

Chapter 4: Assessing Regional Groundwater Vulnerability

Table of Contents

4 Assessing Regional Groundwater Vulnerability	4
4.1 Groundwater Vulnerability	5
4.1.1 Methodology	6
4.1.2 Evaluate Uncertainty	13
4.2 Highly vulnerable aquifer mapping (HVAs)	15
4.2.1 Vulnerability Scoring for HVAs	15
4.2.2 Composite Highly Vulnerable Aquifer Map	15
4.3 Significant groundwater Recharge areas	17
4.3.1 Delineating Significant Groundwater Recharge Areas	17
4.3.2 Vulnerability Scoring for SGRAs	19
4.3.3 Evaluate Uncertainty	20
4.4 Drinking Water Threats Evaluation	22
4.4.1 Managed Lands	22
4.4.2 Livestock Density	22
4.4.3 Impervious Surfaces	23
4.4.4 Identifying Areas of Significant/Moderate/Low Threats - Activities	24
4.4.5 Identifying Areas of Significant/Moderate/Low Threats - Conditions	24

List of Tables

Table 4.1-1: Vulnerability based on ISI/AVI Scores..... 7
Table 4.1-2: Lake Simcoe watershed Model Layers (Earthfx, 2006)..... 8
Table 4.3-1: Significant Groundwater Recharge Area Threshold (Earthfx, 2010c). 18
Table 4.3-2: Uncertainty analysis of the PRMS model based on Technical Rule 36 (Earthfx, 2010).
..... 21

List of Figures

~~Figure 4.1-1: Groundwater Vulnerability within the Lake Simcoe Watershed. 26~~
~~Figure 4.1-2: Groundwater Vulnerability Increase due to Transport Pathways. 27~~
~~Figure 4.1-1: Groundwater Vulnerability within the Lake Simcoe Watershed. 25~~
~~Figure 4.1-2: Groundwater Vulnerability Increase due to Transport Pathways. 26~~
Figure 4.2-1: Highly Vulnerable Aquifer Map of the Lake Simcoe Watershed..... 28
Figure 4.2-2: Composite Highly Vulnerable Aquifer Map..... 29
Figure 4.2-3: Nottawasaga Valley and Lake Simcoe Watershed Edge Matching. 30
Figure 4.2-4: Severn Sound and Black-Severn River Watershed Edge Matching..... 31

~~Figure 4.2-1: Highly Vulnerable Aquifer Map of the Lake Simcoe Watershed..... 27~~
~~Figure 4.2-2: Composite Highly Vulnerable Aquifer Map..... 28~~
~~Figure 4.2-3: Nottawasaga Valley and Lake Simcoe Watershed Edge Matching..... 29~~
~~Figure 4.2-4: Severn Sound and Black-Severn River Watershed Edge Matching..... 30~~
Figure 4.3-1: Significant Groundwater Recharge Areas. 32
Figure 4.3-2: Distribution of PRMS recharge estimates within the Lake Simcoe Basin. 34
Figure 4.3-3: Significant Groundwater Recharge Areas With Water Wells..... 35

~~Figure 4.3-1: Significant Groundwater Recharge Areas. 31~~
~~Figure 4.3-2: Distribution of PRMS recharge estimates within the Lake Simcoe Basin. 33~~

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Figure 4.3-3: Significant Groundwater Recharge Areas With Water Wells..... 34
Figure 4.4-1: Highly Vulnerable Aquifers and Managed Lands. 36
Figure 4.4-2: Highly Vulnerable Aquifers and Livestock Density. 38
Figure 4.4-3: Highly Vulnerable Aquifer and percent impervious surfaces..... 40
Figure 4.4-4: Areas Where Chemicals Are or Would be Moderate or Low Threats - Highly Vulnerable Aquifers. 42

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Figure 4.4-1: Highly Vulnerable Aquifers and Managed Lands 35
Figure 4.4-2: Significant Groundwater Recharge Areas and Managed Lands 36
Figure 4.4-3: Highly Vulnerable Aquifers and Livestock Density. 37
Figure 4.4-4: Significant Groundwater Recharge Areas and Livestock Density..... 38
Figure 4.4-5: Highly Vulnerable Aquifer and percent impervious surfaces..... 39
Figure 4.4-6: Significant Groundwater Recharge Areas and percent impervious surfaces..... 40
Figure 4.4-7: Areas Where Chemicals Are or Would be Moderate or Low Threats—Highly Vulnerable Aquifers. 41
Figure 4.4-8: Areas Where Chemicals Are or Would be Moderate or Low Threats—Significant Groundwater Recharge Areas..... 42

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4 Assessing Regional Groundwater Vulnerability

Within the Lake Simcoe study area, approximately 11% of the population relies on municipal drinking water from surface water intakes in Lake Simcoe. The majority of the population 78% relies on municipal drinking water that uses groundwater as the source, while the remaining population relies on private wells (groundwater) as their source of drinking water. The *Clean Water Act, 2006* requires that all sources of drinking water must be assessed for vulnerability. The vulnerability of municipal drinking water is assessed through development of surface water intake protection zones (IPZs) and Wellhead Protection Areas (WHPAs); these are discussed in detail within Chapter 5 and each municipal chapter (Chapters 6 to 13). The vulnerability of private wells (groundwater) is discussed within this Chapter. The vulnerability is determined through a regional groundwater vulnerability assessment which identifies “Highly Vulnerable Aquifers (HVAs)” and “Significant Groundwater Recharge Areas (SGRAs)”.

Surface water and groundwater can be naturally or anthropogenically vulnerable to a decrease in water quantity or decrease in water quality (contamination). The vulnerability of a groundwater system is an expression of the relative ease through which the aquifer could become contaminated by threat activities occurring on or beneath the ground surface. An aquifer that can easily become contaminated is considered to be vulnerable.

The groundwater vulnerability analysis has been undertaken to identify areas that contribute water to regional aquifers and to evaluate the relative vulnerability of these areas to contamination by the types of threat activities that may exist in that area, either now, in the past, or in the future. The groundwater vulnerability is assessed to provide an indication, within the regional landscape, where activities at surface present the greatest risk to contaminate the aquifer(s). The vulnerability analysis considers the groundwater vulnerability as well as the potential for the vulnerability to be increased by man’s activities, through transport pathways, in developing a “vulnerability rating” and assigning a “vulnerability score”. The resulting vulnerability rating can then be used to delineate the “Highly Vulnerable Aquifers (HVAs)” and “Significant Groundwater Recharge Areas (SGRAs)” within the South Georgian Bay-Lake Simcoe Source Protection Region (SGBLS SPR).

It should be noted that this Chapter only documents the methods used to delineate Groundwater Vulnerability for HVAs and SGRAs. Groundwater Vulnerability within each WHPA for individual municipal drinking water systems was determined using a different methodology and each municipal chapter should be referred to for that information.

The following is a summary of the steps taken to delineate the HVA and SGRA vulnerable areas within the Lake Simcoe study area:

Step 1: Delineating Groundwater Vulnerability

The first step in determining both HVAs and SGRAs is to delineate the groundwater vulnerability using a methodology that will categorize vulnerability as “High”, “Medium” or “Low” as prescribed by Technical Rules 37 and 38 (MOE, 2008a), and discussed in Section 4.1.1.

Step 2: Vulnerability Scoring for Highly Vulnerable Aquifers (HVAs)

The second step is to classify the areas categorized as “High” in step one above as Highly Vulnerable Aquifers (HVAs).

Step 3: Delineating Significant Groundwater Recharge Areas (SGRAs)

Recharge rates across the study area are determined using a surface water model (PRMS), which is discussed in great detail within Chapter 3 and Appendix WB-4C. SGRAs were determined by using Technical Rule 44(1) (MOE, 2008a), which specifies SGRAs are the areas where the recharge is 15% greater than the average recharge across the study area.

Step 4: Vulnerability Scoring SGRAs

Using the categorized groundwater vulnerability delineated in step one, the vulnerability within the SGRAs are categorized as “High”, “Medium” or “Low”.

4.1 Groundwater Vulnerability

This Section discusses the methodology used to delineate the groundwater vulnerability for the Lake Simcoe study area.

Various considerations must be given when identifying vulnerable areas and assigning a vulnerability score. Not all vulnerable areas are equally vulnerable, so numeric scores are attached to denote the Intrinsic Vulnerability in each case. Generally, the faster water is able to flow through the ground to an aquifer, the more vulnerable the area is to contamination. The vulnerability scores are determined by factors such as:

- 1) How deep/thick the aquifer and overlying aquitard is;
- 2) What type(s) of soils are present;
- 3) How quickly water can travel through the ground; and
- 4) What type of man-made transport pathways are present

Man-made transport pathways can create a direct route for water at the ground surface to travel to an aquifer that is a drinking water source. Potential Transport Pathways includes (but not limited to): pits, quarries, mines, pipelines, and poorly constructed or abandoned wells. If these pathways exist in a vulnerable area the score can be increased from Medium to High, Low

to Medium or Low to High in accordance with the potential for artificial transport pathways to increase the observed vulnerability.

The Technical Rules (MOE, 2008a) require that an Uncertainty Rating be assigned with each vulnerable area. The uncertainty assessment considers the type, quantity and quality of available data, the methods used to determine the vulnerability assessment components, and the nature of the groundwater flow system. A high uncertainty rating does not necessarily reflect a low degree of confidence in the vulnerability assessment, but instead reflects the irregular distribution and high variability in the quality and consistency of the data available to use for the assessment. Following the delineation of vulnerability scores, the next step is to use the scores to identify the drinking water threats related to water quantity and/or quality that would be rated Significant, Moderate or Low.

The Regional Groundwater Vulnerability within the South Georgian Bay-Lake Simcoe Source Protection Region was delineated by Genivar (2010d), and was delineated in accordance with the Technical Rules (13-15, 37-43) (MOE, 2008a). The following Sections (4.1.1 to 4.2.1) were taken directly from the report.

4.1.1 Methodology

Technical Rules 37 and 38 (MOE, 2008a) provide guidance on categorizing the groundwater vulnerability as either “High”, “Medium” or “Low” using one of the following assessment methods:

- 1) Intrinsic Susceptibility Index (ISI).
- 2) Aquifer Vulnerability Index (AVI).
- 3) Surface to Aquifer Advection¹ Time (SAAT).
- 4) Surface to Well Advection Time (SWAT).

The ISI and AVI methods use a scoring system that reflects the thickness and the type of overburden material. Aquifers of High Vulnerability have an ISI or AVI score less than 30, meaning the overlying material is thin and/or permeable. While aquifers of a Low Vulnerability have an ISI or AVI score greater than 80, meaning the overlying material is thicker and/or less permeable. Aquifers with a Medium Vulnerability will have a score that falls between 30 and 80. Table 4.1-1 outlines the Intrinsic Vulnerability based on an ISI or AVI score. This is explained in greater detail below.

¹ Advection time in the above methods refers to the estimated time for groundwater to move through the subsurface.

Table 4.1-1: Vulnerability based on ISI/AVI Scores.

ISI/AVI Score	Intrinsic Vulnerability
<30	High
30-80	Medium
>80	Low

The SAAT and SWAT methods (#3 and 4 listed above) for determining aquifer vulnerability are determined through use of the calibrated numerical groundwater flow models. Highly Vulnerable Aquifers are determined by a travel time to the aquifer (or well) of less than 5 years, while aquifers of Low Vulnerability are determined by a travel time to the aquifer (or well) of greater than 10 years. A single calibrated numerical groundwater flow model is not available for the SGBLS SPR and it was felt that it would be more appropriate to use a single methodology throughout the entire Source Protection Region.

The approach followed to determine the Regional Groundwater Vulnerability (HVAs and SGRAs) in the SGBLS SPR was the AVI method and is described in detail in Technical Memorandum A1 (Genivar, 2010d) found within Appendix RGV. The approach calculated an AVI for each delineated aquifer to produce a map of regional groundwater vulnerability across the landscape expressed as either “High”, “Medium”, or “Low”. The Technical Memorandum only documents the approach used to determine groundwater vulnerability for the purposes of HVAs and SGRAs. Chapter 5 – Methods and each municipal chapter should be referred to for more information on the methods used to delineate groundwater vulnerability for each municipal system.

The output of this step is a regional map showing the distribution of vulnerability categories as “High”, “Medium”, or “Low”. This will be used in subsequent steps.

Previous Work

The data used to delineate the Highly Vulnerable Aquifers within the South Georgian Bay-Lake Simcoe Source Protection Region were compiled from a variety of sources including:

- 1) North Simcoe Groundwater Study (Golder, 2005);
- 2) South Simcoe Groundwater Study (Golder, 2004);
- 3) NVCA Geological/Hydrostratigraphic Model Development (AquaResource & Golder, 2009);
- 4) CAMC/YPDT and LSRCA borehole database; and
- 5) CAMC/YPDT regional Version 4 ground surface layer.

These studies were reviewed to assess the applicability of information provided for use in the delineation of groundwater vulnerability and Highly Vulnerable Aquifer maps. The studies were also used as a quality control check to provide confidence in the results of the work completed as part of this study (Genivar, 2010d).

Stratigraphy

The vulnerability within the Lake Simcoe watershed was determined using an interpreted hydrostratigraphic model generated by the Conservation Authorities Moraine Coalition and the York-Peel-Durham-Toronto Groundwater Management Study (CAMC/YPDT) in 2006 on a 100 m x 100 m grid.

The work has incorporated analysis of detailed research borehole (“golden spikes”) and other high quality boreholes as well previously completed studies and other well record information to interpret and krige an eight-layer interpreted hydrostratigraphic model. The layers are identified in Table 4.1-2 below. The layers are listed in the order they occur in the model in order of reverse deposition from most recent to oldest.

All of the layers are continued across the model extent and thin to a thickness of 0.1 m in areas where they are interpreted to not exist. This minimal thickness is required for functionality in the numerical modeling, but does not restrict using these layers for the assessment of groundwater vulnerability and the subsequent delineation of the Highly Vulnerable Aquifers.

The CAMC/YPDT study continues to review and revise the hydrostratigraphic interpretation. It is possible that the updated interpretation may be more extensive and more representative of subsurface relationships, but is unlikely that there will be any significant change to this evaluation.

Table 4.1-2: Lake Simcoe watershed Model Layers (Earthfx, 2006).

Layer Order	Layer Identifier	Layer Correlation
1	Recent Deposits	Ground Surface
1	Recent Deposits	Aquifer
2	Halton Till (or equivalent)	Aquitard
3	Oak Ridges Aquifer (or equivalent)	Aquifer
4	Newmarket Till (or equivalent)	Aquitard
5	Thorncliffe Aquifer (or equivalent)	Aquifer
6	Sunnybrook Till (or equivalent)	Aquitard
7	Scarborough Aquifer (or equivalent)	Aquifer
8	Bedrock	Aquifer
8	Bedrock	Interpreted Top of Paleozoic Bedrock

Assessing Vulnerability

The vulnerability was assessed using the AVI method outlined above. The groundwater vulnerability was assessed and included consideration for the effects of man-made structures that may increase the vulnerability. The resulting vulnerability was considered as per the Technical Rules to determine the Highly Vulnerable Aquifers and to assign these a vulnerability score for the Lake Simcoe watershed portion of the SGBLS SPR.

The coverage by the CAMC/YPDT layers does not extend across the entire Lake Simcoe watershed. A portion north of Lake Simcoe is beyond the extent of the CAMC/YPDT layers provided for this study. In the area to the north of Lake Simcoe, the overburden thickness map that was prepared for the Black-Severn River watershed was used. The Black-Severn River watershed is located just north of the Lake Simcoe watershed and is discussed within Part 2 of this assessment report.

This area consists of thin to absent overburden over Paleozoic bedrock, and therefore, the thickness of the overburden cover can be used as a first step to assess vulnerability. This overburden thickness method is an adaptation of the AVI method, whereby a minimum overburden thickness is required to achieve a vulnerability rating of medium or low. For the conservative scenario where there is low permeability material with an assigned K-factor (defined below - Selection of K-Factors) of 5 overlying the aquifer, a minimum thickness of 6 m would be necessary to generate a vulnerability rating of a least medium (>30).

The overburden thickness map was generated from individual well records. The water well records were used to create a bedrock surface topography map that was subtracted from the ground surface layer to create an overburden thickness map. The overburden thickness data was then filtered to identify areas where the overburden thickness is less than 6 meters.

An area along the north and west shores of Lake Simcoe was also not covered by the CAMC/YPDT interpreted layers. Coverage in this area was available from the Nottawasaga Valley and Severn Sound SPAs interpreted hydrostratigraphic layers. These layers were used to fill in this area.

The CAMC/YPDT and Golder and Aqua Resource interpreted hydrostratigraphic models provided an area of overlap in the western portion of the Lake Simcoe Watershed. Section 4.2.2 of this report discusses the overlap and edge matching work completed in the Lake Simcoe Watershed.

More detail on the methodology is available in Technical Memorandum D1 (Genivar, 2010d)

The resulting groundwater vulnerability within the Lake Simcoe watershed is shown in Figure 4.1-1. This figure shows the areas identified as High, Medium and Low groundwater vulnerability.

Data Verification

Technical Memorandum A1 (Genivar, 2010d) outlines the methods employed to check and increase confidence in the work presented in this report. These methods included variations of parameters used in the AVI analysis, including the minimum aquifer thickness required for classification as a significant aquifer, changing the K-factors, utilizing model-generated hydraulic conductivities on model layers (after converting them to K-factors), and previously existing vulnerability mapping. Technical Memorandum A1 (Genivar, 2010d) includes figures showing the results of applying these parameter variations.

Minimum Aquifer Thickness

To avoid designating aquifers as highly vulnerable where they are not interpreted to be present, an aquifer thickness filter was applied to select only areas where the aquifers were considered to be present.

Minimum aquifer thicknesses of 1.0 m and 1.5 m were considered. Applying these thicknesses was intended to select aquifers that may be of sufficient thickness to function as a local water supply. Additional filtering for a minimum aquifer thickness of 1.5 m was considered to follow similar methodologies applied in neighbouring Source Protection Regions.

Very little variation was observed between the resulting maps so the minimum aquifer thickness of 1.5m was selected in consultation with technical staff of the SGBLS SPR in order to be reasonably consistent with methods used in neighbouring SPRs.

Selection of K-Factors

A K-factor (Table A1-2 in Technical Memorandum A1 (Genivar, 2010d)) is a number assigned to represent or simplify the hydraulic conductivity (k) of a material, which is the rate of movement of water through a porous medium such as a soil or aquifer. The lower the K-factor is, the higher the permeability of the material is. For example, gravel has a lower K-factor than clay.

The selection of K-factors of 1 for aquifers and 4 for aquitards is considered to be conservative but is also considered to be reasonable in view of other uncertainties and simplifications employed in the regional methodology. At the request of the technical staff of the SGBLS SPR, different K-factors were applied to determine whether the choice of 1 and 4 may be overly conservative. The K-factor of 1 applies to gravel or fractured bedrock while 4 applies to silt (Table A1-2 in Technical Memorandum A1 (Genivar, 2010d)). As the layers are interpreted hydrostratigraphic units, the geology is likely to be highly variable and heterogeneous. As a result, K-factors of 2 (sand) and 5 (till) were applied to the aquifers and aquitards respectively.

For the Nottawasaga Valley SPA and Severn Sound SPA, hydraulic conductivity values generated from the numerical groundwater flow model created by AquaResource and Golder (2010) were also available for each interpreted layer. These values were converted into K factors (the rough

correlation between hydraulic conductivity and K factor values is presented in Table 3.2 of the Draft Appendix 3 for Assessment Report Guidance Module 3—Groundwater Vulnerability Analysis (MOE, October 2006). These hydraulic conductivities tended to convert to K-factors of 3 for the aquifers and either 4 or 5 for the aquitards.

Very little variation was observed between the resulting maps. The more conservative K-factor selections of 1 and 4 were concluded to be suitable for delineating the groundwater vulnerability using the hydrostratigraphic layers with a minimum aquifer thickness of 1.5 m.

Saturated Aquifer Conditions

In review of the draft, preliminary groundwater vulnerability maps, the study team noticed that the layers identified as high groundwater vulnerable aquifer layers could be above the mapped water table. An additional filter was applied to only select saturated or partially saturated aquifer units by requiring that the water table was interpreted to be present above the bottom of the identified aquifer hydrostratigraphic layer (the water table can either be within or above the interpreted aquifer entirely). If the water table did not meet either of these requirements, the hydrostratigraphic unit was considered to be dry and was not considered as a Highly Vulnerable Aquifer.

This filter was not applied to the base layer in each interpreted hydrostratigraphic interpretation as these layers were assumed to be saturated bedrock layers.

Other Data Sources

Following the generation of the preliminary map of Highly Vulnerable Aquifer(s) which incorporated the above filters, the mapping was compared against the other data sources and mapping products within each Source Protection Area. These data sources include:

- 1) Intrinsic Susceptibility Index (ISI) mapping generated as part of the North and South Simcoe Groundwater Studies (Golder Associates Ltd., Ainley Group, and Waterloo Hydrogeologic Inc., 2004);
- 2) Intrinsic Susceptibility Index (ISI) mapping presented in “Groundwater Modelling of the Oak Ridges Moraine Area” (CAMC/YPDT, 2006); and/or
- 3) Ontario Geological Survey surficial sand and gravel deposit mapping.

Coverage from item 1) extends across parts of the Nottawasaga Valley SPA, Severn Sound SPA, and the Black-Severn River watershed. Item 2) provides coverage only in portions of the Lake Simcoe watershed. The OGS mapping is continuous across all four watersheds within the SGBLS SPR. The other data sources generally provided a good correlation with the vulnerability mapping produced as part of this study.

Consider Vulnerability Increase for Transport Pathways

The groundwater vulnerability as delineated in accordance with Technical Rules 37 or 38 (Part IV) take into account the best available understanding of the natural geological layers in relation to delineated aquifers. Technical Rules 39-41 (Part IV) provide an opportunity to consider situations where man-made or anthropogenic influences can increase the natural vulnerability by decreasing the time required for contaminants to move down to the water supply aquifer.

Examples of features that may provide a Transport Pathway that could result in an increased vulnerability to a water supply source include:

- 1) Existing wells or boreholes (all types);
- 2) Unused or abandoned wells;
- 3) Pits and quarries;
- 4) Mines;
- 5) Construction Activities (such as deep building basements/parking garages);
- 6) Storm water infiltration;
- 7) Septic Systems; and/or
- 8) Storm Sewer, Sanitary Sewer & Water Distribution System Infrastructure.

The methodology followed to determine where to consider a vulnerability increase due to Transport Pathways is described in more detail in Technical Memorandum A1(Genivar, 2010d). Many of these features are typically found in more urbanized environments and would not apply on a regional scale. Within the SGBLS SPR, the most likely activity or feature to be found that might influence the natural vulnerability is extraction from pits and/or quarries. The output of this analysis is a map illustrating the extent to where the vulnerability increase is to be considered.

Technical Memorandum A1 (Genivar, 2010d) outlines the process followed in determining and incorporating the Transport Pathway Increase for the Lake Simcoe watershed as per the Technical Rules. The Vulnerability Rating can be increased from Medium to High, Low to Medium, or from Low to High in accordance with the potential for artificial transport pathways to increase the observed vulnerability. Under the Technical Rules, Vulnerability Ratings cannot be increased beyond High.

The land uses that were considered in the vulnerability increase from Transport Pathways included active or formerly active pits or quarries. These land uses may strip protective cover

that overlies the aquifers in areas that may otherwise warrant vulnerability ratings of Medium or Low.

Figure 4.1-2 shows the areas proposed for a vulnerability increase due to the presence of Transport Pathways within the Lake Simcoe watershed.

Assign Vulnerability Ranking

A vulnerability score was determined for the SGBLS SPR in accordance with Technical Rule 38. According to this rule, an area with an AVI score of less than 30 is identified as having a High Vulnerability, while aquifers of a Low Vulnerability have an AVI score greater than 80. Aquifers with a Medium Vulnerability will have a score that falls between 30 and 80. Table 4.1-1 outlines the Vulnerability based on an AVI score.

The Groundwater Vulnerability map (Figure 4.1-1) expresses the relative degree to which a land use or activity could affect the local aquifers which may serve as drinking water supply aquifers elsewhere in the Source Protection Region. The Vulnerability Scores that pertain to the delineated Wellhead Protection Areas surrounding municipal supply wells as per Part VII.3 of the Technical Rules are presented within the municipal chapters.

4.1.2 Evaluate Uncertainty

As part of the Vulnerability Analysis an Uncertainty Rating is required, as outlined in Technical Rules 13 - 15 (Part I.4 - Uncertainty Analysis-Water Quality (MOE, November 2008a)).

13. An analysis of the uncertainty, characterized by “high” or “low” shall be made in respect of the following:

- (1) the assessment of the vulnerability of groundwater throughout the area undertaken in accordance with Part IV;
- (2) the delineation of highly vulnerable aquifers, significant groundwater recharge areas and wellhead protection areas undertaken in accordance with Part V;
- (3) the delineation of surface water intake protection zones undertaken in accordance with Part VI;
- (4) the assessment of the vulnerability of significant groundwater recharge areas, highly vulnerable aquifers and wellhead protection areas undertaken in accordance with Part VII.

14. The following factors shall be considered in an analysis conducted for the purpose of rule 13:

- (1) the distribution, variability, quality and relevance of data used in the preparation of the assessment report;

- (2) the ability of the methods and models used to accurately reflect the flow processes in the hydrological system;
- (3) the quality assurance and quality control procedures applied;
- (4) the extent and level of calibration and validation achieved for models used or calculations of general assessments completed;
- (5) for the purpose of subrule 13(1), the accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features; and
- (6) for the purpose of subrule 13(4), the accuracy to which the area vulnerability factor and the source vulnerability factor effectively assess the relative vulnerability of the hydrological features.

15. An uncertainty factor of “high” or “low” shall be assigned to each vulnerable area delineated based on the results of the analysis conducted under rule 13.

The Technical Rules only allow Uncertainty Ratings to be either “High” or “Low”. This Uncertainty Rating must take into account the quantity and quality of data available and the technical methods used to determine the Vulnerability Scores and the efforts taken to maintain a quality outcome.

In most cases, the Uncertainty Rating will be governed by the quantity, quality, and distribution of information available on which the understanding of the groundwater flow system is based. In other cases, the natural system itself may justify a High Uncertainty Rating. As data distribution is often highly variable, some areas may be more accurately reflected than others.

In the technical guidance provided by the MOE² prior to the Technical Rules as amended December 2009, the Uncertainty Rating was described as having a specific role in making decisions regarding the selection of management activities to address the identified threats to groundwater or surface water. Although this role is not clearly described in the Technical Rules, it is apparent that the High or Low Uncertainty Rating will play a similar role in the Source Protection Planning process.

The Technical Rules require that an Uncertainty Rating be assigned with each vulnerable area as outlined above. The uncertainty assessment considers the type, quantity and quality of available data, the methods used to determine the vulnerability assessment components, and the nature of the groundwater flow system.

² Now, known as the Ministry of the Environment, Conservation and Parks (MECP).

The Uncertainty Rating assigned for the Lake Simcoe watershed area is High. A High Uncertainty Rating does not necessarily reflect a low degree of confidence in the vulnerability assessment components, and the nature of the groundwater flow system.

The High Uncertainty Rating also reflects the potential variability in the vulnerability interpolated across a 100 m x 100 m gridded area. As the data is extrapolated to generate a surface, some averaging of individual data points occurs and while the variation may not show much variation on a regional scale, on a local scale, the results may not fully reflect local conditions which may influence the susceptibility of the aquifers to contamination from activities at surface. Collection of data in areas demonstrating low data availability may serve to lower the Uncertainty Rating.

4.2 Highly vulnerable aquifer mapping (HVAs)

An understanding of what it means when an area is designated as a Highly Vulnerable Aquifer or Significant Groundwater Recharge Area under the *Clean Water Act (2006)* is crucial for protecting the groundwater resources, found within the SGBLS SPR. *Ontario Regulation 287/07* defines a Highly Vulnerable Aquifer (HVA) as an aquifer on which external sources have or are likely to have a significant adverse effect, and includes the land above the aquifer.

In general, a Highly Vulnerable Aquifer will consist of source granular aquifer materials or fractured rock that have a high permeability and are exposed near the ground surface with a relatively shallow water table. The vulnerability of the aquifer will typically be lower where a greater thickness of fine-grained lower permeability soils is observed to cover the aquifer (Genivar, 2010d).

4.2.1 Vulnerability Scoring for HVAs

A vulnerability score was determined for the SGBLS SPR in accordance with Technical Rule 79. According to this rule, an area identified as a Highly Vulnerable Aquifer is assigned a “vulnerability score” of 6.

The map of Highly Vulnerable Aquifer Scores expresses the relative degree to which a land use or activity could affect the local aquifers which may serve as drinking water supply aquifers elsewhere in the region. The vulnerability scores that pertain to the delineated Wellhead Protection Areas surrounding municipal supply wells as per Part VII.3 of the Technical Rules are presented in other studies.

In areas where an HVA area overlaps a delineated wellhead protection area, the shallower aquifer will be delineated as an HVA.

Composite Highly Vulnerable Aquifer Map

Following the delineation of the Highly Vulnerable Aquifer within each of the four watersheds, these maps were combined to create a continuous and consistent Highly Vulnerable Aquifer map that provided coverage across the entire SGBLS SPR. The below section discusses edge matching challenges and decisions made in order to combine the four Highly Vulnerable Aquifer maps. All of the checks employed returned similar results, providing confidence that the product presented in this report is defensible and adequately representative of the study area, based on the data available at this time.

Following the data verification and edge matching discussed below, the Highly Vulnerable Aquifer map generated for each SPA (Figure 4.2-1) was combined to provide a composite Highly Vulnerable Aquifer map covering the entire SGBLS SPR. This map is presented in Figure 4.2-2.

Edge Matching

The individual watershed Highly Vulnerable Aquifer maps (discussed in their respective Assessment Reports) produced overlaps at their relative boundaries. As a result, each of these overlaps required examination and a decision as to how to address the overlaps. Each of the overlaps encountered are discussed below.

Nottawasaga Valley Source Protection Area to Lake Simcoe Watershed

The hydrostratigraphic models produced by Golder and AquaResource (Nottawasaga Valley SPA/Severn Sound SPA) and CAMC/YPDT (Lake Simcoe watershed) produce an overlap that extends across the Townships of Bradford-West Gwillimbury, Innisfil, and the City of Barrie. Both Highly Vulnerable Aquifer maps show slightly different results and relative proportions of High, Medium, and Low Vulnerability Ratings. The results from each model are shown side-by-side on Figure 4.2-3 for the overlap area. While both models incorporated high quality data and professional judgment, the SGBWLS model was chosen for this area. The SGBWLS model was commissioned as part of this study and was produced using recent data that was not available when the CAMC/YPDT model was originally prepared. This decision results in a consistent product within the municipalities in Simcoe County.

Severn Sound Source Protection Area to Black-Severn River Watershed

The hydrostratigraphic model produced by Golder and AquaResource for the Nottawasaga Valley and Severn Sound watersheds and the overburden thickness map combined with surficial sand and gravel deposits produce an overlap that extends across parts of the Townships of Severn, Oro-Medonte and Tay. Both resulting maps show similar results and relative proportions of High, Medium, and Low vulnerability ratings. The results from each model are shown side-by-side on Figure 4.2-4 for the overlap area. The overburden thickness map was used only within the boundaries of the Black-Severn River watershed and was extended beyond these boundaries to reduce edge kriging errors when generating the original layer. The model covering the Severn Sound watershed was commissioned as part of this study

and was produced using more current high quality data than was available in the water well database available for the Black-Severn River watershed and was chosen for coverage across the extent of the Severn Sound watershed.

4.3 Significant groundwater Recharge areas

An area where rain or snow seeps into the ground and flows to an aquifer is called a recharge area. Recharge areas tend to be areas that are characterized by permeable soils, such as sand or gravel which allow the water to seep easily into the ground. A recharge area is considered significant when it helps maintain the water level in an aquifer that supplies a community with drinking water, or supplies groundwater recharge to a cold water ecosystem that is dependent on this recharge to maintain its ecological function (MOE, 2007).

The Technical Rules indicate that Significant Groundwater Recharge Areas (SGRAs) need to be delineated for each Source Protection Area within the Source Protection Region. Recall that due to the large size of the Lake Simcoe and Couchiching-Black River Source Protection Area, it was subsequently divided into two watersheds to create more manageable sized study areas. The Significant Groundwater Recharge Areas were delineated using the recharge results from the water budget described in Chapter 3 within this document. The Lake Simcoe recharge estimates were completed by the PRMS-surface water model developed for the Tier Two studies within the Lake Simcoe Watershed (Earthfx, 2010c). The aforementioned report is the guiding document for this section of the Assessment Report, and can be referred to for more detail.

The SGRAs within the Lake Simcoe watershed have been delineated in accordance to Technical Rules 44-46, 80-81 (MOE, 2008a).

4.3.1 Delineating Significant Groundwater Recharge Areas

The delineation of the Significant Groundwater Recharge Areas within the Lake Simcoe watershed were completed using the recharge results from the PRMS surface water model (Precipitation-Runoff Modelling System, U.S. Geological Survey—See Chapter 3: Water Budget and Stress Assessment, Appendix WB-4C for more details). The model considers variations in surficial soil, land cover and climate, when estimating average annual recharge.

The Technical Rules for delineating Significant Groundwater Recharge Areas are as follows:

44. Subject to rule 45, an area is a Significant Groundwater Recharge Area if,
- (1) the area annually recharges water to the underlying aquifer at a rate that is greater than the rate of recharge across the whole of the related groundwater recharge area by a factor of 1.15 or more; or
 - (2) the area annually recharges a volume of water to the underlying aquifer that is 55% or more of the volume determined by subtracting the annual evapotranspiration for the

whole of the related groundwater recharge area from the annual precipitation for the whole of the related groundwater recharge area.

45. Despite rule 44, an area shall not be delineated as a Significant Groundwater Recharge Area unless the area has a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system.

46. The areas described in Rule 44 shall be delineated using the models developed for the purposes of Part III of these rules and with consideration of the topography, surficial geology, and how land cover affects groundwater and surface water.

The SGRA threshold for the Lake Simcoe watershed has been delineated in accordance with Technical Rule 44(1) with consideration for Technical Rules 45 and 46. The “related groundwater recharge area” identified in Technical Rule 44(1) was taken as the entire study area covered by the calibrated PRMS model. The average annual recharge for the Lake Simcoe watershed is 164 mm/year; therefore, all recharge areas exceeding 189 mm/year were deemed significant (Figure 4.3-1).

Table 4.3-1 shows the Significant Groundwater Recharge Area threshold calculated for this assessment. The threshold is calculated based on the spatially averaged annual recharge rate for the Lake Simcoe watershed, multiplied by 115%. Figure 4.3-1 illustrates all areas in the Lake Simcoe watershed where the estimated average annual groundwater recharge rates are greater than the threshold rate (189 mm/yr). As shown in this figure, SGRAs are identified predominantly within the sand and gravel regions of the watersheds.

Table 4.3-1: Significant Groundwater Recharge Area Threshold (Earthfx, 2010c).

Related Groundwater Recharge Area	Average Annual Recharge Rate (mm/yr)	Threshold Recharge Rate (115%) (mm/yr)
Lake Simcoe Watershed	164	189

According to Technical Rule 45, the areas identified as Significant Groundwater Recharge Areas must be hydrologically connected to a surface water body or to an aquifer that is a source of drinking water. All recharge occurring within the Lake Simcoe watershed is considered to be hydrologically connected to drinking water supplies (as per Technical Rule 45) based on ~~two~~ the following assumptions:

- ~~1. Since there is no evidence for, or indication of, a deep/lower bedrock aquifer, all water is assumed to eventually discharge as streamflow that drains into Lake Simcoe, which has a number of municipal and private drinking water systems.~~
- ~~2. All wells (private and municipal) take water from shallow and deeper aquifer units within the study area. To show that all delineated SGRAs are hydrologically connected to~~

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groundwater sources used for drinking water purposes (Technical Rule 45), public, domestic and municipal well locations are shown on Figure 4.3-3. Due to the high density of water wells within the Study Area, it is assumed that all identified SGRAs are hydraulically connected to a water supply. As well, groundwater will discharge to streams as baseflow, which will eventually discharge to a water body that is used as a source of drinking water, such as Lake Simcoe.

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As described in the PRMS modelling report (Earthfx, 2010c), the unit response functions are delineated across the watershed with a very high level of precision as a reflection of detailed geological and land cover mapping. Consequently, the map of estimated groundwater recharge is very detailed, showing relatively small parcels of land that are above the SGRA threshold. The high level of precision in the output may not reflect the certainty of the modelling results or certainty in the initial surficial geology and land cover mapping, as much of the mapping is not field verified. As well, for the purposes of the Clean Water Act, it will likely be difficult to develop workable policy for these small parcels. As such, after estimating SGRAs a modification of the SGRA map that removes all isolated polygons with an area less than or equal to 0.1 km² (10 ha) based on the scale of the features reflected in the mapping was done. The modification focuses the delineated SGRAs to larger geologic and physiographic features that are considered more representative of mapped surficial geology features. This modification is considered more practical and workable for planning purposes.

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4.3.2 Vulnerability Scoring for SGRAs

Once each SGRA is delineated, vulnerability scores are determined by overlaying the Groundwater Vulnerability Scoring (Section 4.1 & Figure 4.1-1) with the SGRAs (Section 4.3 & Figure 4.3-1), as required in the Technical Rules 80 and 81 (MOE, Nov. 2009). The SGRAs with the vulnerability scores are shown in Figure 4.3-2. Areas with no colour are not significant groundwater recharge areas.

Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas are scored differently for vulnerability. The HVAs show only the high classification of the vulnerability analysis (with a score of 6), but SGRAs show all vulnerability classifications (see Table 4.3-2).

Table 4.3-2: Vulnerability Scores Translated into Vulnerability Categories for SGRAs.

Vulnerability Score	Category
6	High
4	Medium
2	Low

4.3.3.2 Evaluate Uncertainty

As per Technical Rule 13(2) (Nov. 2009), an analysis of the uncertainty with respect to the delineation of significant groundwater recharge areas was performed in accordance with the “factors” of Technical Rule 36. This analysis is shown in

[Table 4.3-2](#)~~Table 4.3-3~~.

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Table 4.3-23: Uncertainty analysis of the PRMS model based on Technical Rule 36 (Earthfx, 2010).

Factor	Uncertainty	Reasoning
(1) The distribution, variability, quality and relevance of the available input data.	High	As mentioned in the Tier 1 Water Budget report, the primary limitation of the model directly relates to the distribution of calibration gauges. Much of the modelled area thus had to be assumed homogenous. The validity of this assumption is quite uncertain.
(2) The ability of the methods and models used to accurately reflect the hydrologic system.	Low	PRMS is a long-standing, well-practiced surface water runoff model. The model has been calibrated to a network of measured streamflow data using an independent network of meteorological data and solar radiation data. Considering the model's performance against such measured data, this model does accurately reflect the (assumed homogenous) hydrologic system.
(3) The quality assurance and quality control procedures applied.	Low	All measured data used in this model have gone through QA & QC procedures both at their source (i.e., Environment Canada and the Water Survey of Canada) and by Earthfx upon receipt. It is implicitly assumed that the errors in these data are the inherent errors associated with measurement that cannot possibly be entirely rectified.
(4) The extent and level of calibration and validation achieved for any groundwater and surface models used or calculations and general assessments completed.	Low	This model was relentlessly calibrated/validated until it both performed well against measured data and, in the end, reasonably represented the hydrological system based on the professional judgment of the modellers, clients, and peer reviewers.

Figure 4.3-3 illustrates the bimodal distribution of recharge that occurs in the study area. The aggregate distribution demonstrates how the spatial distribution of Significant Groundwater Recharge Areas is insensitive to the choice of Significant Groundwater Recharge Area threshold. For example, a threshold ranging between 110 and 310 mm/year would result in very little change in SGRA mapping. This bimodal distribution also emphasizes distinct physiographical regions that characterize the Lake Simcoe Basin and their inherent effect on hydrological processes; therefore, this basin and its accounting of water must be viewed as heterogeneous (Earthfx, 2010).

4.4 Drinking Water Threats Evaluation

Part II of the Technical Rules (16(9) to 16(11)), requires maps showing the percentage of Managed Lands, Livestock Density, and percentage of Impervious Surfaces for all Vulnerable Areas in the SGBLS SPR. In this section we discuss these maps for the ~~two~~-regional scale ~~Vulnerable Areas – HVAs and SGRAs~~ Highly Vulnerable Aquifers (HVAs). Similar maps have been prepared for the WHPAs and IPZs, and these can be found within the municipal vulnerability and threats chapters (Chapter 6-13). Here we present a short summary of how the maps were prepared, with full details presented in Technical Memorandum A5 (Appendix MO) and Genivar 2010d.

4.4.1 Managed Lands

Managed Land means land to which agricultural source material, commercial fertilizer, or non-agricultural source material is applied (Part 1.1 Technical Rules; Definitions).

The Managed Lands are used in the identification of Threat activities associated with the application of agricultural source material, non-agricultural source material and commercial fertilizer.

The following land uses were included in the Managed Land areas and were identified from the MPAC property codes:

- 1) Residential (assumed that 50% of the property area would be Managed Land);
- 2) Golf Courses;
- 3) Parks/Recreational Facilities/Sporting Fields;
- 4) Institutional lands;
- 5) Agricultural Managed Lands (see below).

Managed Land Areas were estimated using the total area of properties that intersect individual vulnerable areas as provided in “Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source Material and Commercial Fertilizers” (MOE, ~~September-December~~ 2009).

Figure 4.4-1 ~~and Figure 4.4-2~~ illustrates the proportion of Managed Lands within the HVAs ~~and SGRAs, respectively~~. For the majority of the Watershed, the percent Managed Lands is estimated to be within the 40-80% range, the exceptions being the Barrie Creeks and Hawkestone Creeks subwatersheds which are estimated to be at <40%.

4.4.2 Livestock Density

The Livestock Density was determined for the HVA ~~and SGRA~~ based on the methodology described in Technical Memorandum A5 (Appendix MO). However, the methods were revised

slightly for the regional vulnerable areas in that the Livestock Density estimates were based on Census 2006 data for each subwatershed, rather than interpretation of aerial photographs. The following steps were taken to calculate Livestock Density in the regional vulnerable areas:

- 1) Calculate the number of different types of livestock using Canada Census Data (2006) for the subwatershed that the vulnerable areas are located within.
- 2) Determine the nutrient units for the numbers of livestock located within the subwatershed using the conversion factors provided within Table 2 of the Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source Material, Non-Agricultural Source Material and Commercial Fertilizers (MOE, September 2009).
- 3) Determine the number of acres of agricultural managed lands within the subwatershed (i.e. the area nutrients could potentially be applied to).
- 4) Calculate the Livestock Density for the subwatershed by dividing the nutrient units by the number of acres of land where application of nutrients may be occurring.

The Livestock Density within each subwatershed was then assigned to the mapped HVAs ~~and SGRAs~~. The Livestock Density is used in the identification of Threat activities associated with the storage of agricultural source material and the grazing and/or confinement of livestock.

As this method differs to that recommended in the MOE/~~MECP~~ Technical Bulletin, Directors Approval was requested in accordance with Technical Rule 15.1. At the time this report was in preparation, Directors permission had not yet been received. This approach was used for Regional Scale Vulnerable areas as it: (1) significantly reduces the time and resources needed for completion, especially considering the potential number of farms that would require aerial interpretation if the recommended approach was used; and (2) there are a number of inherent uncertainties and assumptions that the aerial interpretation method requires, that would not occur using the census data. For example, the assumption used to determine what buildings are housing animals and what type of farm animal are being housed. Overall, this departure is considered equivalent or better to that within the Technical Rules as it relies on data provided by Census Canada, but in all other steps follows the general methods outlined in the MOE/~~MECP~~ Technical Bulletin.

Figure 4.4-3 ~~2~~ and Figure 4.4-4 illustrates the Livestock Density within the delineated ~~SGRA and HVA, respectively~~. The Livestock Density of the watershed ranges from 0 to <0.5 nutrient units/acre.

4.4.3 Impervious Surfaces

The Impervious Surface was determined for the HVAs ~~and SGRAs~~ using the methodology described in Technical Memorandum A5 (Appendix MO). The proportion of Impervious

Surfaces reflects the relative density of roads and streets within the wellhead protection area or intake protection zone within 1 km grid squares relative to the centre of the SGBLS SPR.

For the majority of the study area the proportion of Impervious Surfaces is low and does not trigger any policies. There is more impervious surface cover in some more urban areas and these are the area where policies may apply. The proportion of Impervious Surfaces varies between < 1% and 1–8% through much of the rural areas covered by the SGRAs. The density of Impervious Surfaces within settlement areas were typically between 8 and 80%. The Impervious Surfaces are used in the identification of Threat activities associated with the application of winter de-icing agents (salt).

The percentages of the Impervious Surfaces were determined for the HVAs and SGRAs are shown in Figure 4.4-5-3 and Figure 4.4-6, respectively.

4.4.4 Identifying Areas of Significant/Moderate/Low Threats - Activities

The areas where Activities are or would be Drinking Water Threats within the SGRA for the Lake Simcoe Watershed are based on the assigned distribution of Vulnerability Scores within the SGRA.

Review of the Table of Drinking Water Threats indicates that Activities involving pathogen parameters would not be designated as a Drinking Water Threat within a SGRA.

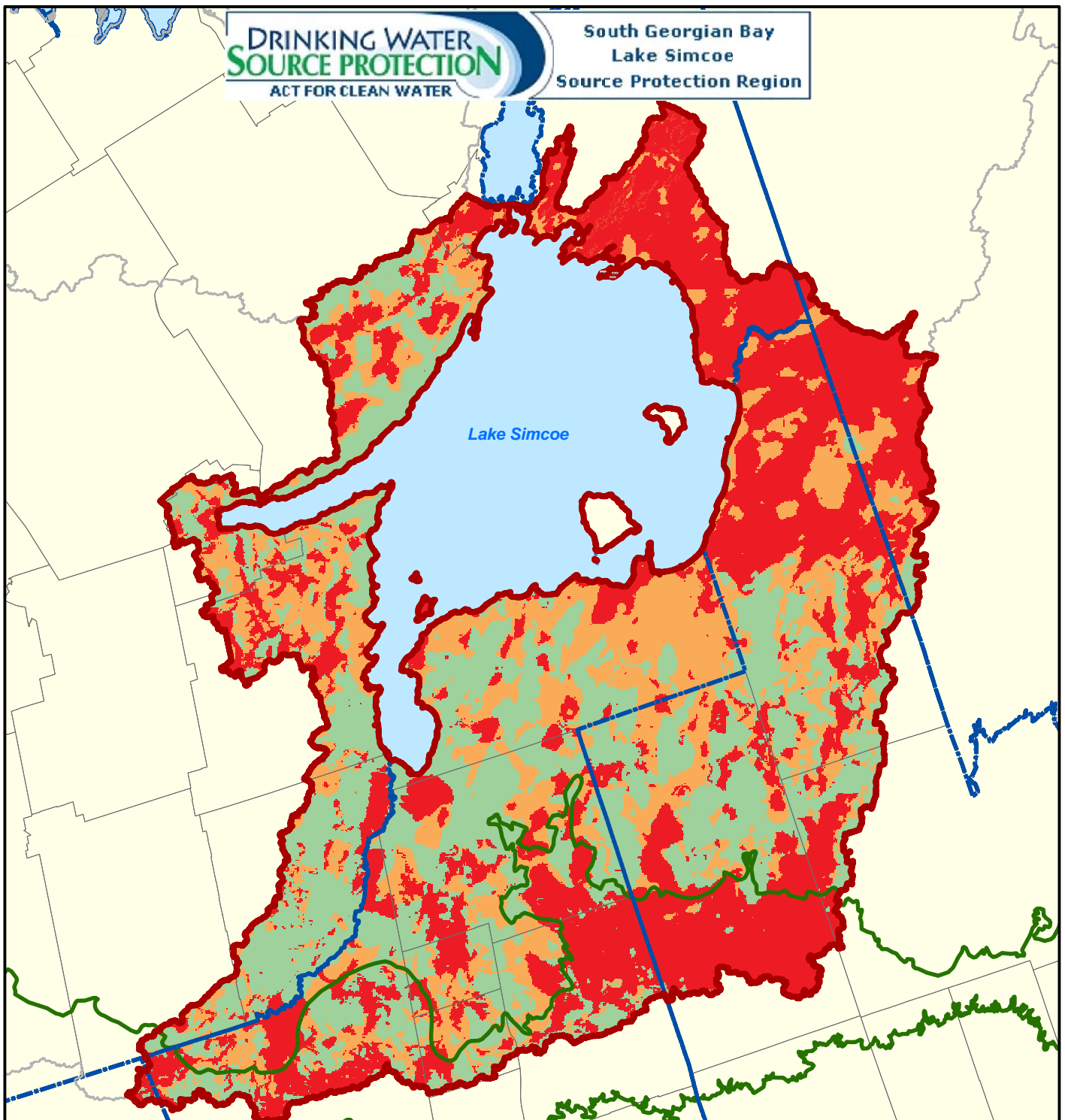
The key table on Figure 4.4-7-4 and Figure 4.4-8 can be used in conjunction with the Vulnerability Scores Technical Rules to identify areas where Activities associated with chemical Threats are or would be Moderate or Low Drinking Water Threats to the drinking water sources within the identified HVAs, and SGRAs. Activities can be a Threat where the Vulnerability Score within the SGRA is 6. Activities cannot be a Significant Drinking Water Threat within the HVA.

4.4.5 Identifying Areas of Significant/Moderate/Low Threats - Conditions

The areas where Condition are or would be Drinking Water Threats within the SGRA for the Lake Simcoe Watershed are based on the assigned distribution of Vulnerability Scores within the SGRA.

A Condition or potential Condition that has not been identified could potentially be a Significant, Moderate, or Low Threat to Drinking Water based on the combination of Hazard Rating and Vulnerability Rating as described in Section 5.5.5 (Chapter 5: Methods Overview) and Technical Memorandum A5 (Appendix MO). The Hazard Rating is dependent on whether there is evidence the Condition is causing off-site contamination, and whether there is evidence the Condition is causing off-site contamination. As the SGRAs and HVA have a maximum Vulnerability Score of 6, only areas with a Moderate Threat can occur. There are no areas with Low or High potential Threats for Conditions.

Figure 4.2-1 and Figure 4.3-2 illustrates the Vulnerability Score map HVAs and SGRAs respectively. These maps can be used to determine where a Condition is or would be a Moderate Threat to Drinking Water.



Legend

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability
- Oak Ridges Moraine Boundary
- Lake Simcoe Watershed



6 3 0 6 Kilometres

Note: Groundwater Vulnerability presented in this figure does not include a Vulnerability Increase for Transport Pathways.

**LAKE SIMCOE WATERSHED
GROUNDWATER VULNERABILITY**

DELINEATION OF HIGHLY
VULNERABLE AQUIFERS (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:460,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F3-10

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



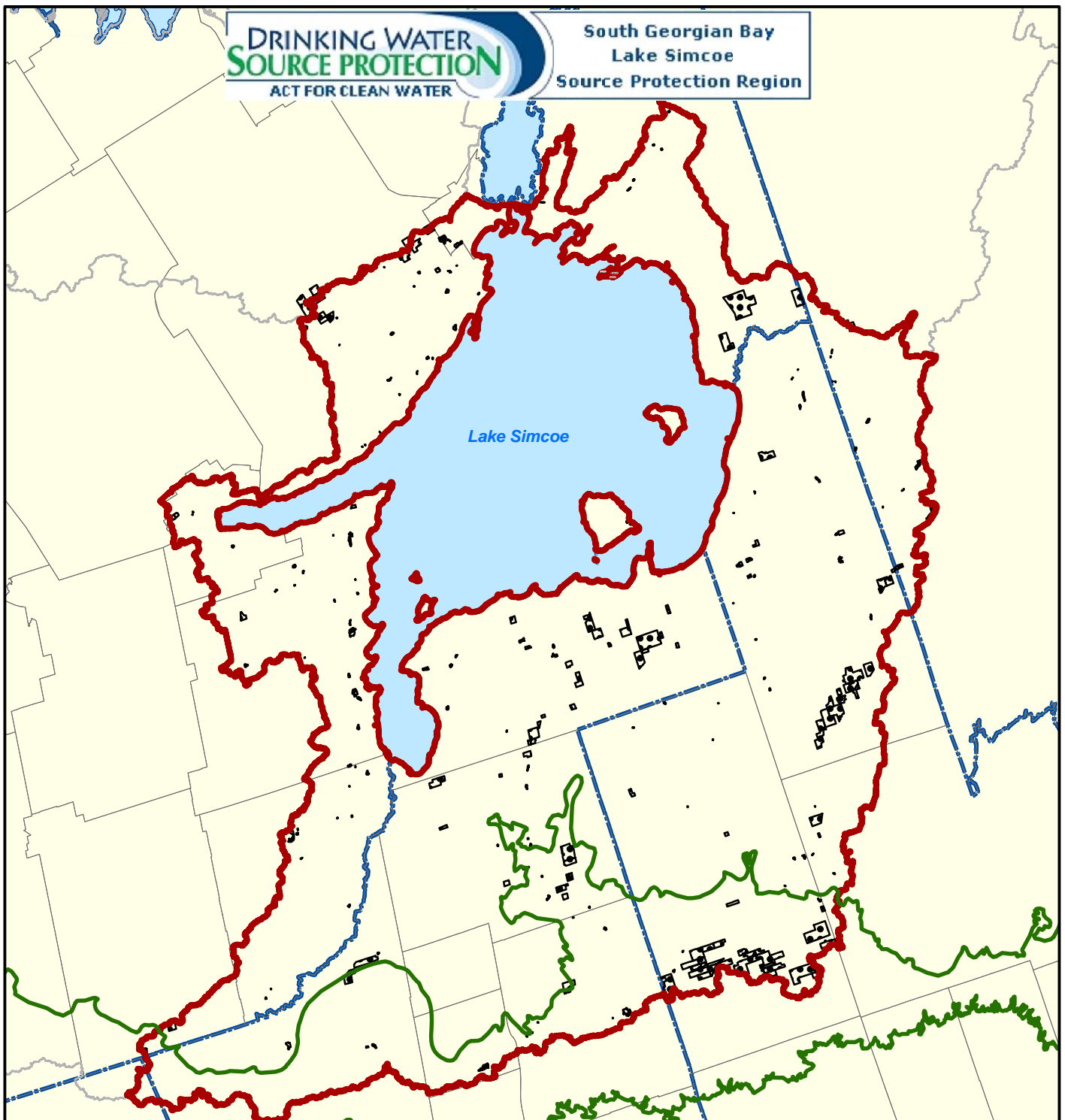
GENIVAR






Ontario

FIGURE

4.1-1



Legend

-  Proposed Transport Pathways
-  Oak Ridges Moraine Boundary
-  Lake Simcoe Watershed



6 3 0 6 Kilometres

**LAKE SIMCOE WATERSHED PROPOSED
AREAS FOR VULNERABILITY INCREASE
FROM TRANSPORT PATHWAYS**

DELINEATION OF HIGHLY
VULNERABLE AQUIFERS (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:460,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F3-11

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



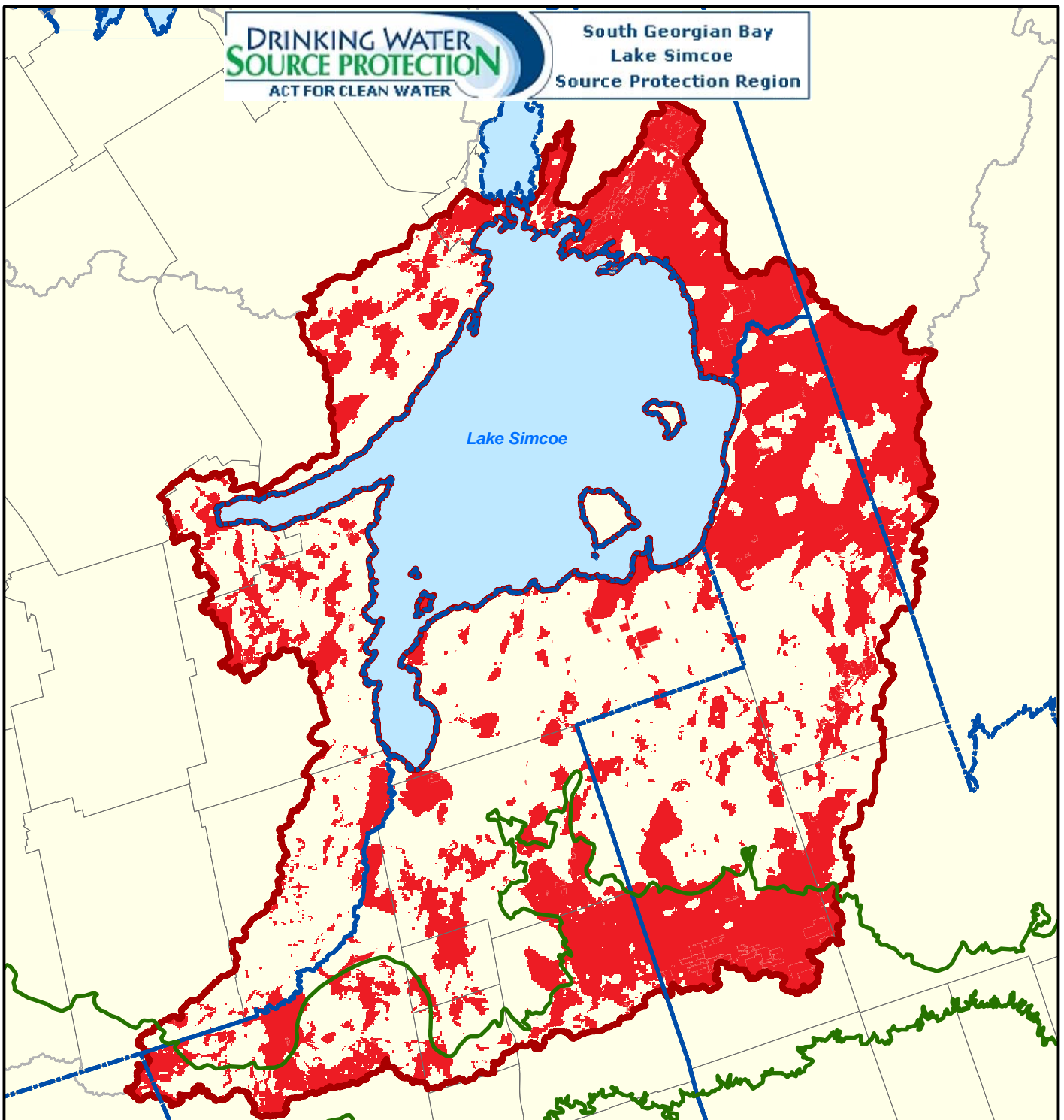
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Ontario

FIGURE

4.1-2



Legend

- High Vulnerability (Vulnerability Score = 6)
- Oak Ridges Moraine Boundary
- Lake Simcoe Watershed



3 1.5 0 3 Kilometres

Note: Highly Vulnerable Aquifers consider a Vulnerability Increase for Transport Pathways.

**LAKE SIMCOE WATERSHED
HIGHLY VULNERABLE AQUIFER**

DELINEATION OF HIGHLY
VULNERABLE AQUIFERS (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:460,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F3-12

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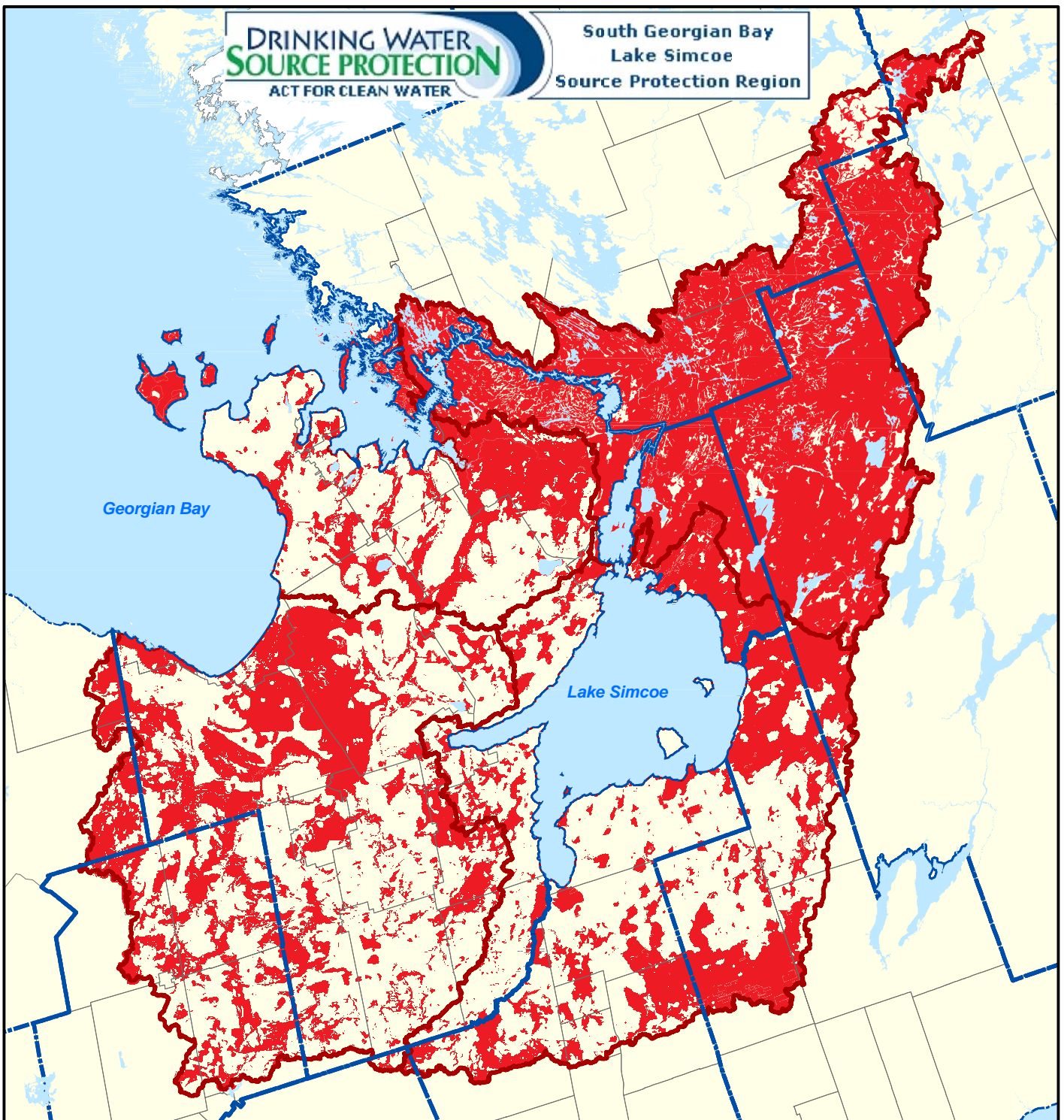
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Ontario

FIGURE

4.2-1



Legend

 High Vulnerability (Vulnerability Score = 6)



10 5 0 10 Kilometres

**SOUTH GEORGIAN BAY LAKE SIMCOE
SPR HIGHLY VULNERABLE AQUIFER**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:810,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4-3

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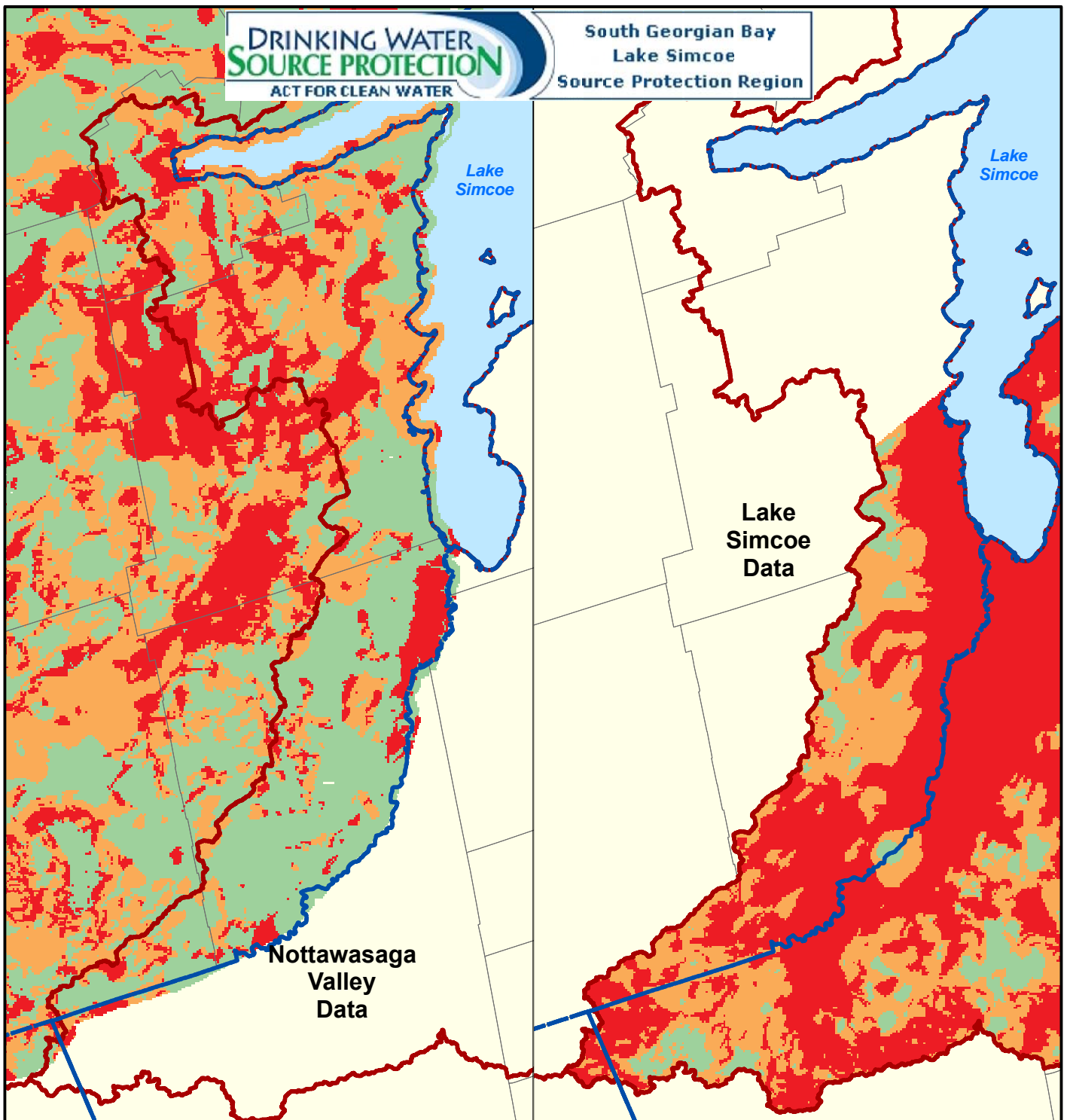
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Ontario

FIGURE

4.2-2



Legend

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability



2 1 0 2 Kilometres

EDGE MATCHING BETWEEN NOTTAWASAGA VALLEY SPA AND LAKE SIMCOE WATERSHED

DELINEATION OF HIGHLY VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:290,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4-1

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



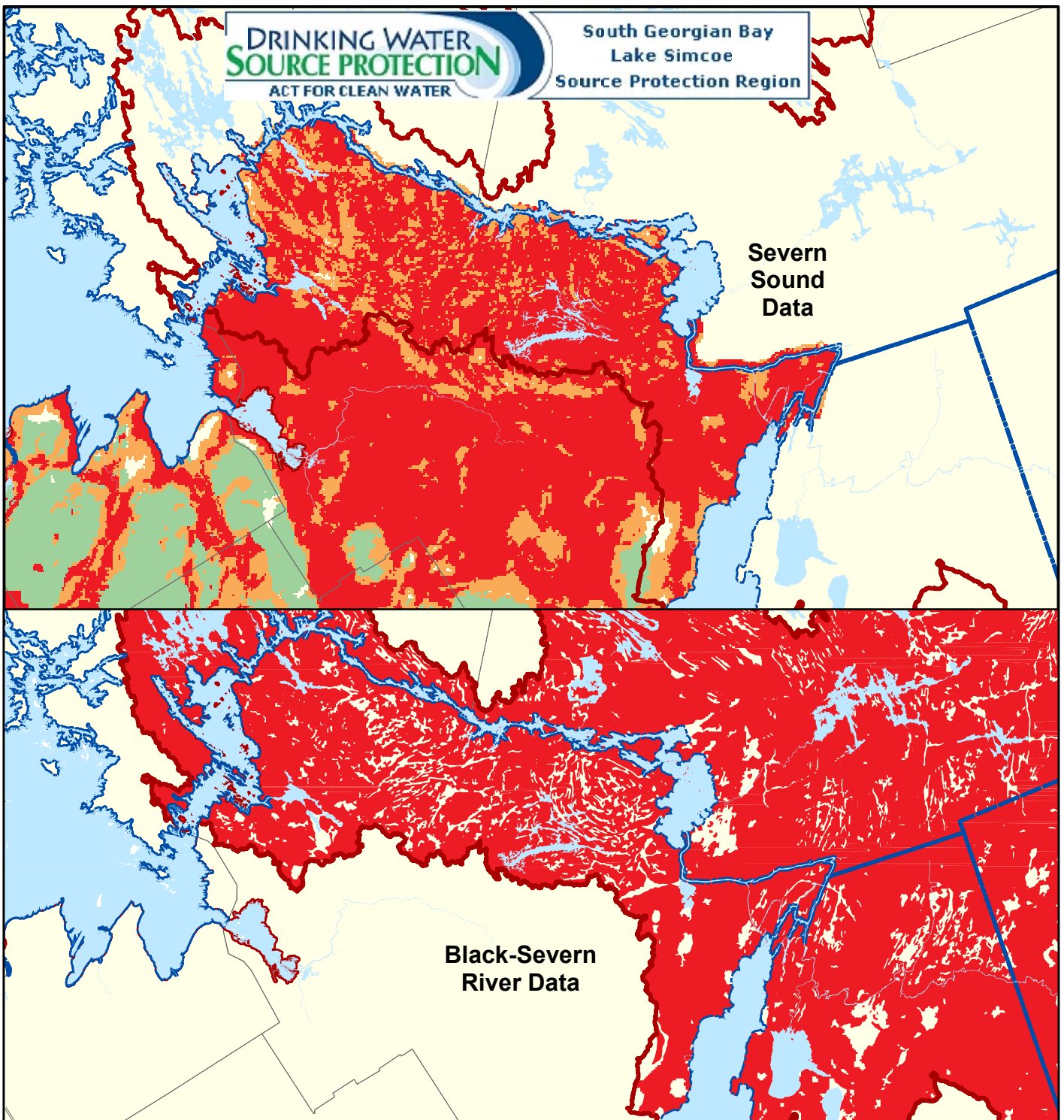
GENIVAR



Ontario

FIGURE

4.2-3



Legend

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability



3 1.5 0 3 Kilometres

**EDGE MATCHING BETWEEN SEVERN SOUND
SPA AND BLACK-SEVERN RIVER WATERSHED**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:300,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4-2

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



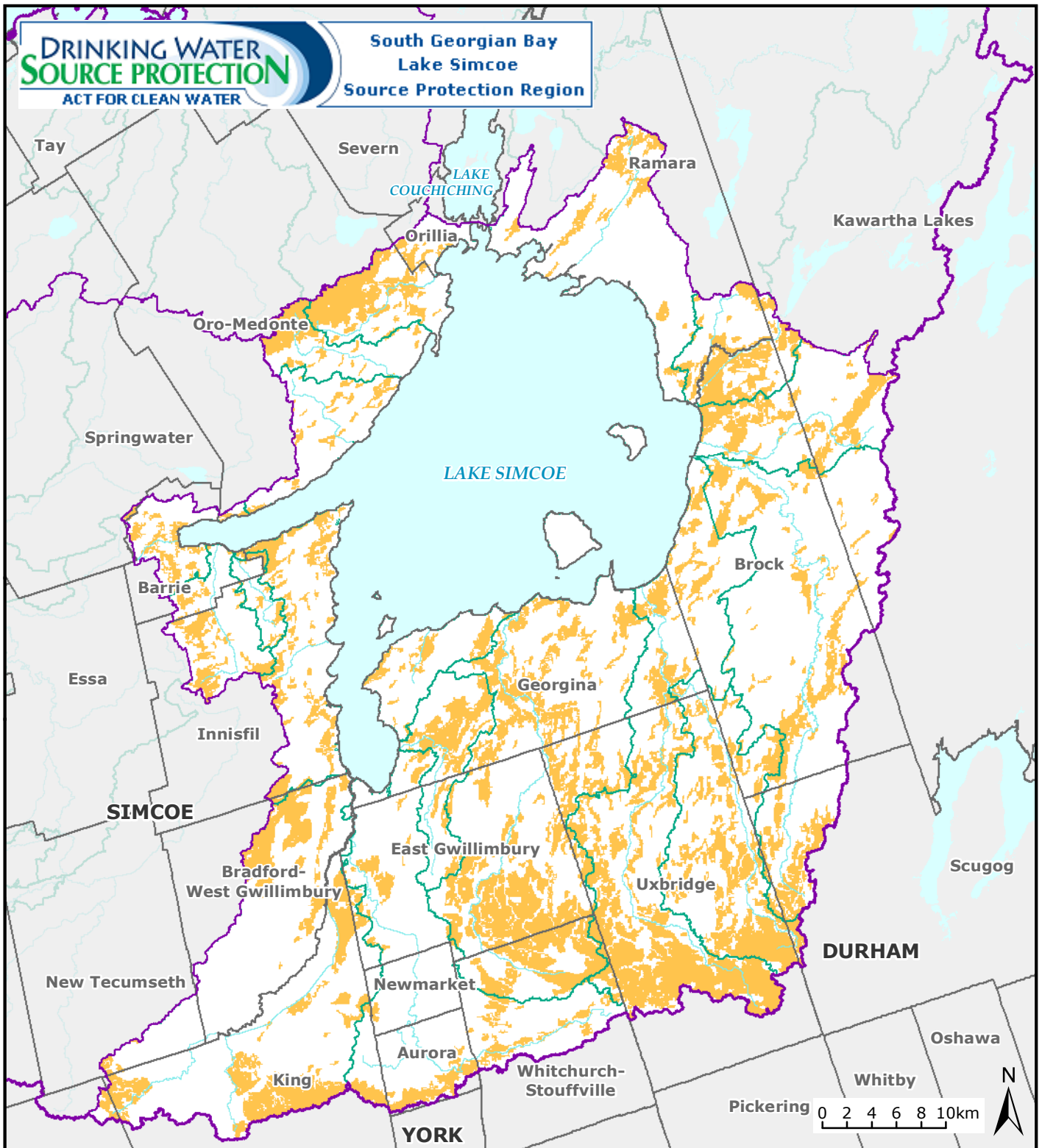
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Ontario

FIGURE

4.2-4



- Significant Groundwater Recharge Areas
- SWP Watershed Area
- Subwatershed Boundary
- Municipal Boundary
- Water Body
- Main Water Courses

Significant Groundwater Recharge Areas (SGRA)

Created by: LSRCA
Date: 2010-08-25

Scale: 1:450,000
UTM Zone 17N, NAD83

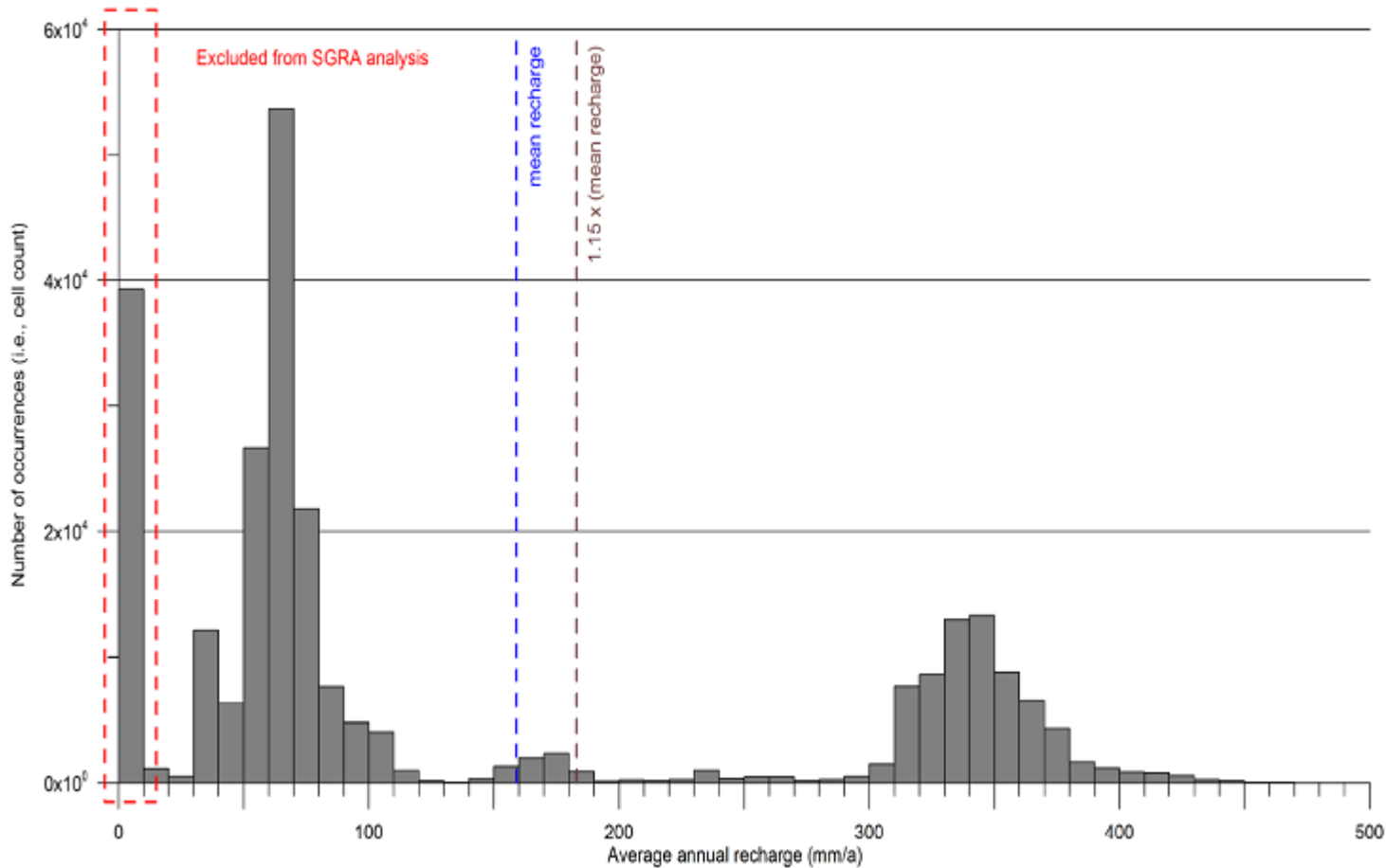


This map was produced by the Lake Simcoe Region Conservation Authority, lead agency of the South Georgian Bay Lake Simcoe Region Source Protection Region. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



Figure 4.3-1

**Distribution of Recharge
Within the Lake Simcoe
Basin**

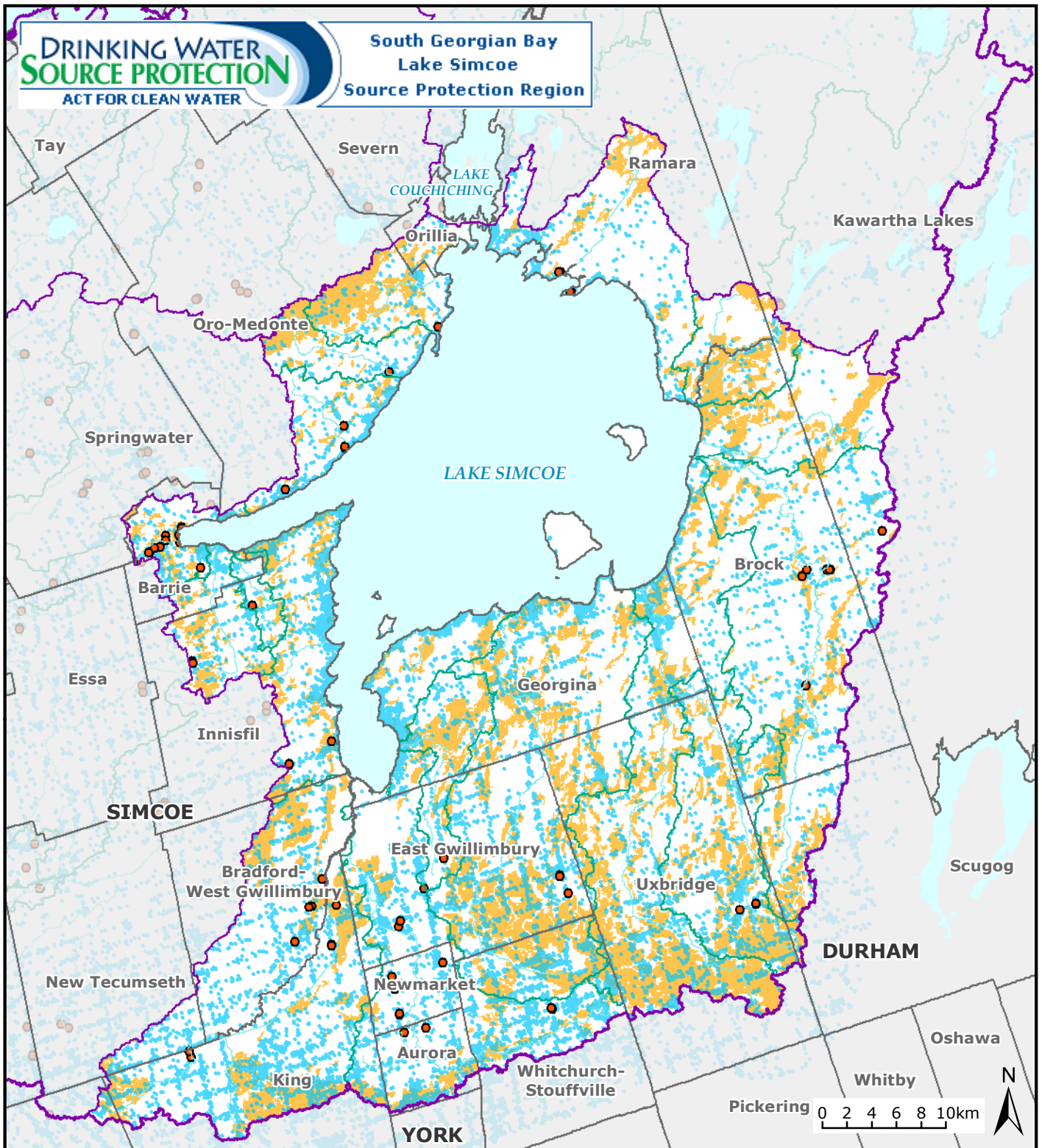


Created by: LSRCA
Date: 2010-07-22



Figure 4.3-2

This map was originally created for the Nottawasaga Valley Conservation Authority Water Budget Model - Geological/Hydrostratigraphic Model Development June 2009, for the purposes of completing the South Georgian Bay Lake Simcoe Assessment reports. While every effort has been made to accurately depict the base data, errors may exist.



- Municipal Supply Wells
- Other Wells
- Significant Groundwater Recharge Areas
- SWP Watershed Area
- Subwatershed Boundary
- Municipal Boundary
- Water Body
- Main Water Courses

**Significant Groundwater
Recharge Areas With Water Wells**

Created by: LSRCA
Date: 2010-08-25

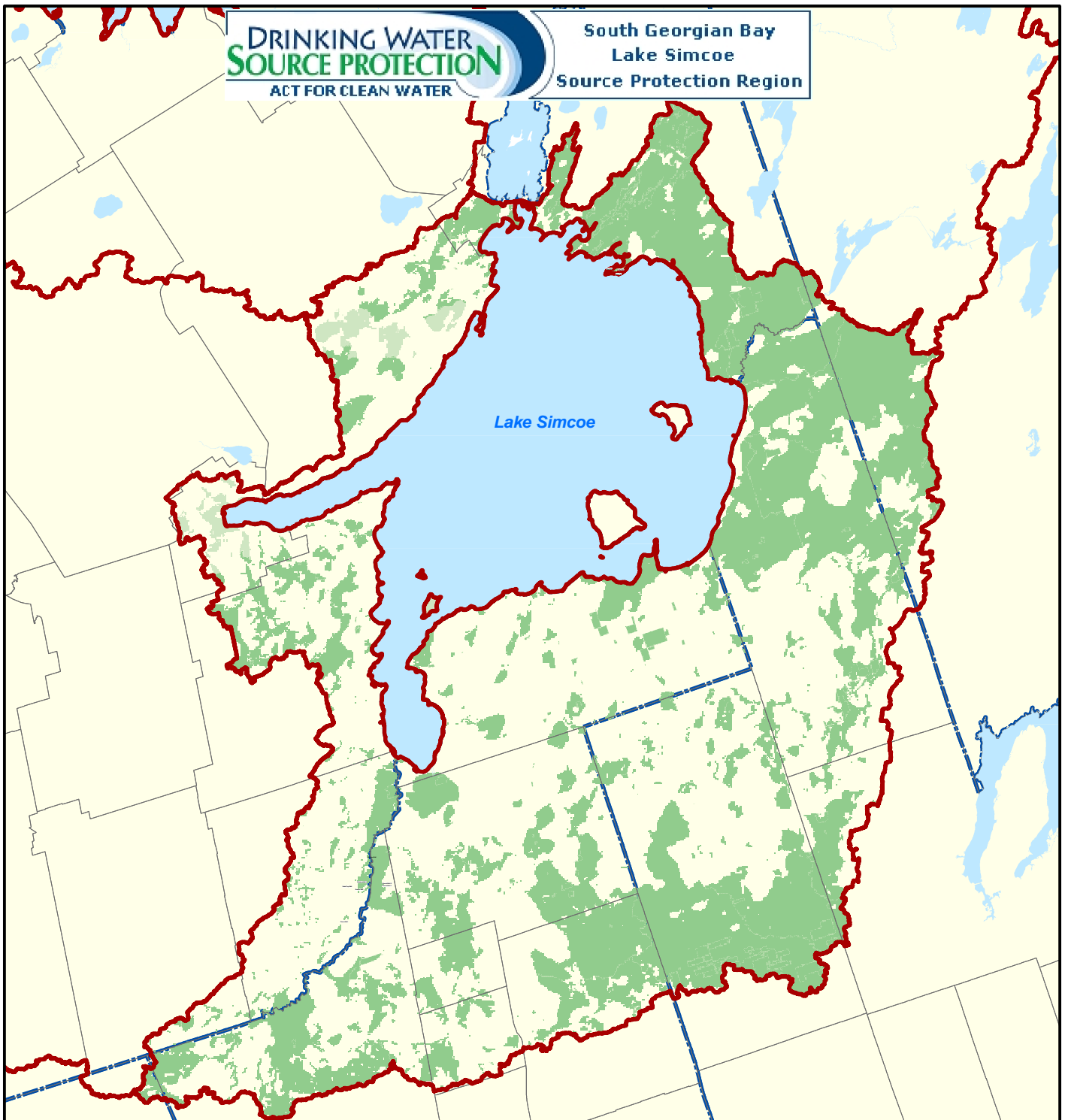
Scale: 1:450,000
UTM Zone 17N, NAD83



This map was produced by the Lake Simcoe Region Conservation Authority, lead agency of the South Georgian Bay Lake Simcoe Region Source Protection Region. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



Figure 4.3-3



Legend

- MANAGED LANDS (<40%)
- MANAGED LANDS (40-80%)
- MANAGED LANDS (>80%)



6 3 0 6 Kilometres

**HVA AND MANAGED LANDS -
LAKE SIMCOE WATERSHED**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:460,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4.4-1

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

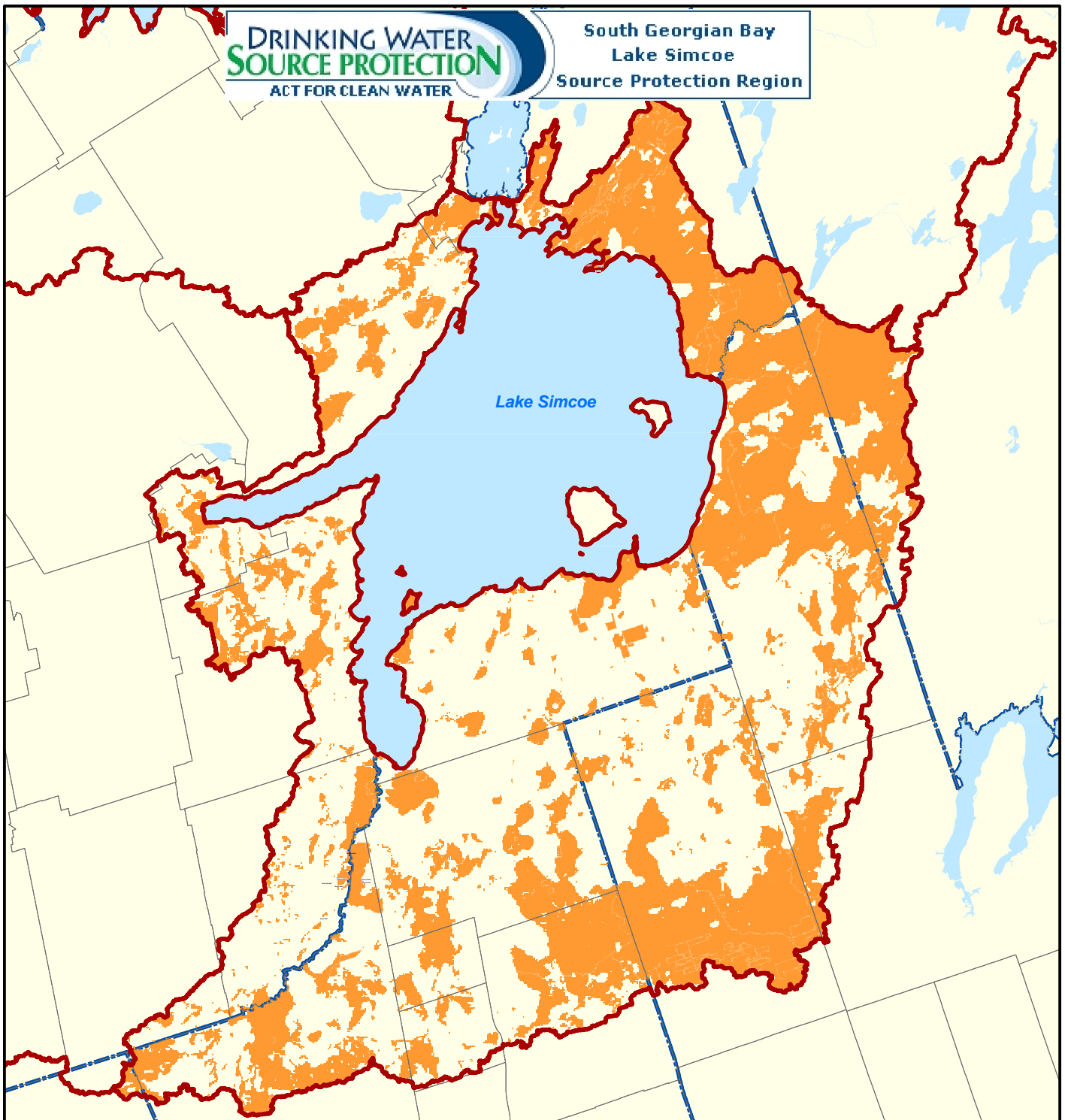


GENIVAR






Ontario

FIGURE
4.4-1



Legend

-  LIVESTOCK DENSITY (<0.5 NUTRIENT UNITS/ACRE)
-  LIVESTOCK DENSITY (0.5-1.0 NUTRIENT UNITS/ACRE)
-  LIVESTOCK DENSITY (>1.0 NUTRIENT UNITS/ACRE)



6 3 0 6 Kilometres

**HVA AND LIVESTOCK DENSITY -
LAKE SIMCOE WATERSHED**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:460,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4.4-3

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.

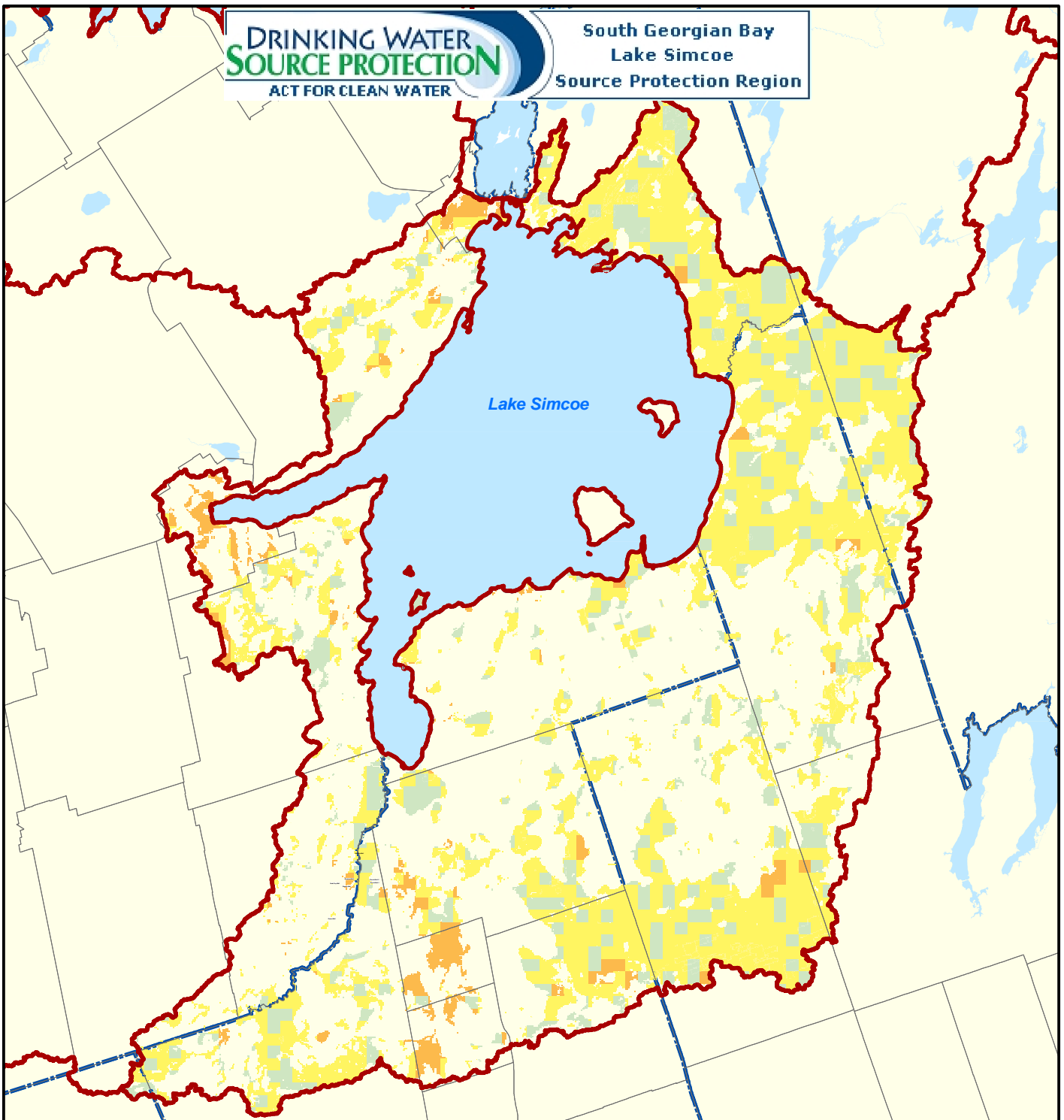


GENIVAR



Ontario

FIGURE
4.4-2



Legend

IMPERVIOUS SURFACE

- <1%
- >1% and <8%
- >8% and <80%



6 3 0 6 Kilometres

**HVA AND IMPERVIOUS SURFACES -
LAKE SIMCOE WATERSHED**

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:460,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4.4-5

This map was produced for the South Georgian Bay Lake Simcoe Source Protection Region for the purposes of completing the South Georgian Bay Lake Simcoe Assessment Report. Base data have been compiled from various sources, under data sharing agreements. While every effort has been made to accurately depict the base data, errors may exist.



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FIGURE


4.4-3

Georgian Bay

Lake Simcoe

CHEMICALS

Legend

 High Vulnerability (Vulnerability Score = 6)



6 3 0 6 Kilometres

This figure is to be used to identify the areas where a landuse activity is or would be a drinking water threat based on the Technical Rules. The key table is intended to correlate the vulnerability score with circumstances that are significant, moderate, or low threats in the Table of Drinking Water Threats. The table shows the number of circumstances and references the table designation in the Provincial Tables of Circumstances for each threat category.

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HVA AND CHEMICAL THREATS - LAKE SIMCOE WATERSHED

DELINEATION OF HIGHLY
VULNERABLE AQUIFER (HVA) -
South Georgian Bay Lake Simcoe
Source Protection Region

DATE: JULY 2010

SCALE: 1:500,000

PROJECT: 0-071948.14

FILE. NO.:0-071948.14F4.4-7



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FIGURE

4.4-4