	9	46 (PIPZWE9S)	50 (PIPZWE9M)	59 (PIPZWE9L)
IPZ-2	7.2	*Below threshold*	53 (PIPZWE7.2M)	62 (PIPZWE7.2L)

5.15.4.3 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 5.15.5* and is tabulated in *Table 5.15.6*.

Table 5.15.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Rockland

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	20.3	2.9	0	2.9	14%
IPZ-2	1,066.5	36.3	0	36.3	34%

5.15.4.4 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 5.15.6*and is tabulated in *Table 5.15.7*.

Table 5.15.7: Livestock Density Assessment, Rockland

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.2
IPZ-2	0.2

5.15.4.5 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 5.15.7* and tabulated in *Table 5.15.8.*

Table 5.15.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Rockland

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	0.8	0	19.5	0
IPZ-2 (Clipped at Provincial Border)	299	117	632	0

5.15.4.6 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.

5.15.4.7 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.

5.15.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 0 activities that are or would be drinking water quality threats have been counted at 0 locations.

Specific activities and location counts are listed in *Table 5.15.9*.

Table 5.15.9: Significant Drinking Water Threat Activities, Rockland

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

5.15.5 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.

5.15.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.15.10*. The information sources quoted below may contain additional expanded references.

Table 5.15.10: Key Information Sources, Rockland

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2010. *Rockland Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, City of Clarence-Rockland.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, City of Clarence-Rockland.*	Technical Study	Engineering Assessment
Managed Lands	WESA. 2010. *Surface Water Threats Assessment, Clarence-Rockland Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Surface Water Threats Assessment, Clarence-Rockland Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Surface Water Threats Assessment, Clarence-Rockland Water Supply.*	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

Section	Source(s)	Type	Analysis Method(s)
Water Quality Threats Assessment	WESA. 2010. *Surface Water Threats Assessment, Clarence-Rockland Water Supply.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.15.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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*. Furthermore, a state of the art, Acoustic Doppler Current Profiler was used to account for backflow conditions and potential eddies in the vicinity of the intake.

The hydraulic model used for IPZ-2 delineation was well calibrated and contained sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The delineated IPZ-2 for the Ottawa River intakes, is considered very conservative, as statistically, a contaminant introduced at the upstream limit of IPZ-2 would, 98.5% of the time, take more than 2 hours to reach the intake. The uncertainty for IPZ-2 delineation is considered 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 threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.15.11*.

Table 5.15.11: Summary of Uncertainty Analyses, Rockland

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

5.16 Wendover

Wendover is located in the Eastern Ontario Township of Alfred-Plantagenet, about50 kilometers east of the City of Ottawa. The municipal intake is located in the Ottawa River at a depth of 4 meters below normal water level and 100m off shore. The intake is located north of the water treatment plant, at 3081 Highway 17 in Wendover. A total population of 850 is estimated to be serviced by the Wendover drinking water system.

The site location is shown on *Map 5.16.1*. Drinking water system information is presented in *Table5.16.1.*

Table5.16.1: Drinking Water System Information, Wendover

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	260004293
Drinking Water System Name	Wendover Water Treatment Plant
Owner	Township of Alfred and Plantagenet
Operating Authority	Ontario Clean Water Agency
Source Water Type	Surface Water
Source Water	Ottawa River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	C
Coordinates of Intake	490023 Easting, 5046851 Northing (NAD 83, Zone-18)
Area served by System	Wendover
Number of Users (approx. residents)	850
Minimum Daily Taking	
Average Daily Taking	423 m³/day
Maximum Daily Taking	1,550 m³/day

5.16.1 Intake Classification

The intake is located in the Ottawa River, and neither the direction nor the velocity of the flow of the water at the intake is affected by a water impoundment structure. The Ottawa River is not considered a connecting channel. For these reasons, the intake is classified as type C.

5.16.2 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 5.16.2*. The respective area calculations are summarized in *Table 5.16.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.16.2: Total Area by Vulnerable Area, Wendover

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	7.6	1 %
IPZ-2	706.8	99 %
Total	**714.4**	**100** %

5.16.2.1 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 200 metres extending upstream from the center point of intake and a rectangle with a length of 400 metres and a width of 10 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 Ottawa River.

As there are no Regulation Limits along the Ottawa 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.

5.16.2.2 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, 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 Ottawa 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 Ottawa River (via HEC-RAS model and wind vectors) and an up-tributary portion representing 10 tributaries (via time of concentration calculations). Contributing drainage areas including anthropogenic transport pathways (e.g. ditches, roads, channels) were accounted for through up-tributary hydraulic calculations.

During the bank-full flow condition (i.e. 2 year flow), there is an interprovincial contribution to the IPZ-2 from Quebec. The limit to IPZ-2 has been clipped to the interprovincial border for the purpose of this assessment.

Acoustic Doppler Current Profiler (ADCP) technology was used to assess the Ottawa River current's directions and velocity in the vicinity of the intake. The ADCP results indicated no backflow conditions or reverse-eddies in the vicinity of the intake. Hence, the IPZ-2 delineation was not altered from its default configuration.

5.16.3 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.

5.16.3.1 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.

The area vulnerability factor for IPZ-2 was set at 8 after considering:

- The ratio of land to water is moderate(53% land vs. 47% water);
- Land cover is predominantly agricultural and urban, there is low permeability and moderate slopes;
- There are many transport pathways present (storm sewers and tile drainage).

Although the intake protection zone boundaries have been clipped at the Ontario-Quebec border for the purpose of this assessment, conditions on the Quebec side which influence the area vulnerability factor were considered.

5.16.3.2 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 0.9 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 after considering:

- The intake is relatively shallow (4 m below mean river level);
- The intake is close to shore (100 meters);
- No water quality issues have been reported.

5.16.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.16.3* and shown on and shown on *Map 5.16.3*.

Table 5.16.3: Vulnerability Scores, Wendover

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

5.16.4 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.

5.16.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.16.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.16.4* and *Table 5.16.5*. The applicable circumstance tables are also referenced visually on *Map 5.16.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.16.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Wendover

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	10	19 (CIPZ10S)	23 (CIPZ10M)	31 (CIPZWE10L)
IPZ-2	8	22 (CIPZWE8S)	26 (CIPZWE8M)	34 (CIPZWE8L)

Table 5.16.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Wendover

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	10	45 (PIPZ10S)	49 (PIPZWE10M)	58 (PIPZ10L)
IPZ-2	8	48 (PIPZWE8S)	52 (PIPZWE8M)	61 (PIPZWE8L)

5.16.4.3 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 5.16.5* and is tabulated in *Table 5.16.6*.

Table 5.16.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Wendover

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	7.65	1.64	0	1.64	21%
IPZ-2	706.8	309.6	0	309.6	43%

5.16.4.4 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 5.16.6*and is tabulated in *Table 5.16.7*.

Table 5.16.7: Livestock Density Assessment, Wendover

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.18
IPZ-2	0.18

5.16.4.5 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 5.16.7* and tabulated in *Table 5.16.8.*

Table 5.16.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Wendover

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	0.9	0	6.8	0
IPZ-2 (Clipped at Provincial Border)	119	176	411	0

5.16.4.6 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.

5.16.4.7 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.

5.16.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 82 activities that are or would be drinking water quality threats have been counted at 39 locations.

Specific activities and location counts are listed in *Table 5.16.9*.

Table 5.16.9: Significant Drinking Water Threat Activities, Wendover

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		39
The application of non-agricultural source material to land.		39
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.		4
Total – All Activities		**82**

5.16.5 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.

5.16.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.16.10*. The information sources quoted below may contain additional expanded references.

Table 5.16.10: Key Information Sources, Wendover

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Wendover Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, Township of Alfred and Plantagenet.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, Township of Alfred and Plantagenet.*	Technical Study	Engineering Assessment
Managed Lands	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	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

Section	Source(s)	Type	Analysis Method(s)
Water Quality Threats Assessment	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.16.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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*. Furthermore, a state of the art, Acoustic Doppler Current Profiler was used to account for backflow conditions and potential eddies in the vicinity of the intake.

The hydraulic model used for IPZ-2 delineation was well calibrated and contained sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The delineated IPZ-2 for the Ottawa River intakes, is considered very conservative, as statistically, a contaminant introduced at the upstream limit of IPZ-2 would, 98.5% of the time, take more than 2 hours to reach the intake. The uncertainty for IPZ-2 delineation is considered 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 threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.16.11*.

Table 5.16.11: Summary of Uncertainty Analyses, Wendover

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	High

5.17 Lefaivre

Lefaivre is located in the Eastern Ontario Township of Alfred-Plantagenet, about60 kilometers east of the City of Ottawa. The municipal intake is located in the Ottawa River at a depth of 15 meters below normal water level and 90m off shore. The intake is located north of the water treatment plant, at 2015 Lajoie Street in Lefaivre. Treated water from the Lefaivre municipal system is also piped to distribution systems for Alfred, Plantagenet and St-Isidore. A total population of 4500 is estimated to be served by this drinking water system.

The site location is shown on *Map 5.17.1*. Drinking water system information is presented in *Table5.17.1.*

Table5.17.1: Drinking Water System Information, Lefaivre

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	220002841
Drinking Water System Name	Lefaivre Water Treatment Plant
Owner	Township of Alfred and Plantagenet
Operating Authority	Ontario Clean Water Agency
Source Water Type	Surface Water
Source Water	Ottawa River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	C
Coordinates of Intake	508198 Easting, 5054182 Northing (NAD 83, Zone-18)
Area served by System	Lefaivre, Alfred, Plantagenet, St-Isidore
Number of Users (approx. residents)	4,500
Minimum Daily Taking	
Average Daily Taking	1000 m^3/day
Maximum Daily Taking	2154 m^3/day (2001); 2900m^3/day (Max Permitted)

5.17.1 Intake Classification

The intake is located in the Ottawa River, and neither the direction nor the velocity of the flow of the water at the intake is affected by a water impoundment structure. The Ottawa River is not considered a connecting channel. For these reasons, the intake is classified as type C.

5.17.2 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 5.17.2*. The respective area calculations are summarized in *Table 5.17.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.17.2: Total Area by Vulnerable Area, Lefaivre

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	12.0	3%
IPZ-2	415.8	97%
Total	**427.8**	**100** %

5.17.2.1 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 200 metres extending upstream from the center point of intake and a rectangle with a length of 400 metres and a width of 10 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 Ottawa River.

As there are no Regulation Limits along the Ottawa 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.

5.17.2.2 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, 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 Ottawa 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 Ottawa River (via HEC-RAS model and wind vectors) and an up-tributary portion representing 7 tributaries (via time of concentration calculations). Contributing drainage areas including anthropogenic transport pathways (e.g. ditches, roads, channels) were accounted for through up-tributary hydraulic calculations.

During the bank-full flow condition (i.e. 2 year flow), there is an interprovincial contribution to the IPZ-2 from Quebec. The limit to IPZ-2 has been clipped to the interprovincial border for the purpose of this assessment.

Acoustic Doppler Current Profiler (ADCP) technology was used to assess the Ottawa River current's directions and velocity in the vicinity of the intake. The ADCP results indicated backflow conditions and potential eddies in the vicinity of the intake. Hence, the IPZ-2 was extended downstream to account for possible backflows.

5.17.3 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.

5.17.3.1 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.

The area vulnerability factor for IPZ-2 was set at 8 after considering:

- The ratio of land to water is high (76% land vs. 24% water);
- Land cover is predominantly agricultural and urban, there is low permeability and moderate slopes;
- Relatively short length of transport pathways (storm sewers and tile drainage).

Although the intake protection zone boundaries have been clipped at the Ontario-Quebec border for the purpose of this assessment, conditions on the Quebec side which influence the area vulnerability factor were considered.

5.17.3.2 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 0.9 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 0.9 after considering:

- The intake is relatively deep (15 m below mean river level);
- The intake is located close to land (an offshore distance of approximately 90 m);
- There is no history of water quality concerns.

5.17.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.17.3* and shown on and shown on *Map 5.17.3*.

Table 5.17.3: Vulnerability Scores, Lefaivre

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	0.9	9
IPZ-2	8	0.9	7.2

5.17.4 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.

5.17.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.17.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.17.4* and *Table 5.17.5*. The applicable circumstance tables are also referenced visually on *Map 5.17.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.17.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Lefaivre

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	9	20 (CIPZWE9S)	24 (CIPZWE9M)	32 (CIPZWE9L)
IPZ-2	7.2	*Below threshold*	27 (CIPZWE7.2M)	35 (CIPZWE7.2L)

Table 5.17.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Lefaivre

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	9	46 (PIPZWE9S)	50 (PIPZWE9M)	59 (PIPZWE9L)
IPZ-2	7.2	*Below threshold*	53 (PIPZWE7.2M)	62 (PIPZWE7.2L)

5.17.4.3 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 5.17.5* and is tabulated in *Table 5.17.6*.

Table 5.17.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Lefaivre

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	12	4.2	0	4.2	34%
IPZ-2	416	175	0	175	43%

5.17.4.4 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 5.17.6*and is tabulated in *Table 5.17.7*.

Table 5.17.7: Livestock Density Assessment, Lefaivre

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.18
IPZ-2	0.18

5.17.4.5 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 5.17.7* and tabulated in *Table 5.17.8*.

Table 5.17.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Lefaivre

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	12	0	0	0
IPZ-2 (Clipped at Provincial Border)	21	124	31	0

5.17.4.6 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.

5.17.4.7 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.

5.17.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 0 activities that are or would be drinking water quality threats have been counted at 0 locations.

Specific activities and location counts are listed in *Table 5.17.9*.

Table 5.17.9: Significant Drinking Water Threat Activities, Lefaivre

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

5.17.5 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.

5.17.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.17.10*. The information sources quoted below may contain additional expanded references.

Table 5.17.10: Key Information Sources, Lefaivre

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

Section	Source(s)	Type	Analysis Method(s)
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2009. *Lefaivre Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, Township of Alfred and Plantagenet.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, Township of Alfred and Plantagenet.*	Technical Study	Engineering Assessment
Managed Lands	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	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
Water Quality Threats Assessment	WESA. 2010. *Surface Water Threats Assessment, Wendover and Lefaivre Water Supplies.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.17.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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*. Furthermore, a state of the art, Acoustic Doppler Current Profiler was used to account for backflow conditions and potential eddies in the vicinity of the intake.

The hydraulic model used for IPZ-2 delineation was well calibrated and contained sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The delineated IPZ-2 for the Ottawa River intakes, is considered very conservative, as statistically, a contaminant introduced at the upstream limit of IPZ-2 would, 98.5% of the time, take more than 2 hours to reach the intake. The uncertainty for IPZ-2 delineation is considered 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 threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.17.11*.

Table 5.17.11: Summary of Uncertainty Analyses, Lefaivre

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

5.18 Hawkesbury

The Town of Hawkesbury is located on the shores of the Ottawa River, about 75 kilometres east of the City of Ottawa and across the river from the province of Québec. The Town is a small to midsized eastern Ontario town, covering a total area of approximately 9.46 square kilometres with a population of approximately 11,000.

The Hawkesbury Water Treatment Plant is located at 670 Main Street West, and the intake is located 40 m from shore at a depth of 4.5 m below normal water level of the Ottawa River. The intake is located approximately 1.4 km upstream of the John Street bridge in Hawkesbury that crosses the Ottawa River and upstream of a bay. The river bends and narrows just upstream of Hawkesbury and then opens up to a wider section near the intake where it is greater than 2 km across at its widest point and then narrows again at Hawkesbury where the river width at the intake is 1360 m

The Town of Hawkesbury's water works includes two raw water intakes (approximately 10 meters apart). Currently, the water works uses only the eastern (downstream) intake.

The site location is shown on *Map 5.18.1*. Drinking water system information is presented in *Table5.18.1.*

Table5.18.1: Drinking Water System Information, Hawkesbury

Drinking Water System Type (MOE)	**Existing, Large Municipal Residential System**
Drinking Water System Number (MOE)	220002832
Drinking Water System Name	Hawkesbury Water Treatment Plant
Owner	Town of Hawkesbury
Operating Authority	Town of Hawkesbury
Source Water Type	Surface Water
Source Water	Ottawa River
Number of Surface Water Intakes	2 (10m apart)
Intake Type (CWA Classification)	C
Coordinates of Intake	1) 529559 Easting, 5051621Northing (NAD 83, Zone-18) 2) 529552 Easting, 5051630Northing (NAD 83, Zone-18)
Area served by System	Hawkesbury, L'Orignal, Vankleek Hill, Laurentian Park
Number of Users (approx. residents)	14,154
Minimum Daily Taking	5,600 m^3/day
Average Daily Taking	7,500 m^3/day
Maximum Daily Taking	

5.18.1 Intake Classification

The intake is located in the Ottawa River, and neither the direction nor the velocity of the flow of the water at the intake is affected by a water impoundment structure. The Ottawa River is not considered a connecting channel. For these reasons, the intake is classified as type C.

5.18.2 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 5.18.2*. The respective area calculations are summarized in *Table 5.18.2*. Rationale and methodologies for zone delineation are discussed in sections: *Intake Protection Zone 1* and *Intake Protection Zone 2* below.

Table 5.18.2: Total Area by Vulnerable Area, Hawkesbury

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	6.7	1%
IPZ-2	594.5	99%
Total	**601.2**	**100%**

5.18.2.1 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 200 metres extending upstream from the center point of intake and a rectangle with a length of 400 metres and a width of 10 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 Ottawa River.

As there are no Regulation Limits along the Ottawa 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.

5.18.2.2 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, 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 Ottawa 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 Ottawa River (via HEC-RAS model and wind vectors) and an up-tributary portion representing 12streams and ditches (via time of concentration calculations). Contributing drainage areas including anthropogenic transport pathways (e.g. road side ditches, roads, channels) were accounted for through up-tributary calculations.

During the bank-full flow condition (i.e. 2 year flow), there is an interprovincial contribution to the IPZ-2 from Quebec. The limit to IPZ-2 has been clipped to the interprovincial border for the purpose of this assessment.

Acoustic Doppler Current Profiler (ADCP) technology was used to assess the Ottawa River current's directions and velocity in the vicinity of the intake. The ADCP results indicated no backflow conditions or potential eddies in the vicinity of the intake. Hence, the IPZ-2 was not modified from the default configuration.

5.18.3 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.

5.18.3.1 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 scori5ng 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 moderate (63% land vs. 37% water);
- Moderate runoff potential; low permeability (CN 84), high slope (3.8%);
- Relatively short length of transport pathways, 75.6 km (storm sewers).

Although the intake protection zone boundaries have been clipped at the Ontario-Quebec border for the purpose of this assessment, conditions on the Quebec side which influence the area vulnerability factor were considered.

5.18.3.2 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 0.9 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 after considering:

- The intake is relatively shallow (4.5 m below mean river level);
- The intake is located close to land (an offshore distance of approximately 40 m);
- There is some history of water quality concerns, namely taste and odour (however, the source water is acceptable for treatment and the treatment process is capable of meeting the ODWQS)

5.18.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.18.3* and shown on and shown on *Map 5.18.3*.

Table 5.18.3: Vulnerability Scores, Hawkesbury

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

5.18.4 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.

5.18.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.18.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.18.4* and *Table 5.18.5*. The applicable circumstance tables are also referenced visually on *Map 5.18.4.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.18.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Hawkesbury

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	10	10 (CIPZ10S)	23 (CIPZ10M)	31 (CIPZWE10L)
IPZ-2	8	22 (CIPZWE8S)	26 (CIPZWE8M)	34 (CIPZWE8L)

Table 5.18.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Hawkesbury

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	10	45 (PIPZ10S)	49 (PIPZWE10M)	58 (PIPZ10L)
IPZ-2	8	48 (PIPZWE8S)	52 (PIPZWE8M)	61 (PIPZWE8L)

5.18.4.3 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 5.18.5* and is tabulated in *Table 5.18.6*.

Table 5.18.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Hawkesbury

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	6.7	0	0	0	0%
IPZ-2	594.5	178.8	0	178.8	30%

5.18.4.4 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 5.18.6*and is tabulated in *Table 5.18.7*.

Table 5.18.7: Livestock Density Assessment, Hawkesbury

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.2
IPZ-2	0.2

5.18.4.5 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 5.18.7* and tabulated in *Table 5.18.8.*

Table 5.18.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Hawkesbury

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	7.1	0	0	0
IPZ-2 (Clipped at Provincial Border)	219	137	238	0

5.18.4.6 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.

5.18.4.7 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.

5.18.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 23 activities that are or would be drinking water quality threats have been counted at 12 locations.

Specific activities and location counts are listed in *Table 5.18.9*.

Table 5.18.9: Significant Drinking Water Threat Activities, Hawkesbury

Activity	Sub Threat, if Applicable	Count
The application of agricultural source material to land.		11
The application of non-agricultural source material to land.		11
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.		1
Total – All Activities		**22**

5.18.5 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.

5.18.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.18.10*. The information sources quoted below may contain additional expanded references.

Table 5.18.10: Key Information Sources, Hawkesbury

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 South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2010. *Hawkesbury Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, Town of Hawkesbury.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	WESA and J.F. Sabourin and Associates Inc. 2010. *Surface Water Vulnerability Assessment, Town of Hawkesbury.*	Technical Study	Engineering Assessment
Managed Lands	WESA. 2010. *Surface Water Threats Assessment, Town of Hawkesbury Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Livestock Density	WESA. 2010. *Surface Water Threats Assessment, Town of Hawkesbury Water Supply.*	Technical Study	Engineering Assessment, Spatial Analyses
Impervious Surfaces	WESA. 2010. *Surface Water Threats Assessment, Town of Hawkesbury 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. *Surface Water Threats Assessment, Town of Hawkesbury Water Supply.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.18.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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*. Furthermore, a state of the art, Acoustic Doppler Current Profiler was used to account for backflow conditions and potential eddies in the vicinity of the intake.

The hydraulic model used for IPZ-2 delineation was well calibrated and contained sufficient detail in the vicinity of the intake and the protection zones to give high confidence in the delineated zones. The delineated IPZ-2 for the Ottawa River intakes, is considered very conservative, as statistically, a contaminant introduced at the upstream limit of IPZ-2 would, 98.5% of the time, take more than 2 hours to reach the intake. The uncertainty for IPZ-2 delineation is considered 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 threats includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.18.11*.

Table 5.18.11: Summary of Uncertainty Analyses, Hawkesbury

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

5.19 Casselman

The Village of Casselman's municipal water intake is located in the South Nation River, off Drouin Street, south of the railway bridge. The intake crib is located approximately in the middle of the river at a depth of 7 m below mean river level. Raw water is drawn through a mesh screen at the intake and flows into a raw water well which is located below the water treatment plant on the southeast bank of the river in the Village of Casselman.

The Casselman Water Treatment Plant, located at 832 Laval Street in Casselman, Ontario, is a conventional design plant with two Actiflo process units that provide coagulation, flocculation, clarification, filtration and disinfection with chlorine gas processes. Effluent from the Actiflo units is then directed to one of two UV reactors. The treatment plant has a design capacity of 3,182 m^3/day and services a population of approximately 2,835 persons.

The intake structure is approximately in the middle of the river, approximately 60 m perpendicular to the treatment plant.

The site location is shown on *Map 5.19.1*. Drinking water system information is presented in *Table5.19.1*.

Table5.19.1: Drinking Water System Information, Casselman

Drinking Water System Type (MOE)	Existing, Large Municipal Residential System
Drinking Water System Number (MOE)	210001219
Drinking Water System Name	Casselman Water Treatment Plant
Owner	Casselman, The Corporation of the Village of
Operating Authority	Casselman, The Corporation of the Village of
Source Water Type	Surface Water
Source Water	South Nation River
Number of Surface Water Intakes	1
Intake Type (CWA Classification)	Type D
Coordinates of Intake	492259 Easting, 5017593 Northing (UTM NAD-83, Zone 18)
Area served by System	Village of Casselman
Number of Users (approx. residents)	2,835
Minimum Daily Taking	687 m^3/day (2009 Annual Report)
Average Daily Taking	1,265 m^3/day (2009 Annual Report)
Maximum Daily Taking	2,132 m^3/day (2009 Annual Report)

5.19.1 Intake Classification

The Casselman Dam, located approximately 900 meters downstream of the intake, can affect the direction and velocity of flow of water at the intake. Under extreme low flow conditions the intake may be susceptible to downstream threats and exhibit lake-like behaviour. For this reason, the intake is classified as type D.

5.19.2 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 5.19.2*. IPZ-1 and IPZ-2 are further shown in close up detail on *Map 5.19.3*. The respective area calculations are summarized in *Table 5.19.2.* 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 5.19.2: Total Area by Vulnerable Area, Casselman

Vulnerable Area	Total Area (ha)	Percentage of Total Area
IPZ-1	67.8	0.1 %
IPZ-2	2,296.0	1.8 %
IPZ-3A	87,639.7	70.4 %
IPZ-3B	27,276.9	21.9 %
IPZ-3C	7,184.8	5.8 %
Total	**124,465.2**	**100.0** %

5.19.2.1 Intake Protection Zone 1

A circle with a radius of 1000 meters from the centre point of the intake is used to delineate the extents of IPZ-1. Land area that drains into the river included within the circle was clipped to a maximum setback of 120 meters in accordance with *the Rules*. The part of the river downstream of the dam was excluded from IPZ-1, as it does not contribute to the intake.

5.19.2.2 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*.

Computer modelling using hydraulic simulation software (HEC-RAS) was used to identify instream travel times based on a two-year design flow condition. Additional, up-tributary delineation, was computed using additional approaches: BASINS, a GIS-based USEPA watershed model and regression analysis, and the Index Flood Method.

IPZ-2 areas were adjusted to account for contributing transport pathways including urban sewersheds and agricultural tile drainage networks. Travel time in all contributing sewersheds was calculated to be less than 2 hours. All contributing tile drainage networks were included up to the watershed divide.

A 120m setback was applied to abutted land where overland flow drained into the river.

5.19.2.3 Intake Protection Zone 3

IPZ-3 includes the South Nation River, contributing tributaries and mapped drainage features, online and contiguous lakes and wetland features upstream of the intake, and a 120m setback. Tile drainage areas that may contribute water and are interconnected to the surface water system were also included.

IPZ-3 was divided into IPZ-3A, IPZ-3B and IPZ-3C due to the different potential impacts of these zones on water quality at the intake. IPZ-3A includes the higher runoff potential drainage area immediately upstream of IPZ-2 to the approximate limit of the higher density agricultural land use area within the watershed, at the confluence of two tributaries with the South Nation River (close to Winchester Springs). IPZ-3B continues from Winchester Springs to Spencerville and IPZ-3C includes the drainage area upstream of the dam at Spencerville.

By definition, Intake Protection Zone 3, is the total (buffered) instream contributing area to the intake. The size of IPZ-3 is a direct correlation to the size of the contributing watershed area. The delineation of the contributing watershed area does not, in and of itself, imply that land use activities within the boundaries pose a threat to drinking water.

5.19.3 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.

5.19.3.1 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; and for IPZ-3, the permissible values are whole numbers between 1 and 9 (inclusive).

The scoring for IPZ-2 and IPZ-3 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,
- Proximity of the area to the intake (only for IPZ-3).

The area vulnerability factor for IPZ-2 was set at 9 after considering:

- The ratio of land to water is high (97% land vs. 3% water);
- Land cover is predominantly agricultural and urban, there is low permeability and moderate slopes;
- There are many transport pathways present (storm sewers and tile drainage).

The Rules allow one or more area 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 land use, soil coverage and lower runoff potential.

The area vulnerability factor for IPZ-3A was set at 7 after considering:

- Proximity to the intake;
- The ratio of land to water is very high;
- Moderate runoff potential due to improved drainage and highly impermeable clay soils.

The area vulnerability factors for IPZ-3B and IPZ-3C were set at 3 and 1 respectively after considering:

- Increasing remoteness from the intake (> 50km);
- Increased woodland and wetland coverage;
- Water control structures near Russell, Crysler, Chesterville and Spencerville increase the retention time and reduce the risk of intake contamination due to spills.

5.19.3.2 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 range from 0.8 to 1.0 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 (7 m below mean river level);
- The intake is located close to land (an offshore distance of approximately 40 m);
- There is a history of water quality concerns (significant microbiological counts, elevated total dissolved solids and nitrates and the presence of atrizine and other pesticides).

5.19.3.3 Final Vulnerability Score

The final vulnerability scores for the various vulnerable areas are listed in *Table 5.19.3* and shown on and shown on *Map 5.19.4*.

Table 5.19.3: Vulnerability Scores, Casselman

Vulnerable Area	Area Vulnerability Factor	Source Vulnerability Factor	Vulnerability Score
IPZ-1	10	1.0	10
IPZ-2	9	1.0	9
IPZ-3A	7	1.0	7
IPZ-3B	3	1.0	3
IPZ-3C	1	1.0	1

5.19.4 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.

5.19.4.1 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 in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of 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.

5.19.4.2 Circumstances

The provincial tables of circumstances for chemical and pathogen threats, which apply to the vulnerable areas for this drinking water system, are referenced in *Table 5.19.4* and *Table 5.19.5*. The applicable circumstance tables are also referenced visually on *Map 5.19.5.* The tables of circumstances and the vulnerability maps can be used to determine where or whether a prescribed activity is a significant, moderate or low drinking water threat.

No local circumstances have been added to the provincial tables by the Source Protection Committee for this drinking water system.

Table 5.19.4: Applicable Provincial Tables of Circumstances for Chemical Threats, Casselman

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	10	19 (CIPZ10S)	23 (CIPZ10M)	31 (CIPZWE10L)
IPZ-2	9	20 (CIPZWE9S)	24 (CIPZWE9M)	32 (CIPZWE9L)
IPZ-3A	7	*Below threshold*	28 (CIPZWE7M)	36 (CIPZWE7L)
IPZ-3B	3		*Below threshold*	*Below threshold*
IPZ-3C	1			

Table 5.19.5: Applicable Provincial Tables of Circumstances for Pathogen Threats, Casselman

Vulnerable Area	Vulnerability Score	Provincial Circumstance Table Number (Table Name)		
		Significant	Moderate	Low
IPZ-1	10	45 (PIPZ10S)	49 (PIPZWE10M)	58 (PIPZ10L)
IPZ-2	9	46 (PIPZWE9S)	50 (PIPZWE9M)	59 (PIPZWE9L)
IPZ-3A	7	*Below threshold*	54 (PIPZWE7M)	63 (PIPZWE7L)
IPZ-3B	3		*Below threshold*	*Below threshold*
IPZ-3C	1			

5.19.4.3 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 5.19.6*and is tabulated in *Table 5.19.6*. 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 5.19.6: Managed Lands Assessment for the Purpose of Evaluating Nutrient Application, Casselman

Vulnerable Area	Total Area (ha)	Agricultural Managed Land (ha)	Non-Agricultural Managed Land (ha)	Total Managed Land (ha)	Percent Managed Land
IPZ-1	67.8	18	11	29	43%
IPZ-2	2,296.0	1,777	252	2,029	88%
IPZ-3A	87,639.7	71,057	6,777	77,834	89%

5.19.4.4 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 5.19.7*and is tabulated in *Table 5.19.7*. 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 5.19.7: Livestock Density Assessment, Casselman

Vulnerable Area	Livestock Density of Agricultural Managed Land (NU/acre)
IPZ-1	0.20
IPZ-2	0.20
IPZ-3A	0.20

5.19.4.5 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 5.19.8*and tabulated in *Table 5.19.8.*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 5.19.8: Impervious Area Assessment for the Purposes of Evaluating Threats Posed by the Application of Road Salt, Casselman

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%
IPZ-1	0	30.0	37.8	0
IPZ-2	452	1,186	658	0
IPZ-3A	24,875	56,698	6,067	0

5.19.4.6 Issues Evaluation

An issues evaluation was undertaken and five (5) drinking water parameters were identified as potential issues for the drinking water source: E. Coli, Manganese, Aluminum, Sodium and Total Phosphorus. At this time, the issues contributing area is not confirmed. The delineation of an issues contributing area may be considered in an updated *Assessment Report* (see *Section 6)*.

5.19.4.7 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.

5.19.4.8 Enumeration of Significant Drinking Water Threats

The number of locations at which an activity that is a significant drinking water threat is possibly being engaged in has been enumerated. For the purpose of this assessment report, none of the activities have been verified with the property owners.

In total 384 activities that are or would be drinking water quality threats have been counted at 128 locations.

Specific activities and location counts are listed in *Table 5.19.9*.

Table 5.19.9: Significant Drinking Water Threat Activities, Casselman

Activity	Sub Threat, if Applicable	Count
The application of pesticide to land.		110
The application of road salt.		1
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Industrial Effluent Discharges	1
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Septic Systems	4
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Waste Disposal Site – Landfarming Of Petroleum Refining Waste	1

Activity	Sub Threat, if Applicable	Count
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Waste Disposal Site – Landfilling (Hazardous Waste)	1
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Waste Disposal Site – Landfilling (Municipal Waste)	1
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Waste Disposal Site – Storage Of Hazardous Waste At Disposal Sites	1
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Waste Disposal Site – Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste	1
The handling and storage of commercial fertilizer.		1
The handling and storage of fuel.		5
The handling and storage of pesticide.		1
The storage of agricultural source material.		10
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.	Agricultural Source Material (ASM) Generation	15
Total – All Activities		**384**

5.19.5 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.

5.19.5.1 Information Sources

Key information sources for the assessment of this drinking water system are listed in *Table 5.19.10*. The information sources quoted below may contain additional expanded references.

Table 5.19.10: Key Information Sources, Casselman

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

Section	Source(s)	Type	Analysis Method(s)
	Raisin Region Conservation Authority. 2006. *Summary of Compliance Inspection Reports for Drinking Water Systems in the South Nation Conservation Watershed*.	Report	Literature Review
	Ontario Ministry of the Environment. 2010. *Casselman Water Treatment Plant – Drinking Water System Inspection Report*.	Report	Site Audit
Vulnerable Area Delineation	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Study on the South Nation River, Village of Casselman, Assessment Report Input.*	Technical Study	Hydraulic Modelling, Spatial Analysis
Vulnerability Scoring	Dillon Consulting Limited. 2010. *Surface Water Vulnerability Study on the South Nation River, Village of Casselman, 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
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 and Threats Inventory for the Village of Casselman Municipal Intake.*	Technical Study	Data Analyses
Water Quality Threats Assessment	Dillon Consulting Limited. 2010. *Issues Evaluation and Threats Inventory for the Village of Casselman Municipal Intake.*	Technical Study	Spatial Analyses, Windshield Survey, Engineering Assessment

5.19.5.2 Uncertainty Analysis

Uncertainty analyses have been carried out 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 to delineate IPZ-2 contained sufficient detail in the vicinity of the zone to give high confidence in the delineation. As a result, the low level of uncertainty was assigned to the delineation of IPZ-2. The delineation of IPZ-3 is prescribed by *the Rules.* The uncertainty is related to mapping of setbacks. Good land use and topography data was available, therefore the uncertainty is considered to be 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. 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 includes precautionary assumptions. Professional judgment was used to limit the number of assumptions made, however there are some activities where site visits would be an appropriate means of validating the associated circumstances.

A summary of uncertainty is listed in *Table 5.19.11*.

Table 5.19.11: Summary of Uncertainty Analyses, Casselman

Component	Uncertainty Assessment
IPZ-1 Delineation	Low
IPZ-2 Delineation	Low
IPZ-3 Delineation	Low
IPZ-1 Vulnerability Scoring	Low
IPZ-2 Vulnerability Scoring	Low
IPZ-3 Vulnerability Scoring	High
Issues Evaluation	High
Managed Lands Evaluation	Low
Livestock Density Evaluation	Low
Impervious Surface Evaluation	Low
Threats Assessment	High

6 Next Steps

The Assessment Report findings will be used to develop policies for the Source Protection Plan that will serve to protect the sources of drinking water for the municipal systems within the South Nation Source Protection Area. Policies will be developed by the Source Protection Committee in consultation with municipalities, Conservation Authorities, property and business owners, farmers, industry, health officials, community groups and others working together to create a fair, practical and implementable Source Protection Plan. Public input and consultation will play a significant role throughout the process. Formal public consultation periods will be held on the draft and proposed Source Protection Plan before it is finalized and submitted to the Minister of the Environment by August, 2012.

Throughout the preparation of the Assessment Report a few concerns have been raised at public meetings, stakeholder engagements, council meetings, Source Protection Committee meetings, and Source Protection Authority meetings. The main concerns include: transportation threats, wildlife and deadstock disposal. There is a process to add transportation threats, wildlife and deadstock disposal as local threats. Any local threats added by the Source Protection Committee must be approved by the Director of the Source Protection Programs Branch, Ontario Ministry of the Environment.

Transportation Threats

Many of the drinking water systems that have been assessed in this report are located near transportation corridors (rail, highway or shipping lanes). A major spill in these areas has the potential to contaminate local drinking water supplies. When preparing source protection plans, the Source Protection Committee will undertake a review of all systems located near transportation corridors and may set out policies specifying actions. Policies may include but not limited to:

- updating of spill prevention and spill contingency plans or emergency response plans for the purpose of protecting existing drinking water sources;
- confirming, enhancing or establishing protocols between municipal, provincial, federal governments and agencies to deal with notification procedures should a spill occur; and
- permanent spill containment barriers as a preventative measure.

Wildlife

The deterioration of surface water quality as a source of drinking water can result from natural conditions and/or anthropogenic activities. The Technical Rules require that only drinking water issues that are at least partially a result of anthropogenic activities are to be considered in the identification of drinking water threats. The Source Protection Committee recognizes that wildlife (e.g. Canada Geese) may be a source of contamination for some drinking water systems.

Deadstock Disposal

Deadstock disposal no longer falls within the list of prescribed threats under the Clean Water Act. In March 2009 a new regulation was made under the Nutrient Management Act, 2002 such that the burial of farm animals is now regulated through Ontario Regulation 106/09, Disposal of Dead Farm Animals. Changes were also made from the Food Safety and Quality Act, 2002 to govern off-farm animal use and disposal. The Source Protection Committee recognizes that deadstock disposal may be a source of contamination for some drinking water systems.

7 References

References have been organized by the Assessment Report component which they support.

7.1 Watershed Characterization

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