Drinking Water in Munster

Draft Groundwater Study Findings – May 2009

Why Read This?

Property owners in the Munster area, both on and off municipal water, should review the following groundwater study results currently under public review, to:

- See maps of the underground aquifer where Munster's municipal well water comes from;
- Understand if the aquifer is at risk of contamination; and
- Learn how land use policies in the Munster area will help protect the aquifer.

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.

Your Role

Broad public consultation will occur at each stage to ensure all local interests, concerns and knowledge are considered – please participate! The process of developing Source Protection Plans has been designed so that municipalities, conservation authorities, farmers, property owners, industry, business, community groups, environmental interests, public health officials, First Nations and the public work together to create effective, locally-workable, source protection policies.

Facts about Munster's Municipal Drinking Water System:

- It is operated by the City of Ottawa
- It supplies 1,320 people in Munster with drinking water
- Its water quality is consistently in compliance with the Ontario Drinking Water Standards
- It is made up of 2 wells that draw groundwater from the Nepean sandstone aquifer
- Wells were constructed between 1969 and 1973
- They range in depth from 116m to 122m.
- Prior to water distribution, chlorine is added to disinfect the water

The Nepean Aquifer – Munster's Source of Drinking Water

An aquifer is an underground layer of sand, gravel, or rock that contains enough water to supply a well. Munster's two municipal wells draw water primarily from the Nepean sandstone aquifer. This aquifer is located deep beneath the surface, and is protected by a thick layer of rock and soil. It is a 'confined' aquifer, meaning that the layers of rock and soil above and below it act as a natural barrier between it and other geological formations or the ground surface.

Many private wells in the Munster area, however, draw water not from the deep Nepean aquifer, but from water held closer to the surface, in the Oxford formation aquifer. The Oxford aquifer is also a confined aquifer. The region, therefore, is characterized by two aquifers: a deep aquifer (the Nepean), and a shallow aquifer (the Oxford). Since the Munster wells must pass through the Oxford formation to get to the Nepean, it is necessary to map the size and shape of both aquifers to determine the total area that the wells draw water from.

More specifically, during the construction of the Munster wells, a well casing (circular metal sleeve around the well) was installed in each well. In each well, the well casing extends into the Oxford formation but does not reach the Nepean formation. This means that water from the Oxford formation can enter the well, so it is necessary to study both aquifers.

Munster Groundwater Study

Step 1 – Delineate a Wellhead Protection Area

Experts determined the direction and speed of groundwater moving through the shallow and deep aquifers towards Munster's municipal wells. The size and shape of the area that Munster's municipal wells draw water from is called a Wellhead Protection Area.

Step 2 – Assess Vulnerability

Next, experts assessed how vulnerable Munster's aquifer is to contamination within the Wellhead Protection Area. This is based on how confined or unconfined the aquifer is (how easily contaminants can get down into the aquifer).

Step 3 – Identify Threats and Issues

The province created a list of land uses and activities that could pose a low, moderate or significant threat in areas where the aquifer is vulnerable to contamination. Experts will inventory how many potential significant threats currently exist and identify any existing documented water quality problems. Water quantity threats will be evaluated as part of a water budget study currently underway.

Note: The following study findings provide information about water supplying Munster's municipal wells. These findings may not apply to water supplying private wells in the area. Individuals on private wells should contact staff for more information.

Munster Groundwater Study Findings

The Experts

For the Munster groundwater study, steps 1 and 2 were completed by water resource engineers, hydrogeologists and GIS/database specialists at Golder Associates Ltd. (Golder). Study of the deep aquifer vulnerability was completed in May of 2008. The study of the shallow aquifer vulnerability was completed in May of 2009. Step 3 is currently being completed by water resource engineers, hydrogeologists and GIS/database specialists at Dillon Consulting Ltd. (Dillon). Steps 1 and 2 of the study were peer reviewed by an independent third party and conform 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 a Wellhead Protection Area

Methodology

Golder undertook four steps to delineate Wellhead Protection Areas for Munster:

1. Collection of data and information:

They collected relevant data and information from other groundwater technical studies, and from Federal, Provincial, and Municipal sources. One of the most important data sources was the Water Well Information System, a database of current and historic well records for Ontario, maintained by the Ministry of the Environment.

2. Development of a conceptual model:

   Once data was been collected, they used it to develop a general understanding of the local groundwater system, known as a conceptual model. The conceptual model is a representation of the local physical environment showing how water behaves above and below ground. It requires knowledge of geology, how rainfall makes its way beneath the surface (infiltration), and an understanding of the location, depth, and flow direction of water in the aquifer. An independent third party peer review occurred at this stage to ensure the approach was accepted by other groundwater experts.

3. Selection, development, and calibration of a numerical model:

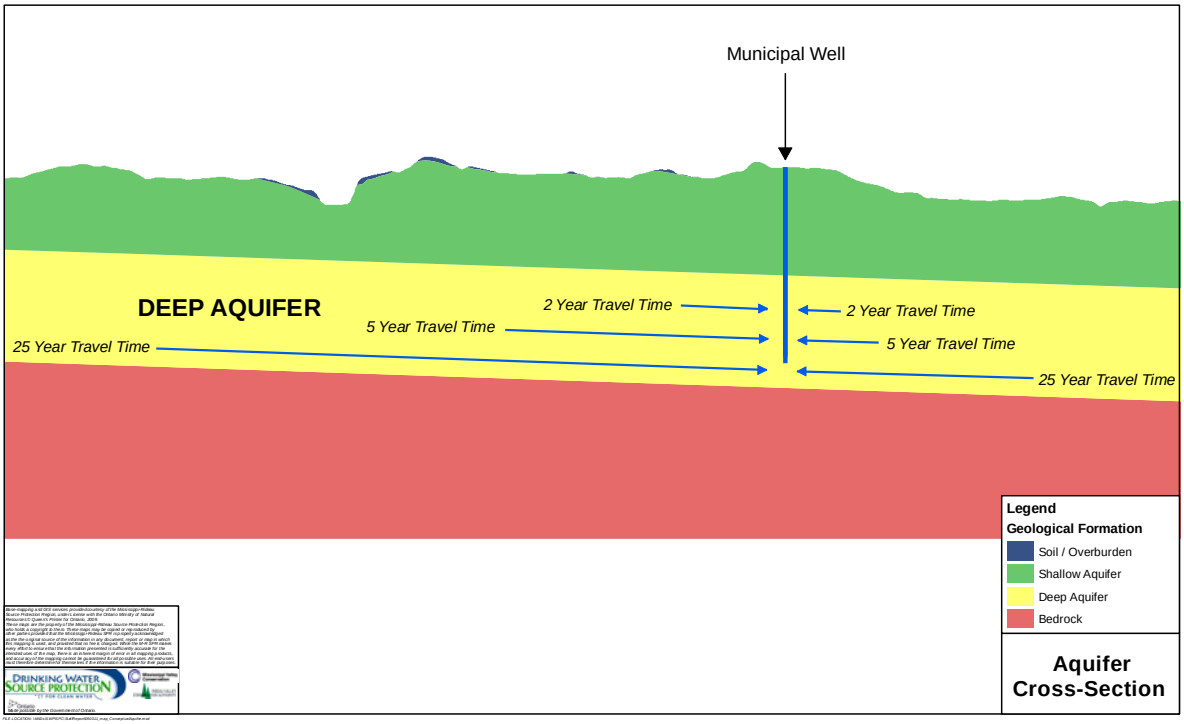
   A numerical model is a set of mathematical equations, usually held within a computer program, that represent how water behaves in the physical environment (or hydrogeological system). Using the conceptual model, a numerical model was developed to best represent Munster's hydrogeological system. The model was calibrated by adjusting model parameters so that results were consistent with observations (e.g. known well water levels). Often it is impossible to identify a single value for an input parameter, so a range of reasonable values are identified. Using a range of values means a calibrated model run can result in different but equally valid results. This is often called a 'sensitivity analysis'.

4. Delineation of the WHPA:

   The numerical model determined the speed water travels in the aquifer towards the wells by using a variety of inputs, including municipal water demand values. This information was used to determine WHPA time of travel intervals. Under the provincial Technical Rules, the required time of travel intervals are 2 years, 5 years, and 25 years – referred to as WHPA-B, WHPA-C, and WHPA-D, respectively. WHPA-A is a 100m buffer (i.e. a circle with a 100m radius) around the wellhead. Since the model had more than one reasonable output (resulting from a range of values for some parameters), the final WHPAs for the shallow and deep aquifers are the combinations, or outer boundaries, of all valid model runs.

Figure 1, below, is a cross-section of a generic aquifer, showing the 2, 5, and 25 year travel times to a municipal well. These underground travel times through the aquifer are projected above ground and mapped around a wellhead to show wellhead protection area zones. As illustrated below, the length of a particular travel time usually varies in all directions from the well. This commonly results in wellhead protection area zones that are oval or elongated, rather than circular.

Figure 1. Theoretical Aquifer Cross-Section – Time of Travel to a Well



Results – Munster Wellhead Protection Area

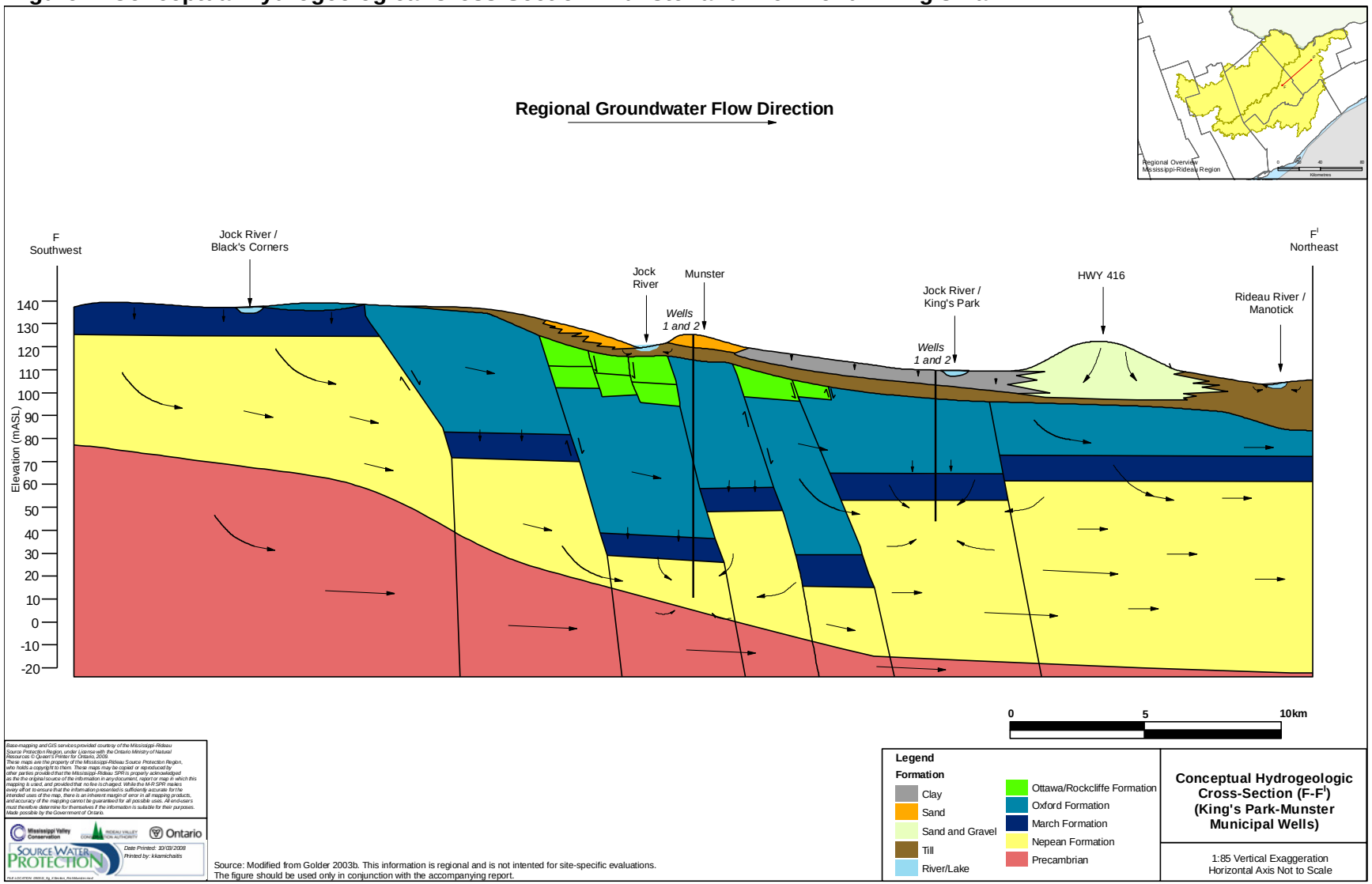
The wellhead protection area delineated for the shallow aquifer in Munster is approximately 2.5km^2. The Wellhead Protection Area for the deep aquifer is approximately 27km^2.

Figure 2 shows a conceptual hydrogeological cross-section of the aquifer that supplies Munster's municipal wells. The wells descend through surface layers of sand and glacial till, then through the upper aquifer (the Oxford/March formations), before arriving at the deep Nepean aquifer. Precambrian bedrock lies below the Nepean aquifer.

Map 1 shows the Munster shallow aquifer wellhead protection area zones around the municipal wellheads. It is made up of a 100m buffer around the wellheads and the 2, 5, and 25 year times of travel.

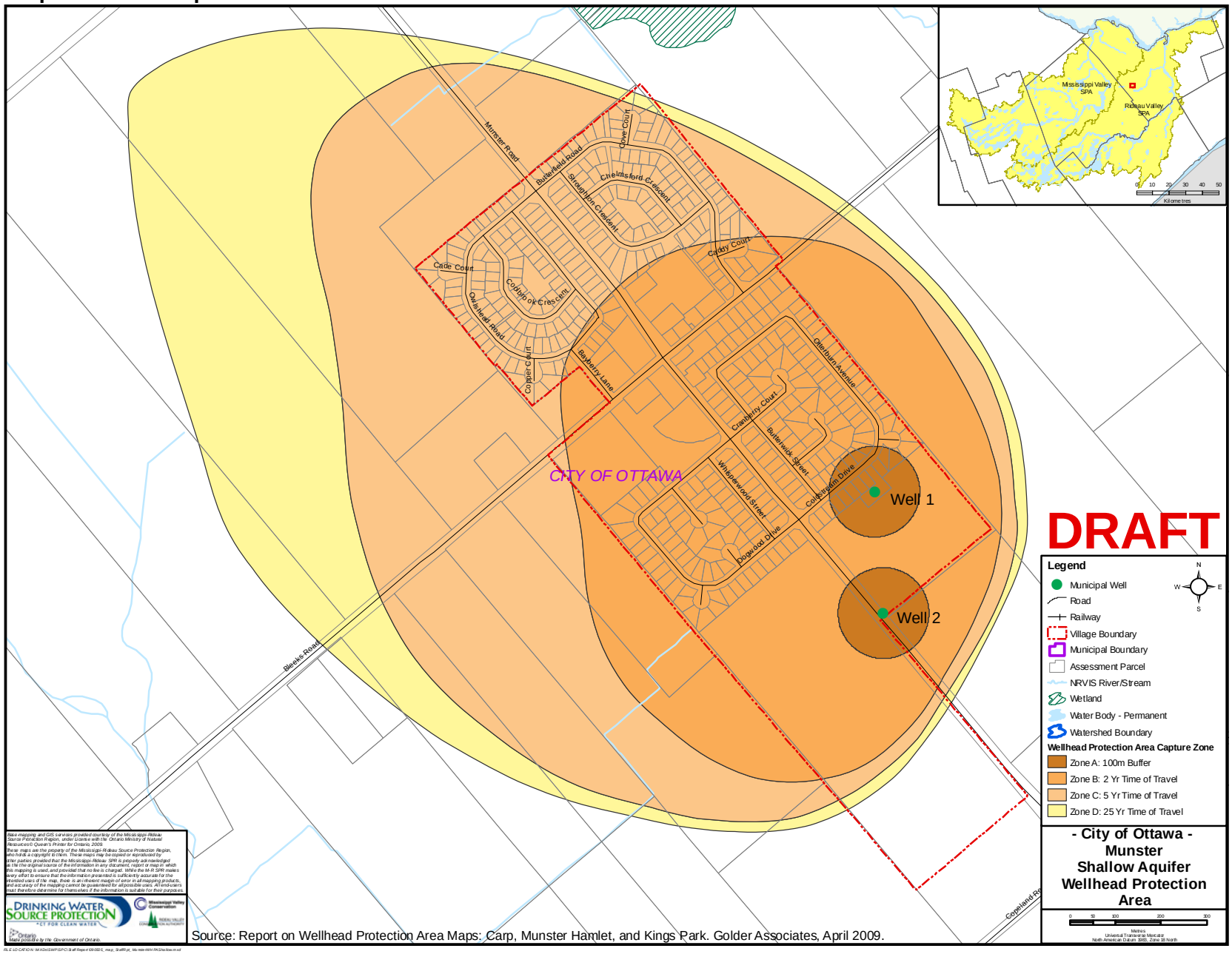
Map 2 shows the Munster deep aquifer wellhead protection area zones around the municipal wellheads. It is made up of a 100m buffer around the wellheads and the 2, 5, and 25 year times of travel.

Figure 2. Conceptual Hydrogeological Cross-Section: Munster and Richmond - King's Park



Source: Modified from Golder 2003b. This information is regional and is not intented for site-specific evaluations.
The figure should be used only in conjunction with the accompanying report.

Map 1. Shallow Aquifer Wellhead Protection Area



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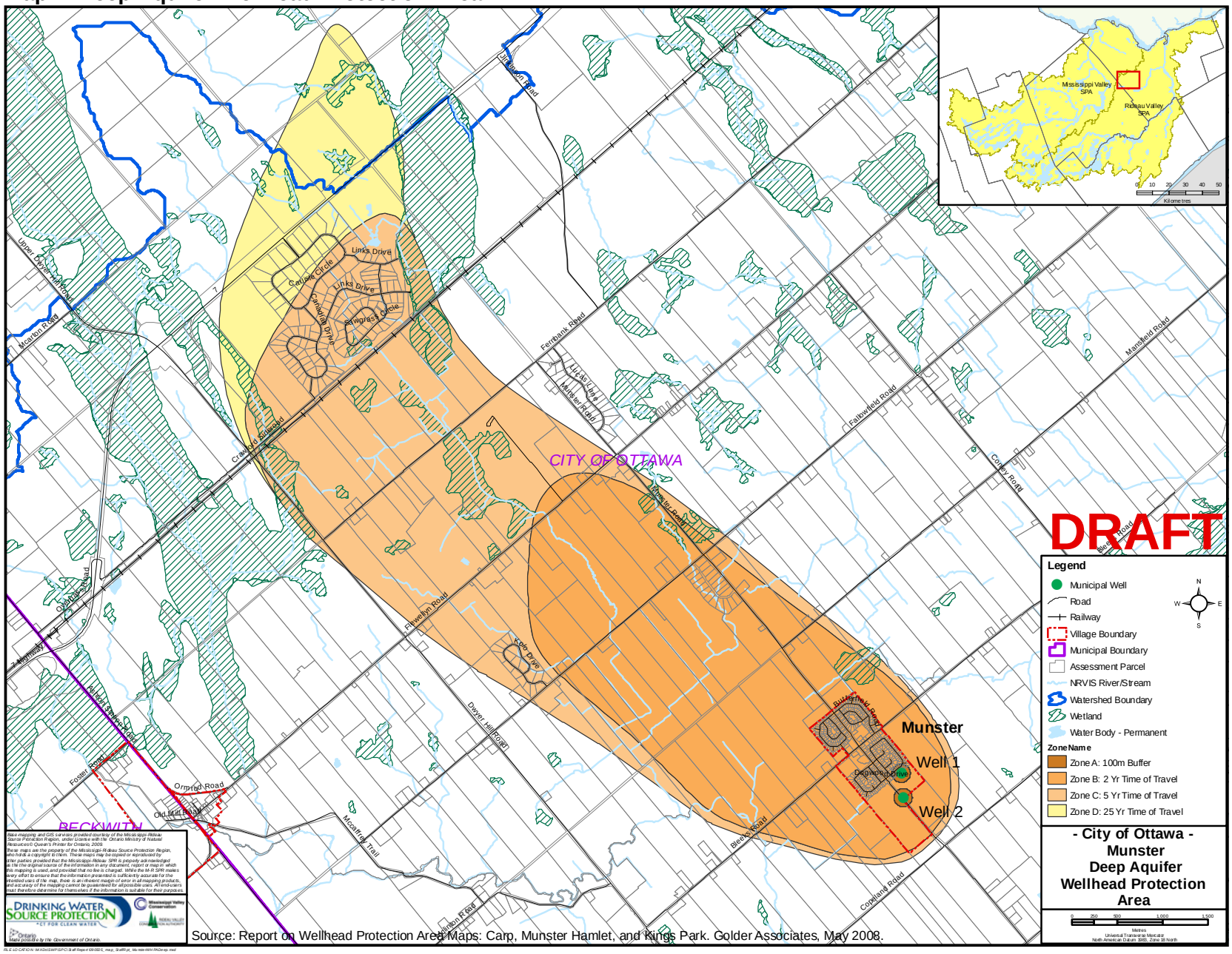
Map 2. Deep Aquifer Wellhead Protection Area



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Step 2 – Assess Vulnerability

Once the WHPA was delineated, Golder assessed how susceptible the aquifer was to contamination in that area. If contaminants can infiltrate through the ground and into the aquifer, then wells that use that aquifer could become polluted. Studying aquifer vulnerability within mapped WHPAs can identify areas where extra care is needed to protect the water supply.

The Technical Rules under the *Clean Water Act* set out a process for scoring vulnerability within a WHPA. It is based on the combination of aquifer vulnerability and overlapping WHPA zones. Simply put, the more vulnerable the aquifer and the closer you are to the well, the higher the vulnerability score.

For Munster, the vulnerability assessment is completed independently for each aquifer WHPA. The final vulnerability score is based on the greater of the deep and shallow aquifer vulnerability.

Methodology

1. Assessment of Intrinsic Aquifer Vulnerability:

   The first step is to determine how easily contaminants can infiltrate into the aquifer. The Province has identified several science-based approaches that can be used. For the Munster WHPA, Golder used a method called groundwater 'Intrinsic Susceptibility Index' (ISI). ISI looks at the thickness and types of soil and rock layers above the aquifer, and how easily water can pass through these layers. Vulnerability values were assigned for specific locations. Values were given as 'Low', 'Medium', or 'High'. This was completed for the deep and shallow aquifers, as shown in Maps 3 and 4.

2. Assessment of Transport Pathways:

   The next step is to determine if human activity in the WHPA has altered the landscape making it easier for contaminants to get into the aquifer. Human made short-cuts to the aquifer are called transport pathways. Since the ISI approach looks only at the geological setting above the aquifer, an assessment of transport pathways within the WHPA provides a more complete understanding of vulnerability.

   Under the provincial Technical Rules, the presence of transport pathways within a WHPA can increase the intrinsic vulnerability. An area with low vulnerability can increase to medium, and an area with medium vulnerability can increase to high. Areas that are already high cannot increase anymore.

   Dillon reviewed water wells, pits and quarries, mines, construction activities, sewer services, septic systems and stormwater infiltration. For the shallow aquifer, Dillon identified two areas where transport pathways pose a risk to the shallow aquifer. One area, located in the centre of Munster, was elevated from Medium to High vulnerability because of the presence of both wells and sewer services. In another area, just west of the centre, the vulnerability was increased from Medium to High because of the presence of surface water ponds.

For the deep aquifer, Dillon increased the vulnerability in two areas from Low to Medium because of the presence of bedrock quarries. Both areas are located several kilometres north-west of Munster.

3. Calculating WHPA Vulnerability Scores:

   Once the vulnerability of the aquifer has been finalized, the next step is to combine it with the wellhead protection area zones to determine final vulnerability scores for the WHPA. Simply put, the more vulnerable the aquifer and the closer you are to the well, the higher the vulnerability score.

   Table 1, below, shows the scoring system laid out in the provincial Technical Rules. Possible vulnerability scores are 2, 4, 6, 8, and 10. A score of 10 is highest, indicating an area where drinking water is most vulnerable to contamination.

Table 1. Wellhead Protection Area Vulnerability Scores

Vulnerability	Well Head Protection Area Zone			
	WHPA-A (100m)	WHPA-B (2 year)	WHPA-C (5 year)	WHPA-D (25 year)
HIGH	10	10	8	6
MEDIUM	10	8	6	4
LOW	10	6	4	2

Results – Munster Vulnerability Scores

Maps 3 and 4 show the vulnerability as determined with the ISI method and adjusted for any transport pathways, for Munster's shallow and deep aquifer wellhead protection areas.

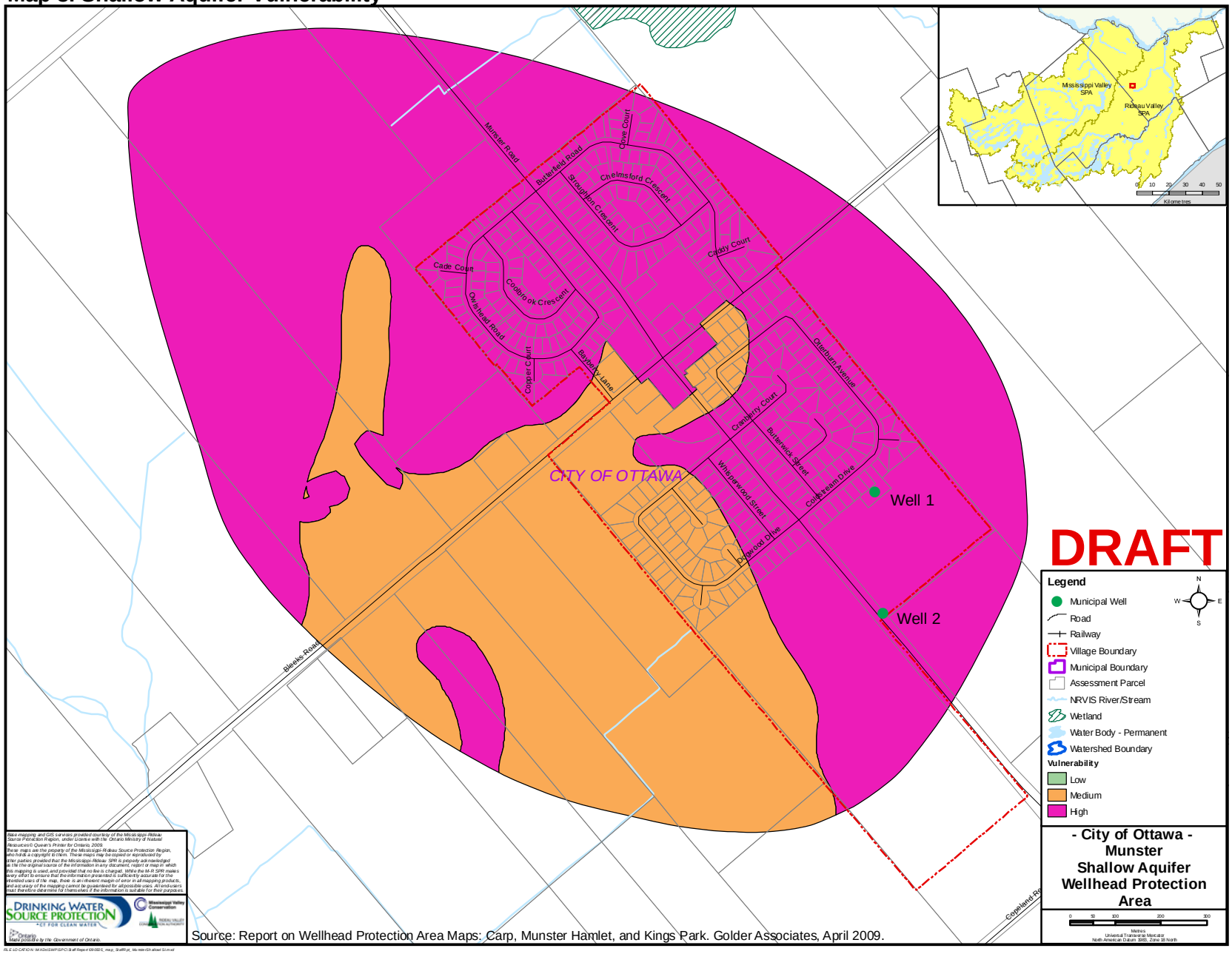
For the shallow aquifer, the aquifer vulnerability varies between Medium and High, because of the variation in the soil over the aquifer (i.e. gravel sand, glacial till, and organic deposits). For the deep aquifer, the aquifer vulnerability varies between Low and Medium because the Nepean aquifer is better protected by the thickness and type of overlying material (silt, loess, and limestone/dolostone).

Maps 5 and 6 show the vulnerability scoring for Munster's shallow and deep wellhead protection areas.

Map 7 shows the final vulnerability scoring for the Munster wellhead protection area. The final vulnerability scoring is based on the highest of the combined scores for the deep and shallow aquifers.

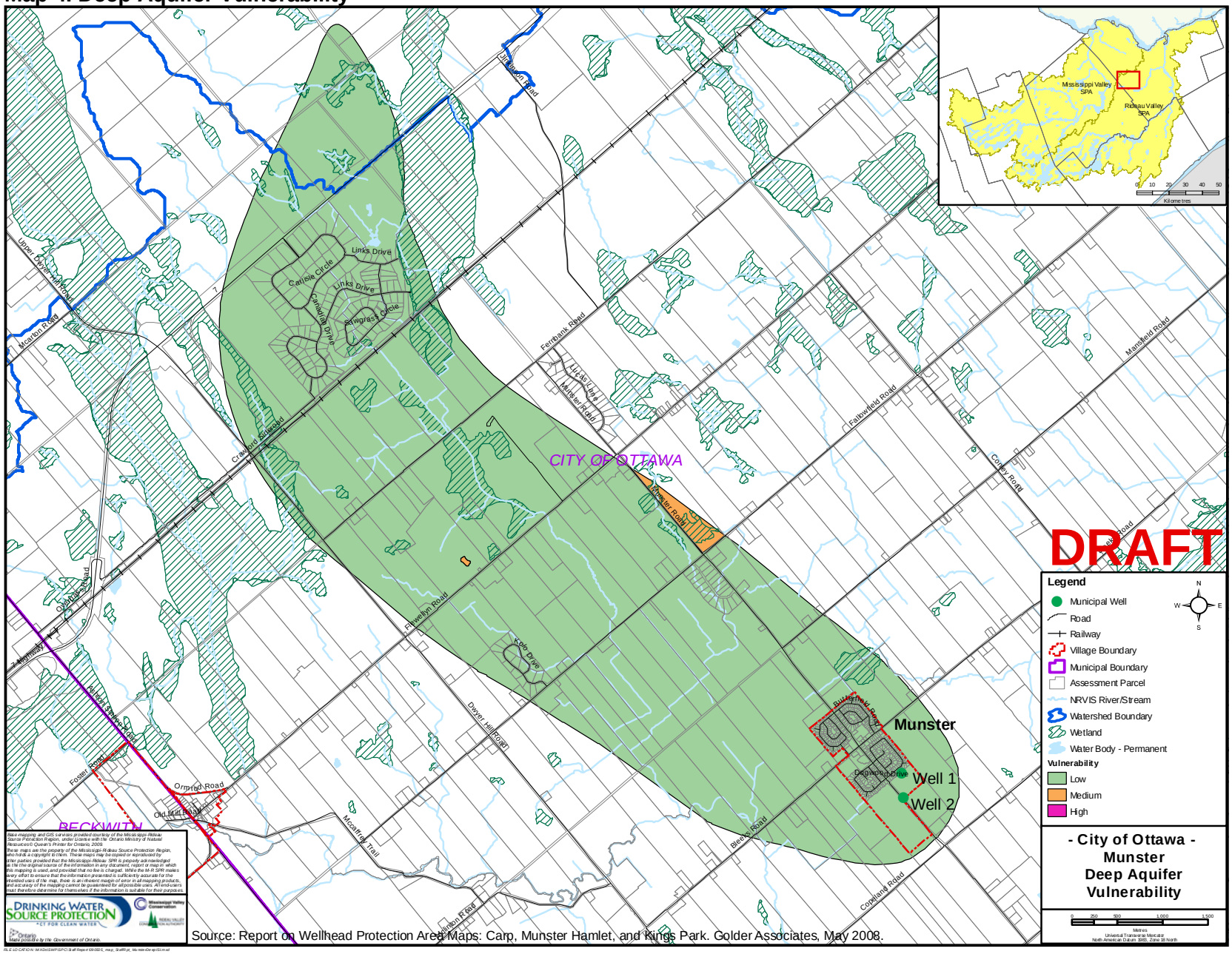
Map 8 shows the final vulnerability scoring, zoomed into Munster.

Map 3. Shallow Aquifer Vulnerability



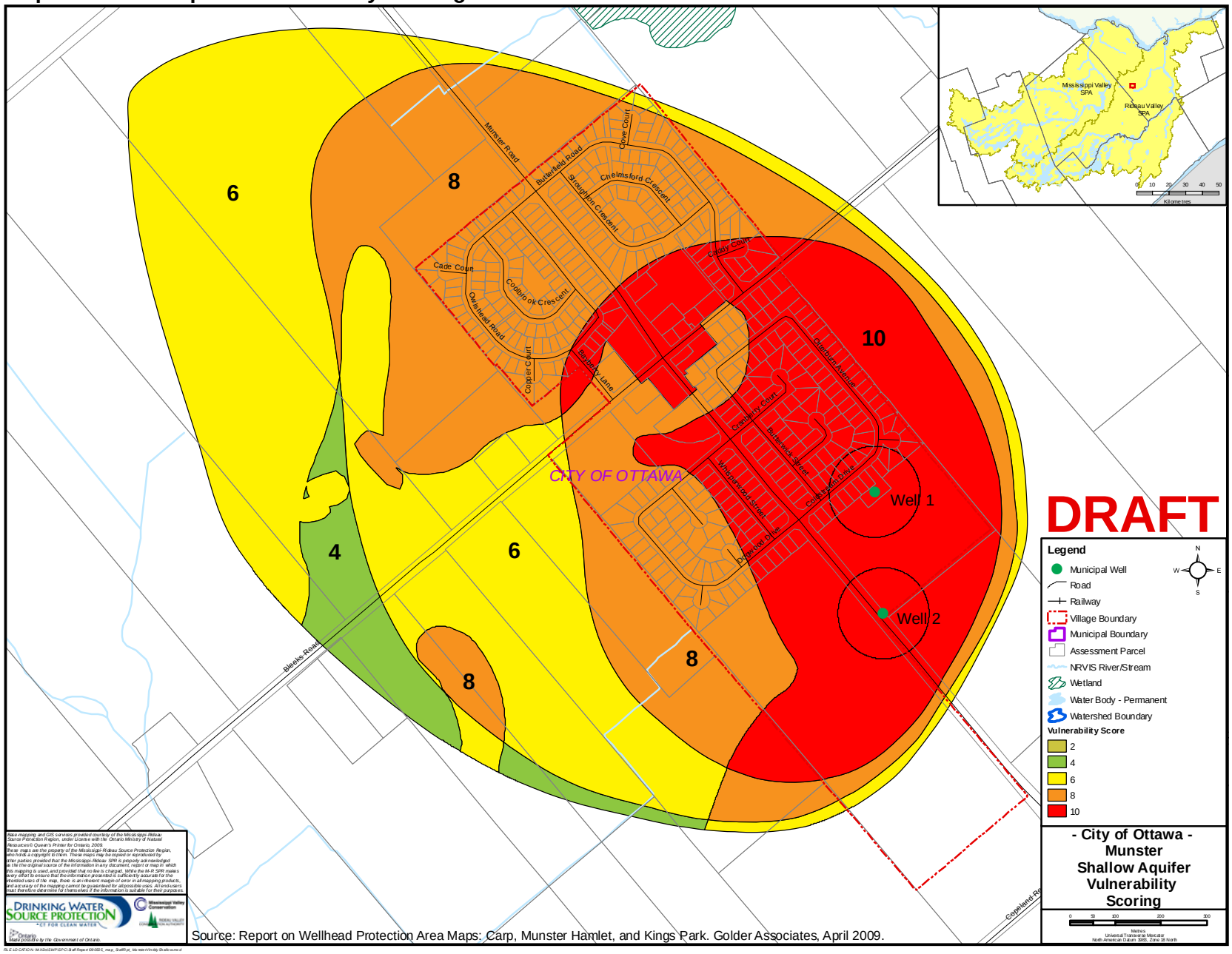
Source: Report on Wellhead Protection Area Maps: Carp, Munster Hamlet, and Kings Park. Golder Associates, April 2009.

Map 4. Deep Aquifer Vulnerability

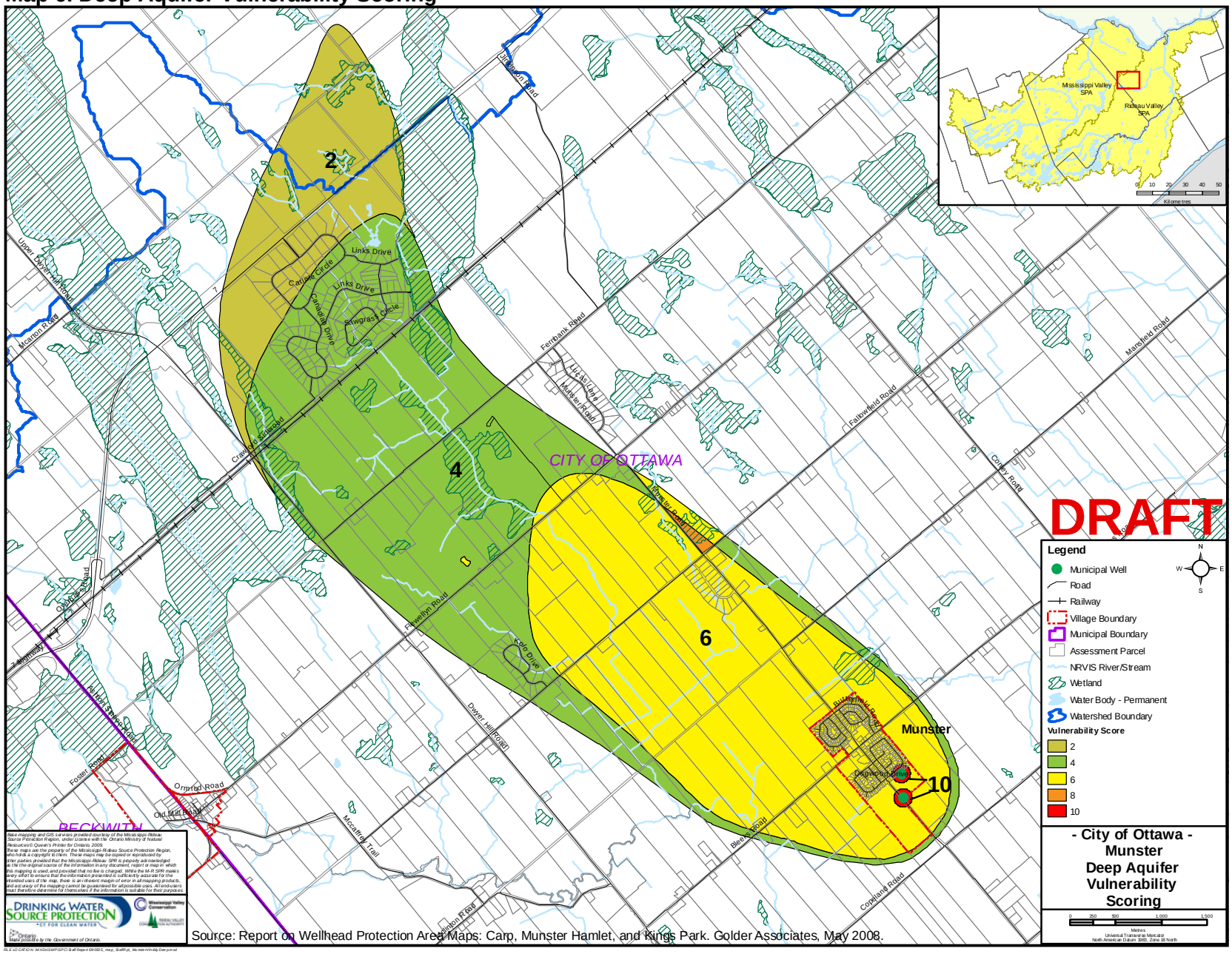


Source: Report on Wellhead Protection Area Maps: Carp, Munster Hamlet, and Kings Park. Golder Associates, May 2008.

Map 5. Shallow Aquifer Vulnerability Scoring



Map 6. Deep Aquifer Vulnerability Scoring



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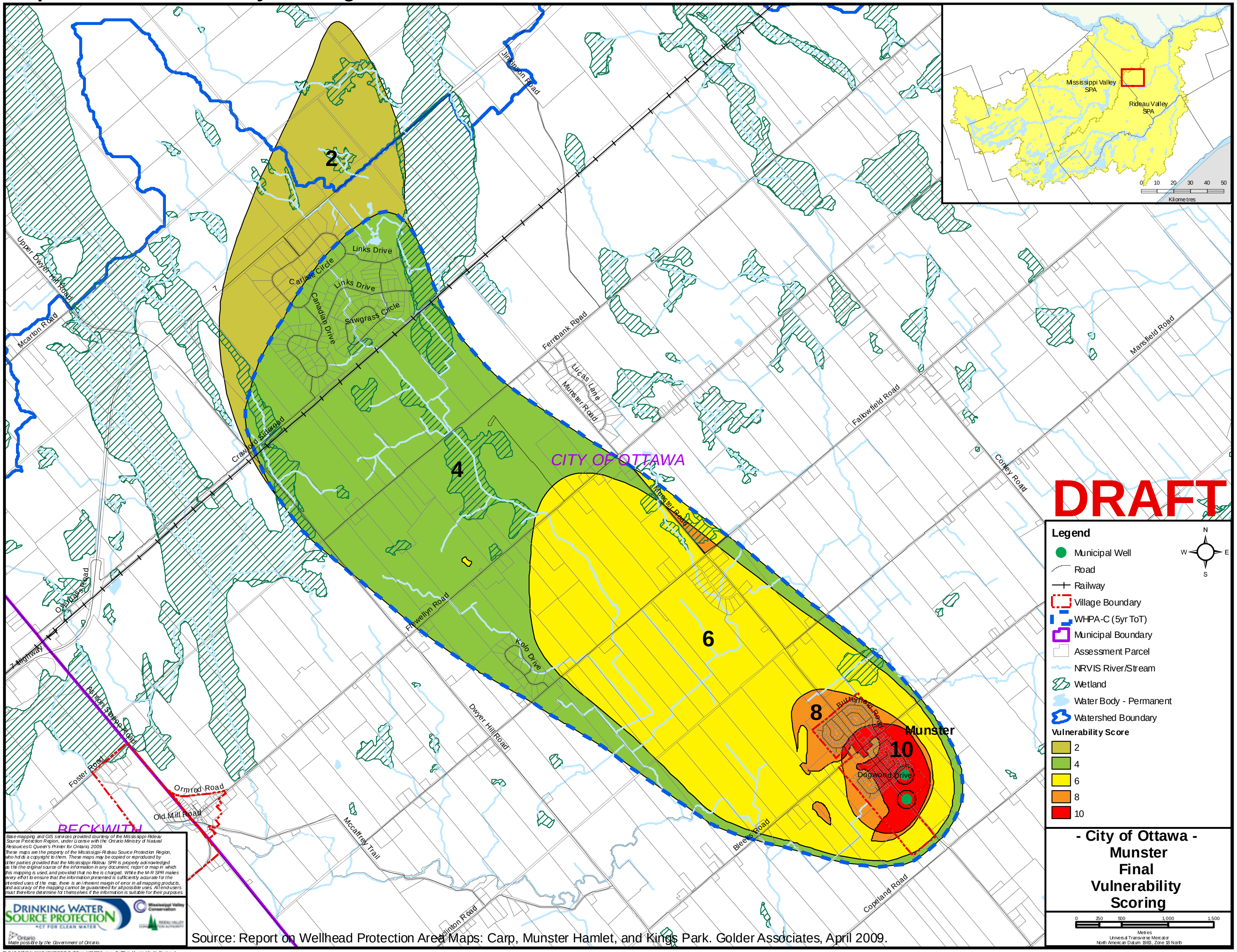
Map 7. Final Vulnerability Scoring



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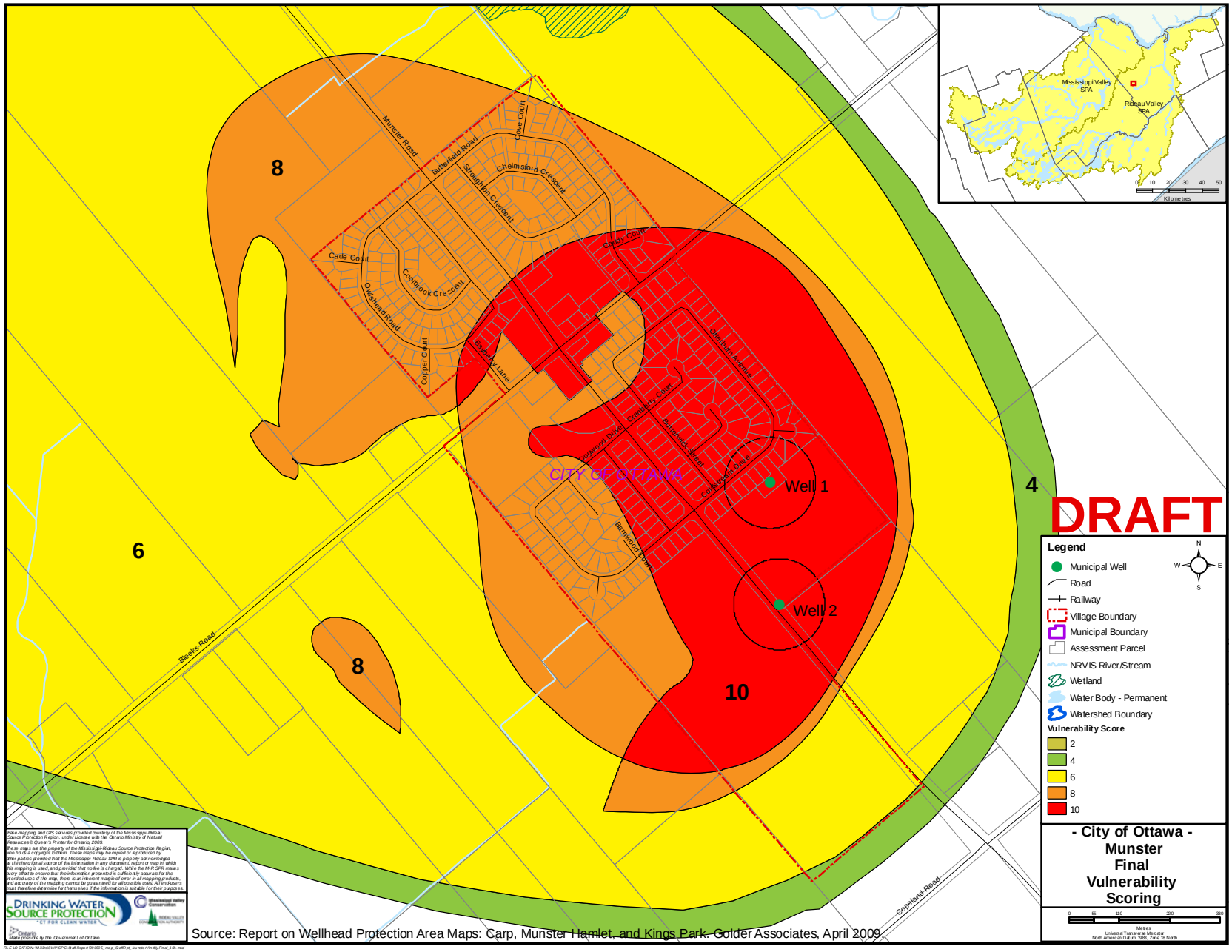
Map 8. Final Vulnerability Scoring: Munster



Source: Report on Wellhead Protection Area Maps: Carp, Munster Hamlet, and Kings Park. Golder Associates, April 2009

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*'. These 21 activities are listed in Table 2 below, and they cover both chemical and pathogenic (i.e., bacteria) 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.

Note: There are two prescribed drinking water threats (numbers 19 and 20) that pertain to water *quantity* threats. These will be evaluated as part of a water budget study currently underway.

Methodology

1. List low, moderate, and significant threats:

   Using the threats tables, the first step is to list all land use activities (circumstances) that pose a low, moderate, and significant threat to the

aquifer supplying Munster's municipal wells (based on the vulnerability scores in the WHPA). This is simply a summary of the provincial drinking water threats tables, it does not reflect what activities are actually taking place in the WHPA.

Under the province's threats tables, a land use activity can only be a *significant threat* if it is in an area that has a vulnerability score of **8** or **10**. The exception is activities that pertain to dense non-aqueous phase liquids (DNAPLs). These are chemicals, such as trichloroethylene, that sink in water, making them difficult to remove from groundwater. DNAPLs within the 5 year WHPA zone are automatically a significant threat, regardless of the area's vulnerability score. This zone is shown on Map 7.

Table 2, below, shows for each vulnerability score, which of the 21 prescribed drinking water threats has one or more circumstances that pose a significant threat. The table shows that the majority of threats must occur in areas with a vulnerability score of **10** to be classed as significant, only three can be significant in areas with a vulnerability score of **8**.

Attached to this document is a complete list of the threats circumstances that can be classed as significant in a WHPA. This table is a *subset* of the full provincial drinking water threats tables.

2. Inventory existing significant threats:

   Under the Technical Rules, Dillon must use the list of significant threats and count how many of those land uses are taking place on the ground.

   Dillon is using air photos, commercial databases, and roadside observations, to develop an inventory of locations that may have significant threats within the Munster WHPA.

3. Confirm inventory of significant threats:

   It is impossible to know the details of a particular land use activity without seeking additional information from the property owner. This information would include details about specific practices and potential contaminants in use. This detailed information is required to confirm if a land use activity is a significant threat or not.

   Dillon will not be approaching property owners for additional information in the Munster WHPA. The inventory of existing potential significant threats will be compiled based on the information available about local land use activities. This list should be completed by late fall. Property owners wishing to confirm whether or not they are a significant threat are welcome to contact staff who will work with them to collect the necessary information to make such a determination.

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:

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

Table 2: Provincial Threat Categories with Circumstances That Could Pose a Significant Threat in a WHPA

		Wellhead Protection Area (WHPA) Vulnerability Scoring									
	Contaminant released:	Chemical					Pathogen				
	Prescribed Drinking Water Threats (Ontario Regulation 287/07)	10	8	6	4	2	10	8	6	4	2
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 (DNAPLs)*.	Anywhere in 5 year time of travel									
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.	✓					✓				

*DNAPLs are chemicals that are heavy and sink in water (e.g. trichloroethylene)

**Water quantity threats will be evaluated as a part of the Water Budget studies

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 municipal drinking water systems issues can refer to chemical, nuclear, or bacterial contaminants. 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.

While all reports to date indicate that Munster's municipal drinking water quality is in compliance with the Ontario Drinking Water Standards, Dillon will be reviewing all available information, as required by the province, to ensure there are no drinking water issues.

For More Information Contact:

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