DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Mississippi Valley Conservation

RIDEAU VALLEY CONSERVATION AUTHORITY

Significant Groundwater Recharge Areas in the Mississippi-Rideau Source Protection Region

Draft Groundwater Study Findings – June 2009

The Clean Water Act

This study was done under Ontario's *Clean Water Act* which requires municipalities and the local community to work together to protect local drinking water sources from becoming contaminated or depleted. The *Act* is primarily focused on minimizing risks to municipal drinking water sources (lakes, rivers and underground aquifers that supply "village water" to residents). Where drinking water sources face significant threats, mandatory action could be required. The key steps under this Act are:

2007 – Source Protection Committee Created

The Mississippi-Rideau Source Protection Committee is made up of 16 people representing a wide variety of local interests and sectors. This Committee is overseeing the development of science-based Source Protection Plans for the Mississippi River and Rideau River watersheds.

2009 – Complete Scientific Studies

Technical studies are mapping local sources of drinking water, determining if they are vulnerable to contamination or overuse, and identifying potential threats. This science will show us where source protection policies are needed, and what threats they need to address.

2012 – Develop Policies to Protect Source Water

Source Protection Plans will contain a combination of voluntary and mandatory land use policies to protect drinking water sources. Under the *Act,* policies must moderate significant threats and prevent others from becoming significant.

What is Groundwater Recharge?

Groundwater recharge is the process by which water moves from the ground surface to the water table, or aquifer.

An aquifer is an underground layer of sand, gravel, or rock that contains enough water to supply a well. Generally speaking, groundwater recharge applies to the shallow aquifer, or 1st aquifer under the surface.

The following primary aquifers have been identified in the Mississippi-Rideau Source Protection Region:

- An Upper Precambrian bedrock aquifer is located in the western portion of the region;
- Nepean sandstone bedrock aquifer is located in the central portion of the region; and
- Sand and gravel aquifers are located along the eastern and northern portions of the region.

What is a Significant Groundwater Recharge Area?

A significant groundwater recharge area, or SGRA, is an area where a significant amount of water recharges from the ground surface to an aquifer. There are several established methods for determining these areas.

Significant Groundwater Recharge Area Study

Step 1 – Delineate Significant Groundwater Recharge Areas

Building on data from the regional water budget study, experts gather relevant information and use established, scientific methods to delineate significant groundwater recharge areas.

Step 2 – Assign Vulnerability

Next, experts assign a vulnerability score to the significant groundwater recharge areas. The scoring process is set out in the Assessment Report Technical Rules issued under the *Clean Water Act*.

Step 3 – Identify Threats and Issues

The province created a list of land uses and activities that could pose a low or moderate threat in significant groundwater recharge areas.

The Experts

For the Mississippi-Rideau Source Protection Region, Step 1 was completed by water resource engineers, hydrogeologists and GIS/database specialists at Intera Engineering, Ltd. (Intera). This work was completed in 2009 as part of the Mississippi-Rideau Source Protection Region Tier I Water Budget Study, and was peer reviewed by an independent third party. Step 2 was completed by Conservation Authority staff at the Mississippi-Rideau Source Protection Region. Step 3 is currently underway, and is also being completed by Mississippi-Rideau

Source Protection Region staff. This work conforms to the Assessment Report Technical Rules (dated December 12, 2008) issued under the *Clean Water Act*. The Technical Rules can be found at http://www.ene.gov.on.ca/en/water/cleanwater/cwa-technicalstudies.php

Step 1 – Delineate Significant Groundwater Recharge Areas

Significant groundwater recharge areas in the Mississippi-Rideau Source Protection Region were delineated by Intera as part of the Tier I Water Budget Study. This study is still in progress.

The Ontario Ministry of the Environment has identified 2 approaches that can be used in to delineate SGRAs. Once the preliminary SGRAs have been identified according to one of the approaches, they are refined according to local conditions and professional judgment before being finalized.

'Method 1' identifies SGRAs as areas where annual groundwater recharge is 1.15 times greater than average annual groundwater recharge.

'Method 2' identifies SGRAs as areas where annual groundwater recharge is greater that 55% of the average regional water surplus.

Intera determined that 'Method 2' is the more suitable of the two MOE methods for the Mississippi-Rideau Region.

In addition to meeting criteria as set out in Method 2, an SGRA must also recharge a water supply (private or municipal well), or be directly connected to a surface water body that is used as a water supply (municipal intake).

The methodology used to delineate SGRAs for the Mississippi-Rideau region is described below.

Methodology

I. Determine Annual Water Surplus

Annual water surplus is an estimate of how much water is available for runoff and recharge to underlying aquifers. It is based on precipitation (rain or snow) and evapotranspiration values. Evapotranspiration is the water lost from the ground surface to the air by evaporation and transpiration (water used by plants). Evapotranspiration and precipitation are outputs from the water budget study.

Using these datasets, experts calculated water surplus, where:

Water Surplus = (Precipitation – Evapotranspiration)

II. Determine Groundwater Recharge

Groundwater recharge is an estimate of how much water travels from the ground surface to become groundwater. This calculation uses the water surplus and considers soil type, surface slope and vegetation cover to calculate the annual groundwater recharge. Calculations were performed on 25 m × 25 m area (or cell) to reflect the variability of groundwater recharge in the region.

Groundwater recharge was determined as part of the water budget study.

III. Identify Preliminary Significant Groundwater Recharge Areas

At this stage, experts follow the methodology for Method 2, as prescribed by the MOE, to identify areas that may be SGRAs. Method 2 compares water surplus values to groundwater infiltration values on a cell-by-cell basis. A cell where groundwater infiltration is greater than **55%** of the average regional water surplus could be a significant groundwater recharge area. The average water surplus value for the Missisippi-Rideau region was calculated (as part of the water budget) as **346 mm/yr**. So, any cell where infiltration is greater than **190 mm/yr** (346 x 0.55 = 190) is identified by Method 2 as a preliminary significant groundwater recharge area.

IV. Refine Preliminary Significant Groundwater Recharge Areas

The next step is to refine the preliminary SGRA areas that were identified by the MOE Method 2 according to local conditions and professional judgement. For the Mississippi-Rideau region, experts considered size, sand and gravel deposits, and the locations of the Nepean formation and eskers. These are explained below.

Size:

The initial output from the Method 2 approach shows a 'paint splatter' effect, because all cells that meet the criteria are selected.

The first refinement was to filter out single cells from consideration - any cell not adjacent to another SGRA cell was excluded.

The second set of refinements is based on the total size of adjacent significant groundwater recharge areas. Intera tested 5 different threshold values: areas > 1, 10, 25, 50, and 100 hectares.

Sand and Gravel deposits:

Experts compared surface deposits of sand and gravel (as mapped in regional geology data) against the areas identified as preliminary SGRAs. Since sand and gravel deposits on the surface can transmit surface water quickly to the groundwater, they are generally accepted to be important recharge areas.

The comparison revealed that the preliminary SGRAs > 25 ha correlate with the location of the sand and gravel deposits. As a result, Intera used area > 25 ha as a basis for further refinements.

Eskers:

Eskers in the region are composed of sand and gravel. Eskers have been identified as important groundwater features. Some of the esker areas have steep slopes and were not identified by Method 2 as a significant groundwater recharge area. Given the importance of eskers in the region, experts identified all above ground eskers as mapped by the Ontario Geologic Survey as significant groundwater recharge areas.

Nepean Formation:

In the Mississippi-Rideau region, the Nepean formation sandstone aquifer is the primary aquifer for municipal water supply. In several locations in the Mississippi-Rideau (and specifically along the edge of the Canadian shield), the Nepean formation comes to the ground surface (called 'outcropping'). Since these outcrop areas provide a direct pathway to the aquifer, experts have identified them as significant groundwater recharge areas.

V. Determine Connectivity to Groundwater or Surface Water Supplies

The geology in the region is complicated by numerous soil types, discontinuous bedrock units, and large bedrock faults. Because of the numerous private bedrock wells and abundance of lakes and wetlands in the region, all of the screened SGRAs were assumed to be connected to a groundwater or surface water supply.

VI. Delineate Significant Groundwater Recharge Areas

Significant groundwater recharge areas for the Mississippi-Rideau source protection region are the combination of:

- significant groundwater recharge areas (delineated using the MOE 'Method 2', and screened for areas > 25 hectares)
- areas identified as eskers
- areas where the Nepean formation is at ground surface

Results

Preliminary Significant Groundwater Recharge Areas

Map 1 shows preliminary SGRAs, as identified by the MOE Method 2 approach, for the Mississippi-Rideau Source Protection Region.

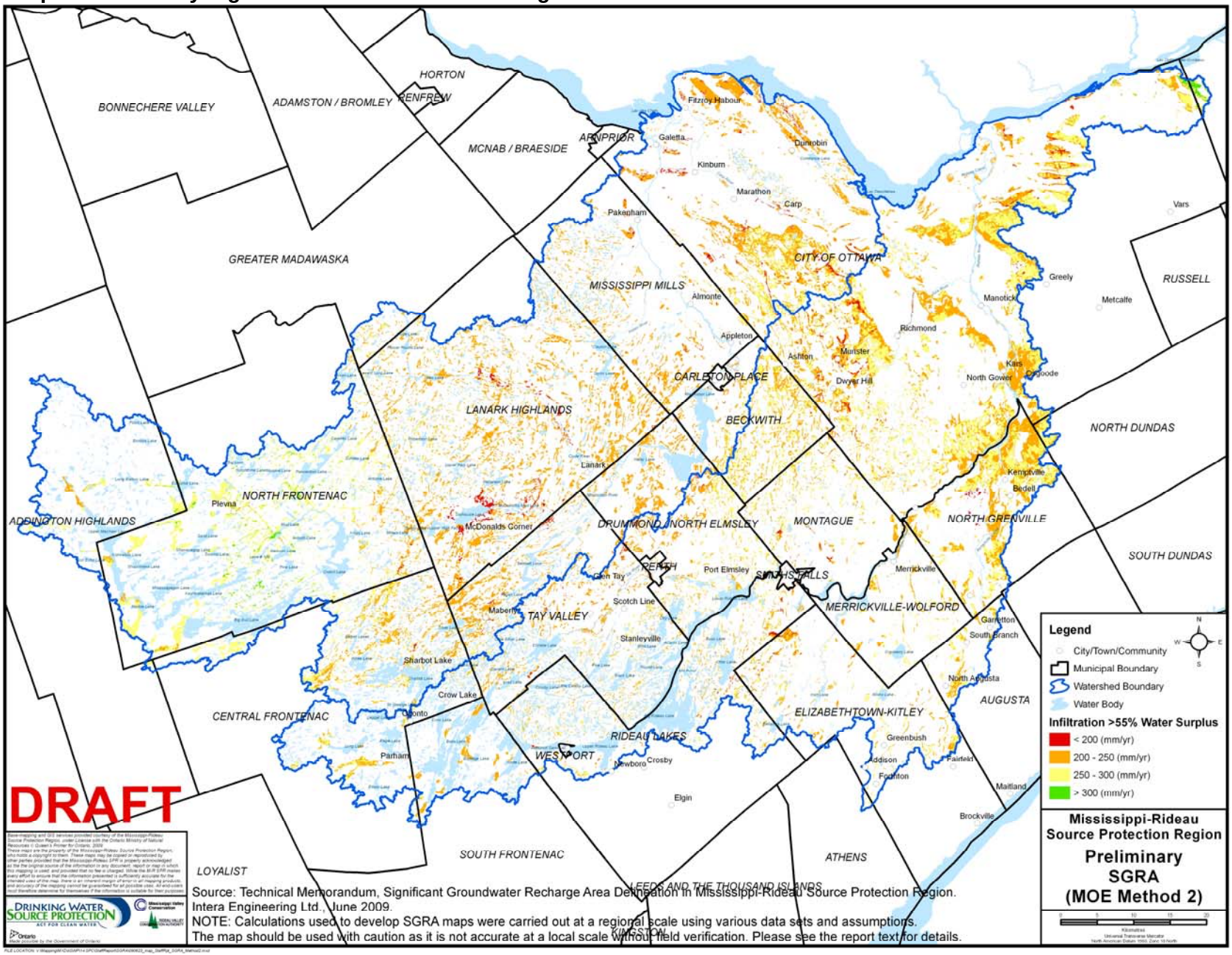
Preliminary Significant Groundwater Recharge Areas > 25 Hectares

Map 2 shows preliminary SGRAs, as identified by the MOE Method 2, screened for areas > 25 hectares.

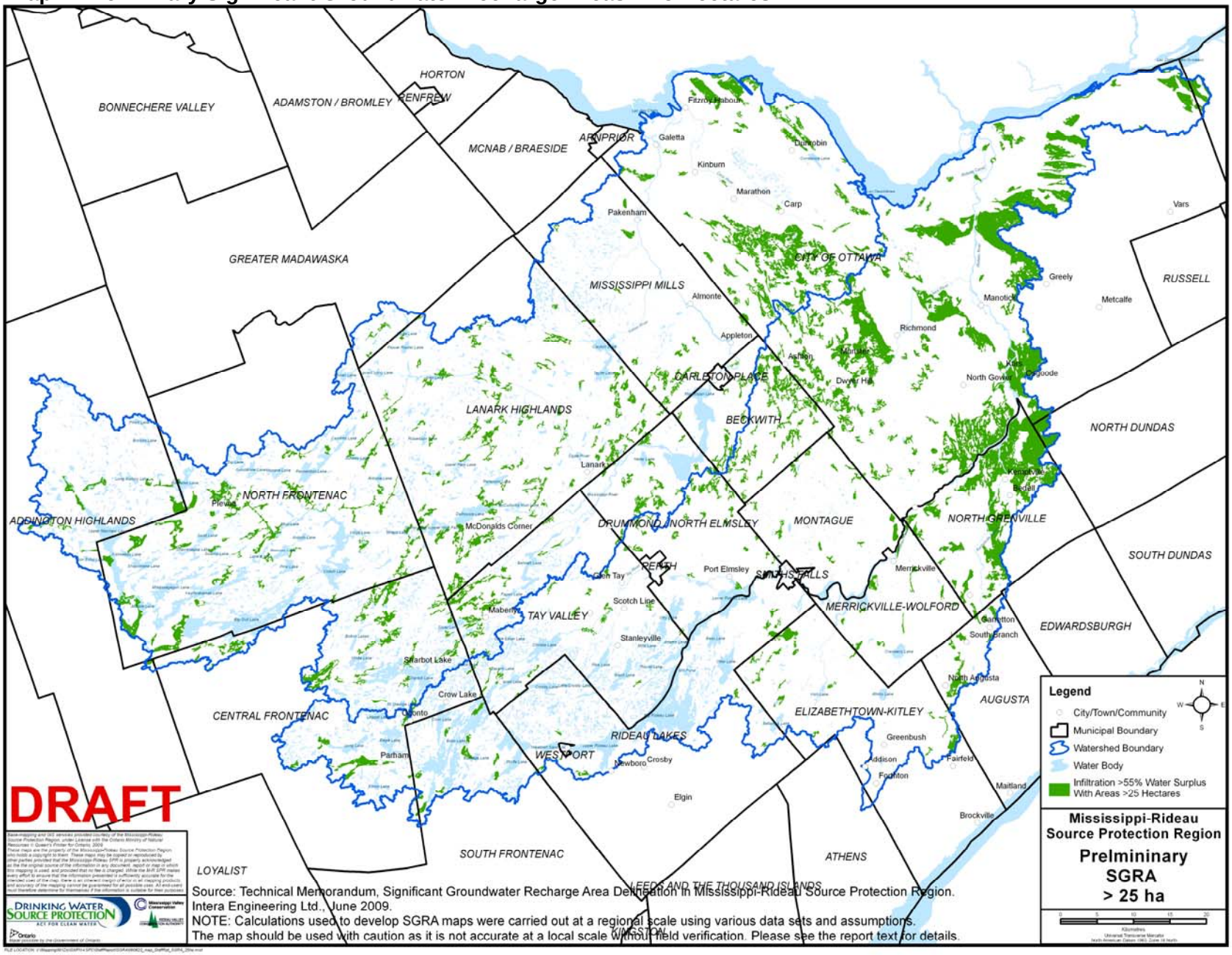
Significant Groundwater Recharge Areas

Map 3 shows the final significant groundwater recharge areas for the Mississippi-Rideau Source Protection Region. SGRAs are the combination of preliminary SGRAs > 25 hectares, esker deposits and Nepean formation outcrops.

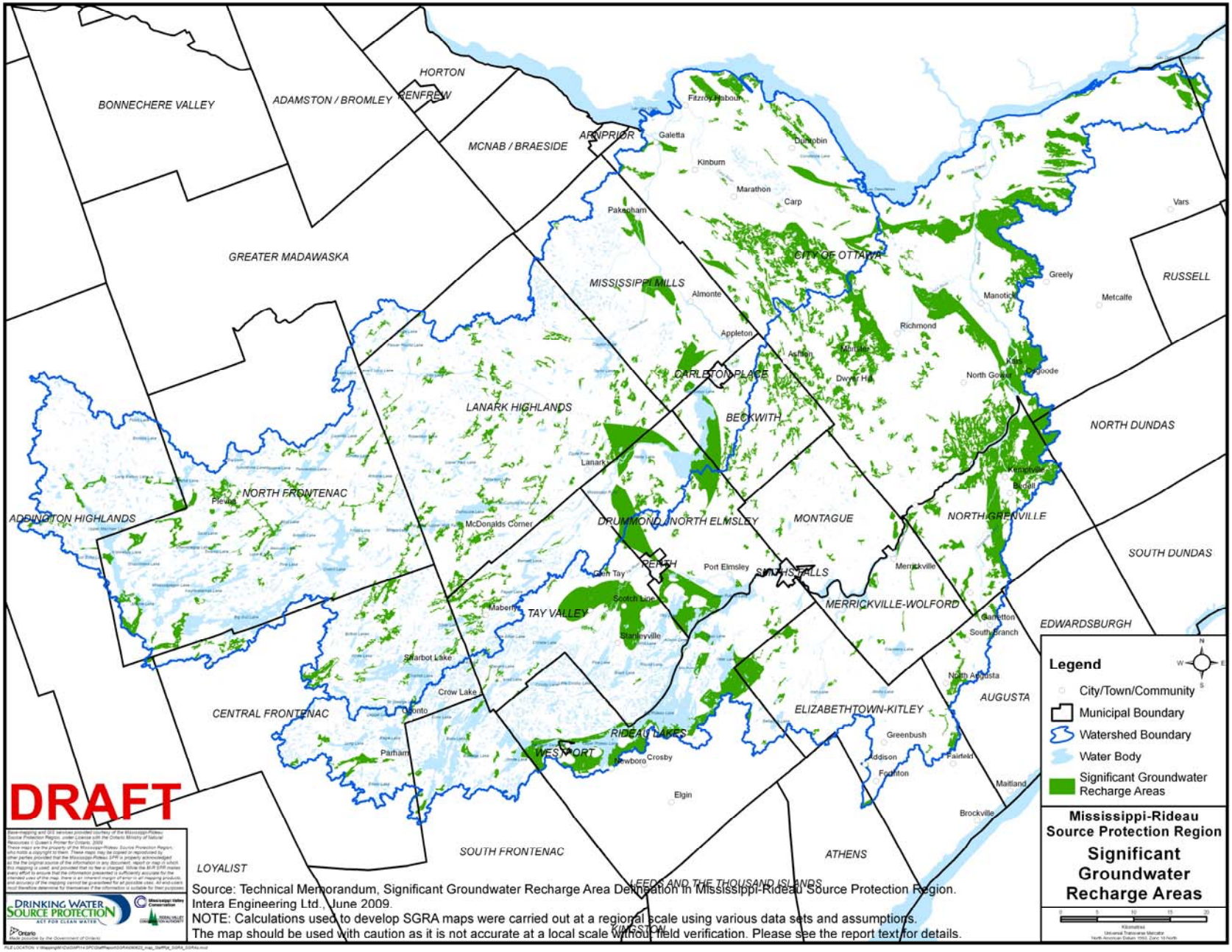
Map 1. Preliminary Significant Groundwater Recharge Areas – MOE Method 2



Map 2. Preliminary Significant Groundwater Recharge Areas > 25 Hectares



Map 3. Final Significant Groundwater Recharge Areas



Step 2 – Assess Vulnerability

The next step is to determine a vulnerability score for the significant groundwater recharge areas in accordance with the technical rules. For SGRAs, the scoring process depends on the vulnerability of the aquifer. Aquifer vulnerability for the Mississippi-Rideau Source Protection Region was completed as part of the Renfrew-Mississippi-Rideau Regional Groundwater Study.

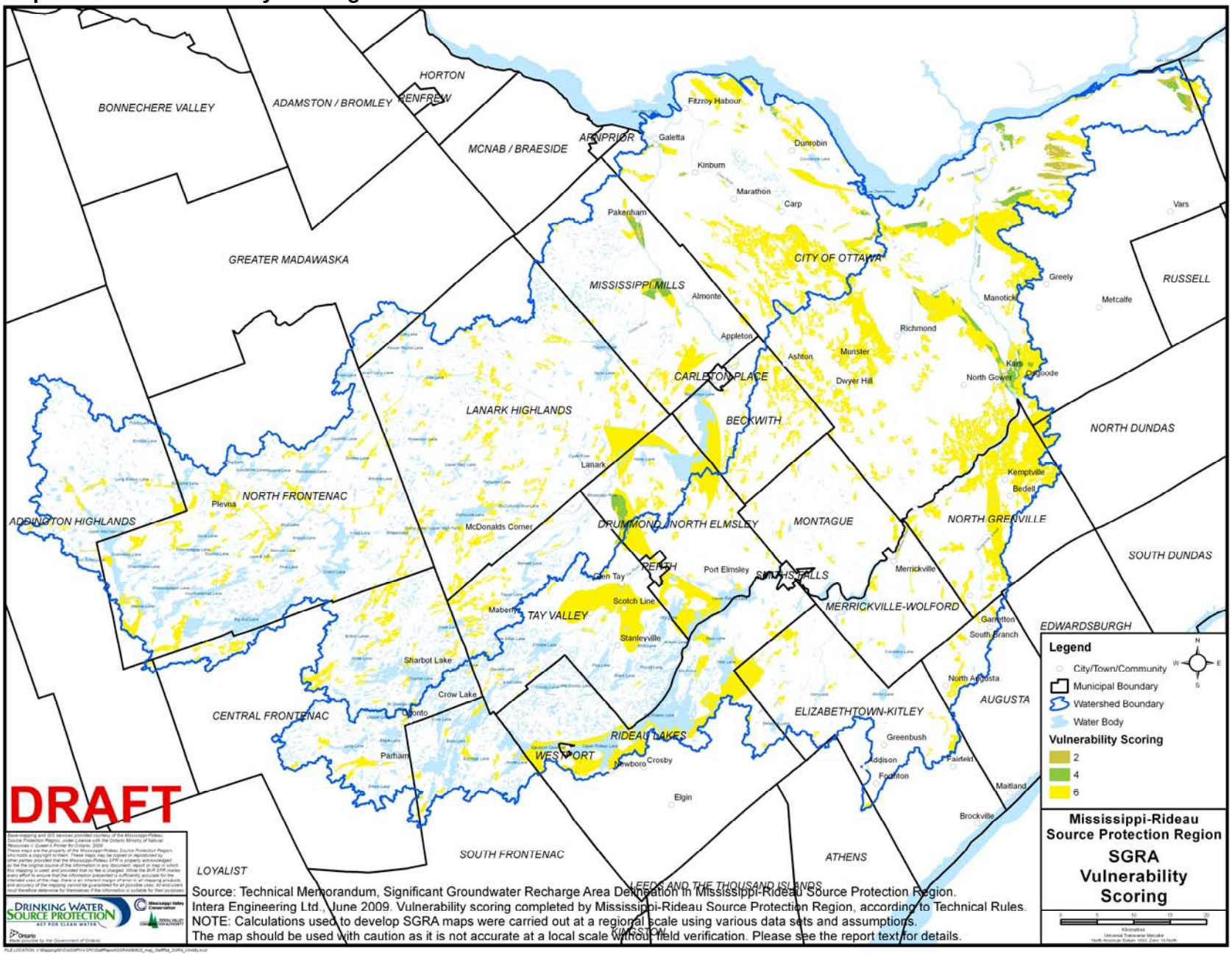
The vulnerability of the aquifer is categorized as high, medium, or low. The technical rules state that SGRA must be assigned the following vulnerability scores:

- **6**, where the aquifer vulnerability is **high**
- **4**, where the aquifer vulnerability is **medium**
- **2**, where the aquifer vulnerability is **low**

Results

Map 4 shows the vulnerability scores for SGRAs in the Mississippi-Rideau Source Protection Region.

Map 4. SGRA Vulnerability Scoring



Step 3 – Identify Threats and Issues for Water Quality

Once experts determine where a drinking water supply is vulnerable to contamination, they need to identify what land use activities could pose a contamination risk in those areas (threats). Experts also need to identify any existing water quality problems (issues) and link them back to the land use(s) causing the contamination.

(1) **Threats** are existing conditions (i.e., contaminated sediment, soil or groundwater) or existing or future land use activities that could contaminate a drinking water supply;

(2) **Issues** are documented cases of water quality contamination approaching or exceeding acceptable provincial levels. While some issues are naturally occurring, many are caused by an existing or historic land use activity.

3a) Threats

The Assessment Report Technical Rules identify the three ways that a water quality threat can be identified:

I. Through an activity prescribed by the Clean Water Act;

II. Through an activity identified by the Source Protection Committee; and

III. Through a condition resulting from past activities.

I. Activities Prescribed by the Clean Water Act

Before threats could be identified, the province had to decide what activities pose a threat, and to what extent. Section 1.1 of Ontario Regulation 287/07 (made under the Clean Water Act) lists 21 broad land use activities as '*prescribed drinking water threats*'.

The province then broke each of the 21 broad activities into various scenarios called *circumstances* (e.g. activity A involving the storage of chemical X in an above ground storage tank greater than 50,000 litres). There are 500 pages of specific circumstances in the provincial Technical Rules and they are divided into two tables – chemical threats and pathogenic threats. The tables of drinking water threats can be found at:
http://www.ene.gov.on.ca/en/water/cleanwater/cwa-technicalstudies.php

These tables identify if a circumstance is a 'significant', 'moderate', or 'low' threat in each vulnerability score (2, 4, 6, 8 and 10). For example, a circumstance may be a *significant* threat in an area with a vulnerability score of 10, and a *moderate* threat in an area with a vulnerability score of 8.

List low and moderate threats:

Using the threats tables, the first step is to list all land use activities (circumstances) that pose a low or moderate threat to significant groundwater recharge areas in the Mississippi-Rideau region. This is simply a summary of the provincial drinking water threats tables; it does not reflect what activities are actually taking place in the SGRA.

Since the vulnerability scores for SGRAs range from 2 to 6, land use activities are categorized as low or moderate threats in the provincial threats tables. No activities can be scored (or labeled) as significant threats within an SGRA.

II. Activity identified by the Source Protection Committee

A drinking water threat can be identified by the Source Protection Committee if the activity is not included in the provincial list of 21 prescribed drinking water threats. This can only occur if a hazard assessment confirms that the activity is a threat, and this assessment is approved by the MOE.

III. Through a condition resulting from past activities.

Threats can also be identified if conditions relating to a past activity (i.e. a contaminated site) have resulted in:

1. the presence of contamination in sediment;
2. the presence of non-aqueous phase liquid (i.e., gasoline) in groundwater;
3. the presence of a single mass of 100 litres of dense non-aqueous phase liquids in surface water.

3b) Issues

A drinking water issue is a documented problem with the quality of drinking water. This can be a chemical or pathogenic problem discovered in the source water of a municipal, monitoring, or private well that exceeds Ontario's established drinking water standards, or shows the potential to exceed these standards in the future.

Under the Technical Rules, for non-municipal wells, issues are limited to chemical or nuclear contaminants. The specific parameters can be found in Schedules 1, 2, or 3 of the Ontario Drinking Water Quality Standards, and in Table 4 of the Technical Support Document for the Ontario Drinking Water Quality Standards, Objectives and Guidelines. The Ontario Drinking Water Quality Standards can be found here: http://www.search.e-laws.gov.on.ca/en/isysquery/4911a9de-3fbb-4359-ad9f-4bb28526e99e/5/frame/?search=browseStatutes&context.

The Technical Support Document for the Ontario Drinking water Standards can be found here: http://www.ontario.ca/drinkingwater/stel01_046947.pdf

The identification of known issues is a way to include historic or cumulative activities in the source protection planning process. For example, an old industrial site could be leaching a contaminant into the aquifer, resulting in poor water quality.

If a parameter or pathogen has been identified in the source water of a well, the following information is required:

- the area or location that is causing the parameter or pathogen, and
- the land use activities, conditions (including naturally occurring conditions), or past activities at that location that are associated with the parameter or pathogen.

If the above information cannot be readily determined, a plan must be developed to collect it for inclusion in a future Assessment Report.

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