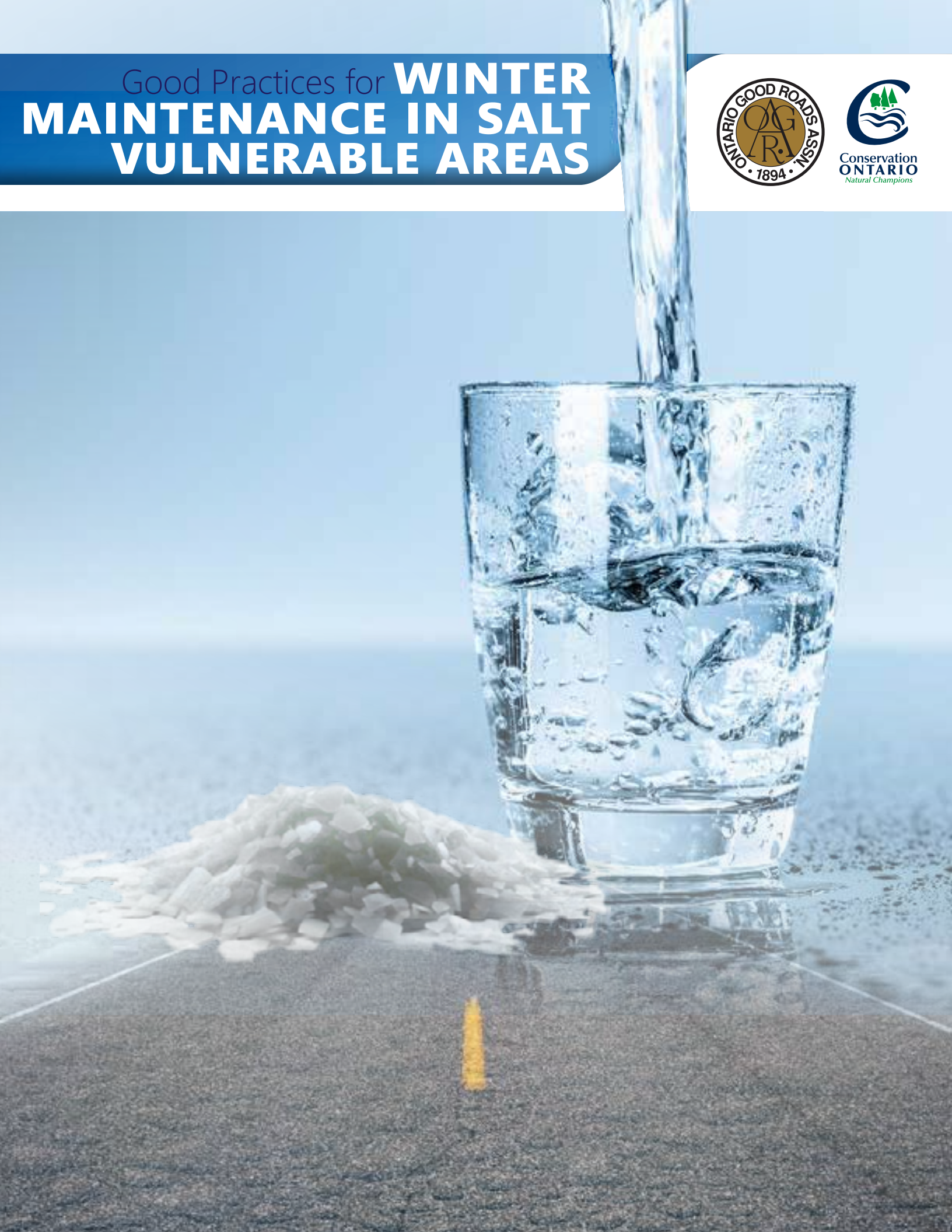
Good Practices for **WINTER MAINTENANCE IN SALT VULNERABLE AREAS**



Good Practices for Winter Maintenance in Salt Vulnerable Areas

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EXECUTIVE SUMMARY

This guidance document serves as a resource on environmental best management practices for organizations managing road salt, where it is used for road maintenance purposes during the winter season, as the dates are locally designated. It is developed by a multi-stakeholder 'Salt Vulnerable Areas' working group comprised of members from municipal organizations, conservation authorities, as well as provincial and federal governments.

This guidance is a living document to help address the impacts of road salt, within specific vulnerable areas, and will be reviewed every two years to remain current with technological and legislative changes. There are several types of 'salt vulnerable areas', with various environment and human health goals including drinking water quality, wetland health, and fisheries. **This document currently prioritizes certain areas where municipal drinking water sources are known to be impacted by road salt. These areas are 'Issue Contributing Areas' specific to sodium and chloride, delineated under the Clean Water Act (2006**).

There are several practices implemented by municipalities in Ontario to help mitigate the long term effects of road salt on surface water and groundwater. These practices are offered as 'good practices' for other municipalities to adopt if Issue Contributing Areas have been delineated around municipal drinking water systems as a result of increased sodium and/or chloride concentrations. While the intent of this document is to provide guidance to municipalities in the interest of protecting municipal sources of drinking water, in all instances, the protection of the travelling public must be paramount in selecting the most appropriate operational practice for local road authorities to adopt.

Care was taken to comply with Accessibility for Ontarians with Disabilities Act, 2005 (AODA) requirements and to include entire website addresses instead of hyperlinks, to accommodate those who read the document in printed form rather than a digital version.

The content of this document was developed by a working group comprised of representatives of the Ontario Good Roads Association, Conservation Ontario, the Province of Ontario, and the Government of Canada, and represents a compendium of good practices for municipal winter maintenance in Ontario at the time of publication. Neither the members of the working group nor the parent organizations warrant or certify this information and assume no responsibility for the accuracy of the information or any harm to persons or property as a result of road agencies adopting or modifying the maintenance practices described in this document.

FOREWORD

The Salt Vulnerable Areas Working Group was formed in 2016, to address road salt application, handling and storage, as well as snow storage, in vulnerable areas that are susceptible to the impacts of road salt. The working group has reviewed related vulnerable areas for drinking water sources, delineated under the *Clean Water Act* (2006) as well as current municipal road operations practices in managing road salt storage and application.

This document is the culmination of efforts by the Salt Vulnerable Areas Working Group members in identifying a range of road salt management practices that can be considered for inclusion in salt management plans prepared by municipalities of varying capacities and budgets, giving due consideration to their mandated road maintenance Level of Service obligations.

This document currently focuses on specific areas around municipal drinking water sources where there are known impacts of road salt. It is envisioned that the document will evolve to consider different types of salt vulnerable areas.

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1. THE LEGAL CONTEXT

1.1 The *Municipal Act, 2001*

The *Municipal Act, 2001* (Section 44 (1)) provides that a municipality must keep its highways "in a state of repair" "that is reasonable in the circumstances". The *Municipal Act, 2001* can be found at the website: https://www.ontario.ca/laws/statute/01m25 O. Reg. 239/02 made under the Act further prescribes maintenance standards for municipal highways.

In the event of a collision, the provincial courts will determine whether that standard was met, and whether the municipality took reasonable steps to prevent the collision from occurring. If the provincial courts decide that a municipality failed to meet its obligations, the municipality must contribute to paying a portion of the damages. Under the principle of joint and several liability enshrined in the *Negligence Act*, a municipality may ultimately be responsible for up to 100% of the damages, even if it is found to have only partially contributed to the cause of the accident.

This potential liability exposure is one of the reasons that municipalities are reluctant to adopt any winter maintenance practices or techniques that may affect their Council-approved Level of Service.

1.2 The *Environmental Protection Act*

Ontario Regulation 339, *Classes of Contaminants – Exemptions* under the *Environmental Protection Act* exempts substances used for keeping a highway safe for traffic under conditions of snow, ice or both from being classified as a "contaminant" as defined under the Act. Visit: https://www.ontario.ca/laws/regulation/900339

"Where any substance used on a highway by the Crown as represented by the Minister of Transportation or any road authority or any agent or employee of any of them for the purpose of keeping the highway safe for traffic under conditions of snow or ice or both is a contaminant, it is classified and is exempt from the Act and the regulations"

1.3 Code of Practice for the Environmental Management of Road Salt (2004)

In 2001, Environment and Climate Change Canada (ECCC) published an assessment report which concluded that high releases of road salts were having an adverse effect on freshwater ecosystems, soil, vegetation and wildlife. The publication of the assessment report initiated a risk management process to address environmental risks posed by road salts. To assist ECCC with this complex task, a multi-stakeholder working group was formed. This national level working group worked towards the development of the Code of Practice for the Environmental Management of Road Salts (Code of Practice) which was published in 2004.

The Code of Practice can be found at: https://www.canada.ca/en/environment-climate-change/services/pollutants/road-salts/code-practice-environmental-management.html

The main objective of the Code of Practice is to ensure environmental protection while maintaining roadway safety. There are two main recommendations in this Code:

1. The development of **salt management plans**, based on a review of existing road maintenance operations, identification of means and goal-setting to achieve reductions of the negative impacts of salt releases; and
2. The implementation of **best management practices** in the areas of salt application, salt storage and snow disposal, as outlined in Transportation Association of Canada's *Syntheses of Best Practices*.

The Code specifies information to be reported to ECCC by road organizations, including road salt usage. Reports are due June 30th each year. The Code is reviewed and revised as appropriate every five years. It is important to note that adoption of the Code is voluntary, and further, that the high level of adoption by road authorities is commendable.

The Code of Practice for environmental management of road salts applies to: organizations that use more than 500 tonnes of road salts per year (five-year rolling average); and organizations that have vulnerable areas in their territory that could be potentially impacted by road salts.
Under the Code of Practice, ECCC defines "organization" as: (a) any public entity that uses or is responsible for the use of road salts on public roads in Canada; or (b) any company that holds a concession or lease to manage a public road, unless the public entity from which the company holds that concession or lease has developed a salt management plan that the company agrees to implement.

1.3.1 Salt Management Plans

Under the Code of Practice, organizations are encouraged to prepare and implement a **salt management plan (SMP)** that contains best management practices. SMPs aim to address salt storage, salt application and disposal of snow containing road salts.

More information on SMPs can be found at: https://www.canada.ca/en/environment-climate-change/services/pollutants/road-salts/code-practice-environmental-management.html

Some of the recommended components of SMPs are: the identification of activities through which road salts may be released to the environment; goals to achieve reduction of the environmental impacts of these releases; the assessment of current practices against recommended best management practices and, a procedure for its yearly review.

1.3.2 Vulnerable Areas

As per the ECCC Code of Practice Annex B, a "vulnerable area" means an area particularly **sensitive to road salts** where additional salt management measures may be necessary to mitigate the environmental effects of road salts in that area. The Code encourages the identification and management of those salt vulnerable areas.

In Annex B of the Code of Practice, ECCC provides brief guidance to assist road organizations in identifying and prioritizing **salt vulnerable areas** such as provincially significant wetlands next to highways; areas draining into vulnerable groundwater recharge areas; areas draining into sources of drinking water where road salts could raise chloride concentration impairing the use of the source of drinking water; and others.

Once a vulnerable area has been identified, organizations may then determine the level of vulnerability and the need to implement additional salt management measures, such as:

- using technologies that further optimize the use of road salts;
- using environmentally, technically and economically feasible alternatives to road salts;
- increasing monitoring and measuring of chlorides and/or their impacts;
- locating patrol yards and snow disposal sites outside of vulnerable areas; or
- considering location and protection of vulnerable areas in the design of new roads and/or upgrading of existing roads.

Read more on the identification of salt vulnerable areas under Annex B at:
https://www.canada.ca/en/environment-climate-change/services/pollutants/road-salts/code-practice-environmental-management/identifying-areas-vulnerable.html

1.4 The *Clean Water Act, 2006*

The *Clean Water Act, 2006* ensures clean and sustainable drinking water for Ontarians, by protecting the quality and quantity of municipal drinking water sources including our lakes, rivers, and aquifers that supply groundwater wells. This Act was passed in 2006, in response to the recommendations of Justice O'Connor following the Walkerton drinking water contamination tragedy of May 2000. Communal and First Nations drinking water sources may also be included in the process.

The *Clean Water Act, 2006*, is available at: https://www.ontario.ca/laws/statute/06c22.
Under this legislation, the drinking water source protection program was established with funding from the Government of Ontario. Decision-making is led by local multi-stakeholder source protection committees. These Committees developed science-based assessment reports and source protection plans supported by local watershed-based source protection authorities, comprised of all of Ontario's conservation authorities and two other organizations. Some source protection areas work together as source protection regions, as shown in **Figure 1**.

For more information visit: http://conservationontario.ca/conservation-authorities/source-water-protection/.

1.4.1 The Science: Assessment Reports

The main purposes of the science-based local Assessment Reports are to identify vulnerable areas around municipal drinking water wells and intakes; and to identify threats that pose risks to sources of drinking water within these areas. The Assessment Reports are prepared

according to scientific methodologies laid out in the Director's Technical Rules, and are available at: https://www.ontario.ca/page/2017-technical-rules-under-clean-water-act
To access the Assessment Reports and related resources, visit the website: http://conservationontario.ca/conservation-authorities/source-water-protection/source-protection-plans-and-resources/

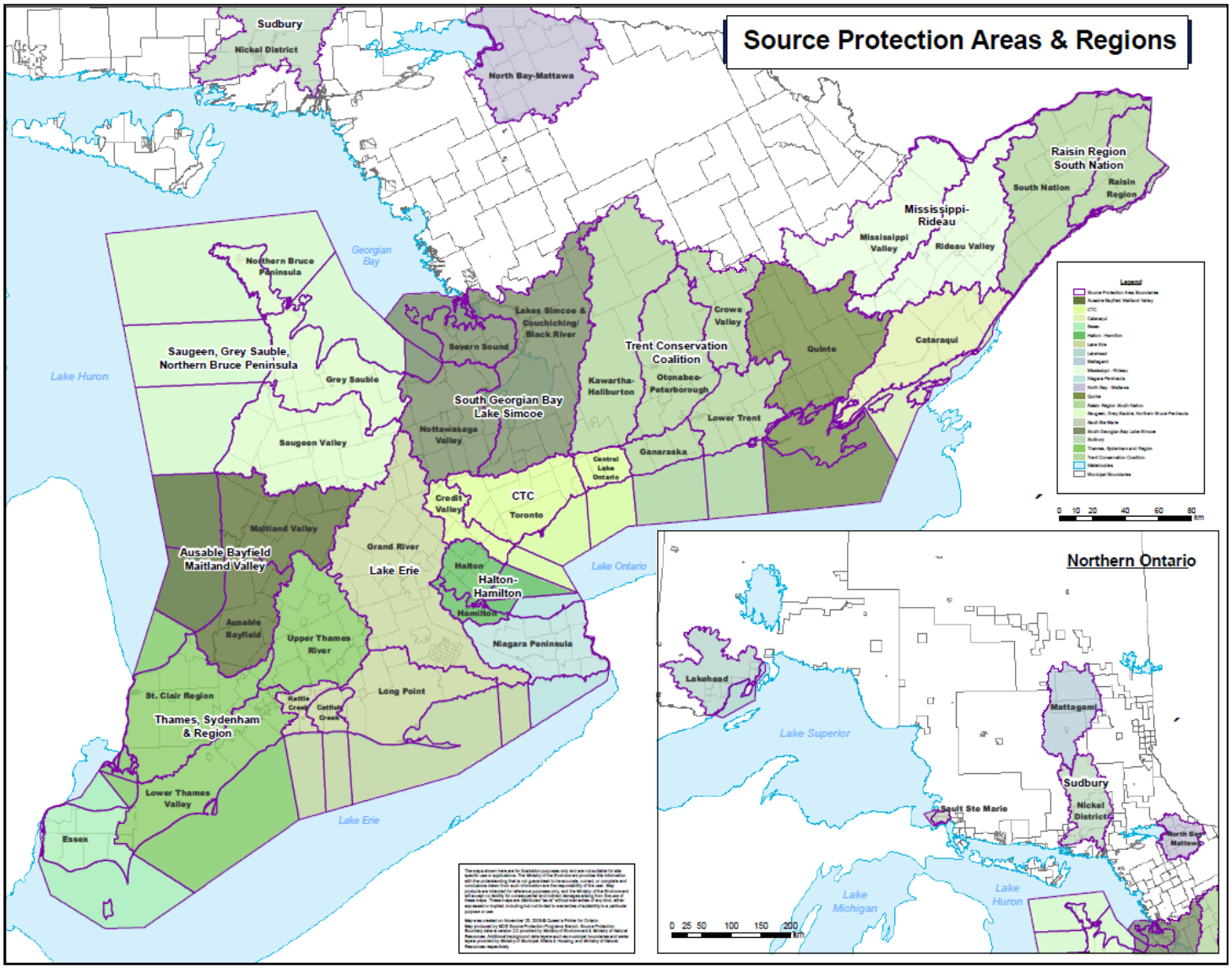

Figure 1: Source Protection Areas and Regions in Ontario

Vulnerable areas

The *Clean Water Act, 2006* requires that four vulnerable areas are delineated within each source protection area:

1. **Wellhead Protection Area (WHPA):** This is an area around a municipal wellhead established based on horizontal time of travel of water to the well and inherent susceptibility to contamination. WHPAs are also delineated where the groundwater aquifer quantity is under stress.
2. **Intake Protection Zone (IPZ):** This is an area around a municipal drinking surface water intake where contaminants could flow into the intake and could cause deterioration to the water quality. IPZs are also delineated where the surface water quantity is under stress.
3. **Highly Vulnerable Aquifer (HVA):** These are areas that are particularly susceptible to contamination based on factors such as the aquifer depth underground, the soil types, soil permeability and other characteristics of the surrounding soil or rock.
4. **Significant Groundwater Recharge Area (SGRA):** These are areas where significant volumes of surface water seep into the ground to replenish an aquifer that supplies municipal or other drinking water.

For more information on vulnerable areas delineated under the *Clean Water Act, 2006*, visit: http://conservationontario.ca/conservation-authorities/source-water-protection/source-protection-plans-and-resources/.

To view vulnerable areas delineated under the *Clean Water Act, 2006*, visit the Province of Ontario - Source Protection Information Atlas at: https://www.gisapplication.lrc.gov.on.ca/SourceWaterProtection/Index.html?viewer=SourceWaterProtection.SWPViewer&locale=en-US

Threats Identification

Within the vulnerable areas delineated per the *Clean Water Act, 2006*, certain 'activities' (existing or future) and 'conditions' (due to past activities) on the landscape are identified as threats to municipal drinking water sources, if they occur under specific circumstances as per the Tables of Drinking Water Threats, available at: https://www.ontario.ca/page/tables-drinking-water-threats#section-0

As of July 1, 2018, there are twenty-two prescribed threat activities under the *Clean Water Act, 2006*. Source protection committees are also able to add "local" threats where appropriate as a result of their local importance. Of particular relevance to the current guidance document are three of the twenty-two prescribed threat activities: road salt application; handling and storage of road salt; and snow storage.

While the focus of this document is on the application of road salt (sodium, calcium and other chlorides) for purposes of winter road maintenance activities, it should be noted that certain chlorides are also used as a dust suppressant. The use of chlorides as a dust suppressant is typically carried out during the summer months on unpaved roads. Dust suppressants can also

be applied at construction sites year-round, potentially contributing to increased concentrations of chloride in surface and ground water.

For each prescribed drinking water threat, there are specific circumstances that indicate whether the threat is considered to be a significant, moderate or low risk to municipal sources of drinking water. The level of risk of each threat influences the policy approach taken by a source protection committee to address the threat. A threat activity that is or could be at a significant risk level must be addressed through the source protection plan so that it ceases to be significant. A Threats Look Up Tool is available at: https://swpip.ca, which allows users to search through the Tables of Drinking Water Threats by the various activities and circumstances.

There are different methods to identify and assign risk levels to threats on the landscape:

1. **Vulnerability scoring approach:** Risk scores are calculated for each threat based on vulnerability scores for the relevant vulnerable areas, and the hazard rating of the threat. Risk scores form the basis of identifying the level of risk of threat activities in vulnerable areas. Through this approach, road salt application; handling and storage of road salt; and snow storage could be threats with significant risk levels within some portions of IPZs and WHPAs. For example, where IPZs and WHPAs have vulnerability scores of 8 or greater, the application of road salt may be a significant risk to drinking water sources. The percentage of impervious area where road salt may be applied can also factor into whether road salt application is a significant threat. Where IPZs and WHPAs have vulnerability scores of less than 8, the application of road salt can be low or moderate risk.

2. **Water quality issues approach:** Water quality issues identified by source protection committees are due to human activities and are known to have caused, or are trending towards causing, the deterioration of source water quality for drinking water purposes. Issues identified in Ontario include sodium and chloride. An **Issue Contributing Area (ICA)** is the delineated region within a vulnerable area, where land-based activities contribute or may contribute to the presence of an issue in source water. Activities which occur in the ICA that can contribute to the identified water quality issue are deemed significant drinking water threats. Through this approach (in conjunction with circumstances that make an activity a threat), road salt application; handling and storage of road salt; and snow storage would be identified as a significant threat within an ICA for sodium and chloride.

3. **Event-based areas approach:** This approach is only used for larger surface water bodies, and is based on the transport of contaminants to intakes impacting water quality during extreme weather events.

See **Appendix B** for maps of the sodium and chloride issue contributing areas delineated in Ontario under the *Clean Water Act, 2006*.

1.4.2 The Policies: Source Protection Plans

The identified threat activities and conditions are addressed through local source protection plans containing policies developed by local, multi-stakeholder source protection committees. There is a range of policy tools that can be employed to manage or prohibit a significant drinking water threat. These policy approaches include 'soft' tools such as education and outreach or incentive programs. Regulatory tools such as risk management plans or provisions under the *Planning Act* could require best management practices to ensure that a threat is mitigated. Source protection committees also had the option of prohibiting an activity, but this approach was typically used as a last resort and the committee had to justify the rationale for their decision. The policies addressing significant drinking water threats are legally binding (mandatory) for the implementing body to which they are directed.

Source protection plan policies across Ontario are implemented by municipalities the Province of Ontario, landowners and renters undertaking significant threat activities, conservation authorities, and others.

Visit http://conservationontario.ca/conservation-authorities/source-water-protection/source-protection-plans-and-resources/ to access all Source Protection Plans developed under the Clean Water Act, as well as other resources.

2. FINDING THE BALANCE: LEGAL FRAMEWORK, GUIDANCE, AND SALT VULNERABLE AREAS

2.1 Finding the Balance

This section briefly discusses some of the commonalities, challenges and viable solutions in implementing the applicable legal frameworks and guidance related to road salt in Ontario, namely the *Municipal Act, 2001*, the Minimum Maintenance Standards (O. Reg. 239/02), the *Clean Water Act, 2006*, the *Environmental Protection Act*, and the federal government's Code of Practice for Environmental Management of Road Salts (2004).

As mentioned previously, as a result of the principle of joint and several liability, municipalities are reluctant to adopt any winter maintenance treatments or techniques that might affect their Council-approved Level of Service. Further, substances used for keeping a highway safe for traffic under conditions of snow, ice or both, are exempt from being classified as a "contaminant" under the *Environmental Protection Act* and its regulations as a result of the operation of Regulation 339 *Classes of Contaminants - Exemptions*.

Municipalities have been able to develop salt management plans in response to the Environment and Climate Change Canada (ECCC) Code of Practice, while maintaining the Council-approved Level of Service, following the *Municipal Act, 2001* and meeting the Minimum Maintenance Standards outlined in O. Reg. 239/02. Municipalities must also conform to source protection plans under the *Clean Water Act, 2006* by implementing legally binding policies that mitigate the impacts of road salt on municipal drinking water sources.

Source protection plan policies seek to mitigate and manage negative impacts to municipal drinking water sources, including the impacts of road salt application, road salt handling and storage, and snow storage. Some of the source protection plan policy approaches to these threat activities are summarized below:

- **Salt management plan updates:** policies may direct municipalities to update their salt management plans to ensure the protection of municipal drinking water sources, including the addition of *Clean Water Act, 2006* vulnerable area mapping in the salt management plans.
- **Risk management plans:** policies may require that private parking lots and roads be subject to risk management plans that address the impacts of road salt storage and application and snow storage on municipal drinking water sources. These plans often require the use of best management practices, such as parking lot design to manage drainage and snow storage locations, or operational controls to require operator training, equipment calibration, and monitoring.
- **Land use planning:** policies may require planning approval authorities to consider water quality while planning for the use of tools such as low impact development (LID), to ensure the protection of ground water from road salt impacts.
- **Training:** policies may encourage training (e.g."Smart About Salt" winter salt management program) for road operations staff, managers and winter maintenance contractors who are under contract to municipalities to provide winter maintenance

services, to better understand the impacts of road salt on drinking water sources, to become familiar with *Clean Water Act, 2006* vulnerable areas, sodium and chloride issue contributing areas, and policy requirements of source protection plans.

ECCC is currently working on the development of guidance to assist road organizations in identifying and prioritizing salt vulnerable areas. In addition to considering aquatic species, terrestrial species, and agricultural and valuable land, the approach being developed by ECCC also takes into consideration drinking water sources (surface water or groundwater) recognizing that the addition of road salt in areas draining to sources of drinking water has the potential to raise the chloride concentration to the point where it could not be used as a source of drinking water.

ECCC is strongly encouraged to consider adapting the methodologies established under Ontario's *Clean Water Act, 2006*, for the delineation of drinking water vulnerable areas and ICAs.

2.2 Prioritization of Salt Vulnerable Areas

In developing this guidance, the multi-stakeholder Salt Vulnerable Areas working group extensively discussed and considered the applicable legal frameworks, existing guidance documents, and the salt vulnerable areas delineated around municipal drinking water sources through the *Clean Water Act, 2006*. **Based on their analysis, the working group recommends that in implementing best practices for road salt management by road organizations, drinking water vulnerable areas be prioritized in the order listed below:**

1. **Issue Contributing Areas** for sodium and/or chloride (delineated per the *Clean Water Act, 2006*) are the highest priority areas.
2. **Intake Protection Zones and Wellhead Protection Areas** (delineated per the *Clean Water Act, 2006*) where road salt related activities are significant level threats.
3. **Other areas** delineated per the *Clean Water Act, 2006* where road salt related activities are low or moderate level threats.

While the intent of employing good practices is the protection of municipal drinking water sources, in all instances the protection of the travelling public must be paramount in selecting the most appropriate operational practices for local road authorities to adopt.

The working group acknowledges that there are several types of 'salt vulnerable areas', with various other important environment and human health goals such as aquatic habitat, wetland health, fisheries and agricultural crop yields. **To reiterate, this document focuses on vulnerable areas around municipal drinking water sources that are susceptible to road salt impacts**. It supports the implementation of applicable source protection plan policies.

3. ROAD SALT GOOD MANAGEMENT PRACTICES

This section describes good management practices that may help municipalities of varying financial and resource capacities in Ontario find the equilibrium in implementing the ECCC guidance, the *Municipal Act, 2001*, and the *Clean Water Act, 2006* requirements.

3.1 Weather Monitoring

Having accurate information about current and forecasted weather conditions and pavement conditions, allows municipalities to pretreat their roads before a winter event arrives. Not only does this increase the safety of the road for users, but also reduces the amount of road salt required to achieve their local Level of Service.

1. **Value Added Meteorological Service (VAMS)** Subscription to a VAMS provider enables you to receive customized weather forecasts four times a day that are specific to your area. The Minimum Maintenance Standards require you to monitor weather conditions three times a day. Subscribing to a VAMS will achieve those requirements as well as give you the information you need to adjust the application rates of road salt to meet local pavement and weather conditions.
2. **Road Weather Information System (RWIS)** Consider installing or accessing nearby RWIS stations to monitor pavement and weather conditions in your immediate vicinity. The Ministry of Transportation has an extensive network of RWIS stations across the province. They will grant municipalities access to relevant segments of their RWIS network provided certain conditions are met. Contact MTO for more information. Some road agencies in your vicinity may have their own RWIS stations that they might allow you to access within certain terms and conditions.

3.2 Equipment

Winter maintenance equipment has become much more sophisticated over the past two decades. A major advancement has been the use of brine, both as a pre-wetting agent, and to pretreat roads to prevent frost and black ice, and the bonding of snow and ice to the pavement. This enables plows to reach bare pavement, which improves safety. In addition, computerized spreader controls allow for much more control over the volume of salt being applied, and far more accurate records of the volume of salt being used.

Municipalities may wish to consider the advice offered in Transportation Association of Canada's (TAC) Syntheses of Best Practice, Road Salt Management, Booklet 9, Winter Maintenance Equipment and Technologies:

> *As new equipment is phased in, priority should be given to allocating the new equipment to Service areas adjacent to salt vulnerable areas, and reallocating less salt-efficient equipment to less sensitive areas. Technologies such as the use of liquids should be implemented as a way of reducing salt use and improving safety.*

Visit: http://www.tac-atc.ca/en/bookstore-and-resources/free-resources-and-tools/syntheses-practice for more information. The following points represent options to improve the efficiency of your winter maintenance equipment. They are offered for your consideration as the local budget allows:

1. **Computerized Spreader Controllers** enable spreaders to maintain consistent salt application rates at different ground speeds, to communicate with AVL systems and to generate accurate records of the amount of salt being applied.
2. **Air and Pavement Temperature Sensors** on both your patrol vehicles and your plow and spreader equipment will assist you in monitoring temperature trends to determine appropriate application rates.
3. **Automatic Vehicle Location (AVL)** systems in your plow and spreader equipment will assist you in tracking salt usage, monitoring equipment location and operational speeds, and handling public concerns.
4. **Carbide Reinforced Plow Blades** conform to the roadway and effectively remove snow, resulting in reduced salt usage.
5. **Spreader Calibration** should be conducted at least twice per season (beginning and mid-season) to ensure accurate application rates, as well as after every repair to the truck.
6. **Onboard Pre-wetting** tanks deliver liquid to salt just before it is applied to roadway. This reduces scatter, activates the salt, enhances its melting capacity, and allows for reduced salt usage.
7. **Direct Liquid Application (DLA)** reduces the amount of chlorides required by up to 10 times by preventing formation of the bond between ice/snow and the pavement. DLA is also effective as a pretreatment for frost events and to prevent black ice from forming.

3.3 Personnel

1. Train all of your Operators before the start of the winter season on both the theory of road salt management and the practical aspects of operating the specialized equipment features and accessories you have installed to support your salt management plan. Even veteran snowplow Operators will benefit from refresher training before the season begins.
2. As local budgets and staff capacity allow, municipalities may wish to consider assigning a Winter Maintenance Specialist to administer their salt management plan and ensure it remains effective. The specialist would ideally have these qualifications and experience:
    - Minimum of 3 years of experience in road operations and winter maintenance
    - Has attended and successfully completed suitable winter maintenance training, such as OGRA's Snow School
    - Is completely familiar with the Local Source Protection Plan for your watershed
    - Is completely familiar with Municipal Maintenance Standards ON Reg. 239/02 and the Council-approved Salt Management Plan for your municipality.

3.4 De-Icing Materials

Deicing is a snow and ice control strategy of removing compacted snow or ice already bonded to the pavement surface by chemical or mechanical means or a combination of the two.

A de-icing chemical must work its way through snow and ice to the road surface to where the bond can be broken and the snow and ice plowed off.

De-icing includes pre-wetted, pre-treated and dry salt applications. Usually de-icing treatments are deployed in combination with plowing, as de-icing by itself has limitations due to:

- Snow and ice accumulation
- Road surface temperature
- Traffic volume

Table 1 summarizes the advantages and disadvantages of the most common de-icing materials currently in use by road agencies in Ontario.

Calcium Chloride and Magnesium Chloride have several uses, including as a pre-wetting agent, mixed with sand to prevent it from freezing, and as a Direct Liquid Application. Their effectiveness at temperatures lower than the generally accepted lowest effective working temperature of minus 7^{o}C for sodium chloride, makes them particularly useful for a broader range of winter conditions. However, their hygroscopic properties must be kept in mind and their use under humid conditions is to be avoided as the road surface can become slippery.

Modified agricultural by-products are derived from products as diverse as sugar beets, corn, beer mash, and whiskey mash. Even the brine from pickle and cheese production has been tested. However, when they biodegrade in water, agricultural by-products have a high biological oxygen demand. This means they decrease dissolved oxygen, which impacts water quality. Studies by MOECC and Toronto and Region Conservation Authority (TRCA) suggest that for some water bodies, agricultural by-products could be much worse than chloride-based salts. A study conducted by TRCA is available at:

http://www.sustainabletechnologies.ca/wp/wpcontent/uploads/2015/11/AlternativeSalt_TechBrief_Nov2015.pdf

Table 1: Advantages and Disadvantages of Common De-icing Materials

Advantages*	Salt (NaCl)	Salt Brine (NaCl)	Calcium Chloride (CaCl)	Magnesium Chloride (MgCl)	Modified Agricultural By-Products
Effective melting action at relatively low cost	•				
Works well in moderately cold weather (to minus 7°C)	•	•			
No cleanup (as with abrasives)	•	•	•	•	•
Readily available	•	•			
Can be manufactured in-house		•			
Accelerates reaction time of dry salt		•			
Works at lower temperatures than sodium chloride			•	•	
Can be added to sodium chloride and magnesium chloride					•
Used as a pre-wetting agent		•	•	•	•
Lowers freeze point of sodium chloride				•	•
Reduces corrosiveness					•
Reduces volume of solid sodium chloride required		•	•	•	•
Disadvantages*					
Effectiveness drops with pavement temperature	•				
Corrosive	•	•	•	To aluminium	
Environmental concerns	•	•	•	•	•
Limited effective temperature range as a direct liquid application (DLA)		•			
Greater need to wash / neutralize salt on equipment		•			
Absorbs moisture from surroundings			•		
Can re-freeze			•		
Avoid use in warm temp (above +7°C)			•		
Some safety concerns regarding handling			•	•	
More expensive than salt			•	•	•
May have quality control concerns					•
Mould in material storage facility					•
Not readily available					•
May separate out in storage					•
Odour and/or public complaints about odour					•
May require equipment modification					•

*** Each chemical should be researched before use for effectiveness and limitations based on local circumstances.**

3.4.1 Effective Working Temperatures of Common De-Icing Materials

Pavement surface temperature has a major effect on how ice control chemicals perform and ultimately, on the treatment decision itself. Snowplow operators should apply only the amount of deicing chemical required to be effective. Too little and the road will refreeze. Too much is a waste of money and resources. When the pavement temperature drops below -7°C the effectiveness of road salt (NaCl) is significantly reduced, so road agencies may choose to add other chemicals to the salt, such as calcium chloride or magnesium chloride, which will lower the freezing point even further. In short, depending on local Level of Service goals, pavement temperature is a significant factor in deciding whether to plow only, plow and apply chemicals, or plow and apply abrasives.

At pavement temperatures near the freezing point, all deicing chemicals work well. A far more important operational consideration is determining the **lower** pavement surface temperature at which the chemical will no longer work within a reasonable timeframe (e.g. less than one hour) and at practical application rates, such as those shown for road salt in Tables 4 and 5. For purposes of this document, the lower temperature has been characterized in Table 2 as the ***Lowest Effective Working Temperature*** for the most common deicing chemicals.

Table 2: Lowest Effective Working Temperatures of Common De-icing Materials

Material	Lowest Effective Working Temperature (°C)
Sodium Chloride	-7
Magnesium Chloride	-23
Calcium Chloride	-29

Note: The materials may work below the specified lowest effective working temperatures, but the effectiveness decreases; the materials will not work well within a reasonable timeframe.

(Source: *Clear Roads*, Chapter Two, Minnesota Department of Transportation Maintenance Manual, St. Paul, MN, October 2010
http://www.dot.state.mn.us/maintenance/pdf/manual/Ch2.pdf)

3.4.2 Timing of Application

Anti-Icing

Anti-icing materials, including Direct Liquid Application, are usually applied *prior* to the start of a winter event but can also be reapplied during the event.

Table 3: Advantages and Disadvantages of Anti-Icing Materials

Advantages	• Snow is easier to remove by plow, as snow and ice are prevented from bonding to the road surface. • Creates safer road conditions quicker with less chemicals used than de-icing. • Especially effective in frost and black ice conditions including on bridges. • Residual chemical remains present if applied just before a winter event. • If applied much earlier, water will evaporate leaving salt crystal residue, which will dissolve and form brine when moisture is present. This enables road crews to pretreat roads well ahead of a forecasted winter event.
Disadvantages	• Additional moisture will dilute the residual chemical and cause slippery road conditions if not acted upon. • An extremely slippery "slurry" condition can occur when there is low humidity and pavement temperatures above +7^{o}C. This condition is more prevalent when magnesium chloride, calcium chloride, or agricultural byproducts are present in the salt brine.

De-Icing

De-icing is a **reactive** use of a melting agent which is applied *after* a bond has been formed between snow/ice and the road surface.

3.5 Application Methods and Application Rates

3.5.1 Pre-wetting with Brine

Pre-wet salt with brine before it is applied to reduce scatter, accelerate melting, and reduce application rates. Pre-treated salt is also a good alternative. Road salt can be pre-wetted on the spreader at the point of discharge, or you may choose to treat your stockpile. Up to 30% less salt is needed if pre-wetted because of reduced scatter on the road surface. Pre-wetting enhances melting action by creating brine. Pre-treating sand with liquids will provide bonding on icy roads as well as melting action.

Note: Adjustment of the spray nozzles is essential to ensure optimal brine coverage of dry salt as it leaves the spinner.

3.5.2 Direct Liquid Application

For best results, the spray bar should deliver the liquid downward in a striped pattern using pencil nozzles. Direct Liquid Application (DLA) can significantly reduce the volume of road salt required compared to the application of dry salt alone. The chloride residue on the road prevents a bond from forming between ice and snow and the pavement, thus reducing the plowing effort required to reach bare pavement conditions. DLA is also an effective pre-treatment to prevent frost and black ice conditions.

3.5.3 Planning Plow Routes

Plan plow routes carefully to ensure road sections and intersections are not double salted. OGRA's *Winter Web App* is a free online application with interactive maps to assist you in the development of a customized salt management plan for your municipality, including plow route planning. Contact Fahad Shuja fahad@ogra.org for more information or assistance in accessing the application from OGRA's website www.OGRAapps.com.

The following charts offer sample application rates for Ontario's most common anti-icing products under varied conditions. These rates are offered as suggestions and do not constitute hard and fast rules, as local conditions such as humidity, precipitation type, traffic, etc. can all affect the most appropriate application rates, or more accurately put, the ***results*** of specific application rates. The rates shown are variable to assist you in adjusting for the conditions listed above, as well as other factors unique to your road network.

Dry Salt (sodium chloride NaCl)

- Application rates are **kg/2-lane km** applied at centre line (as close to the crown as possible in a 30 cm strip)
- Ground speed: 40 km/hr

Table 4: Dry Salt Application Rates

Weather Condition	**Pavement Temperatures/Application Rates (kg/2-lane km)**		
	0° C to -5° C	**-5 °C to -10° C**	**-10°C to -18°C**
Frost	Not applicable	Not applicable	Not applicable. **These temperatures are too low for NaCl to be effective. There is potential for refreeze or excessive use of salt.**
Light snow	100	125	
Heavy snow	150	150	
Freezing rain	150	200	

Pre-wetted Salt (sodium chloride NaCl)

- Application rates are **kg/2-lane km**
- Concentration: 23.3% (salt brine)
- Brine applied at 4.5% per volume
- Ground speed: 40 km/hr

Table 5: Pre Wetted Salt Application Rates

Weather Condition	**Pavement Temperatures/Application Rates (kg/2-lane km)**		
	0° C to -5° C	**-5 °C to -10° C**	**-10°C to -18°C**
Frost	50	70	70
Light snow	70	100	130
Heavy snow	130	130	170
Freezing rain	130	170	170

Anti-Icing With "Enhanced Brine"

- Salt brine with added magnesium chloride ($MgCl_2$), or calcium chloride ($CaCl_2$), etc. - ***NOT for sodium chloride brine alone***
- Ground speed: 40 km/hr

Table 6: Enhanced Brine Application Rates

Application	Light Traffic /Low Volume	Heavy Traffic / High Volume
Frost & black ice prevention	20 to 40 litres/lane km	30 to 50 litres/lane km
Anti-icing	60 to 90 litres/lane km	80 to 110 litres/lane km
De-icing	120 to 140 litres/lane km	140 to 160 litres/lane km

Anti-Icing Using Salt Brine Only

- Ground speed: 40 km/hr

Table 7: Salt Brine (Only) Application Rates

Application	Light Traffic /Low Volume	Heavy Traffic / High Volume
Frost & black ice prevention	30 to 50 litres/lane km	40 to 60 litres/lane km
Anti-icing	80 to 110 litres/lane km	100 to 130 litres/lane km
De-icing	Not applicable	Not applicable

How Much Ice Is Melted For The Quantity of Salt?

In selecting the most appropriate application rate for your local conditions, you may find it helpful to consider the length of time it takes a kilogram of salt to melt a quantity of ice under various pavement temperature conditions. Clearly the colder the temperature, the longer it takes for salt to achieve melting.

Table 8: Amount of Ice Melted for Amount of Salt Used

Kilograms of Ice Melted per Kilogram of Salt (NaCl)		
Pavement Surface Temperature		**Time It Takes to Melt Ice**
-1°C	**1 kg of NaCl will melt 46 kg ice**	5 minutes
-4°C		10 minutes
-7°C		20 minutes
-9°C		60 minutes
-12°C		ineffective
-15°C		ineffective
-18°C		ineffective

(Adapted from the Snow and Ice Management Association)

3.6 Snow and Ice Control Methods

3.6.1 Sidewalks

New municipal standards are being written for the winter maintenance of sidewalks. As of the publication of this document, the new standards had been recently approved by the Province of Ontario under O.Reg. 366/18 and will ultimately be merged with O.Reg. 239/02.

3.6.2 Snow Storage and Disposal Sites

The primary purpose of snow storage and disposal sites is to manage snow that would otherwise be a hazard to the public or impair winter maintenance operations. The snow that is stored at snow disposal facilities contains contaminants that are deposited on the ground or carried away with the melt water as the snow melts. The melt water and debris must be managed and should not be discharged back into the environment until properly treated.

When planning, designing and operating a snow disposal site, the following guiding principles should apply, per **Book 8: Snow Storage and Disposal**, Syntheses of Best Practice, Road Salt Management, published by the Transportation Association of Canada:

- A properly engineered Snow Management Facility that meets all applicable environmental requirement, as applicable
- Public safety is the priority. Organizations must ensure that the hazards caused by accumulated snow are efficiently and safely addressed.
- Snow disposal sites should be located and operated to minimize impacts to the natural environment and control nuisance effects, including noise, dust, litter and visual intrusion on adjacent landowners.
- The actual snow disposal area within the site boundary should be clearly delineated in a way that is easily identifiable under adverse winter conditions, to ensure that the snow is placed in the proper location on the site.
- Melt water must be managed in compliance with local water quality regulations and in a manner that protects surface and groundwater resources.
- Onsite litter, debris and sediment from the melt water settling area must be collected and disposed of in accordance with local waste management legislation.
- Emissions (drainage, noise, dust, litter, fumes) must be controlled to prevent offsite environmental impacts.
- The design of snow handling, storage and disposal facilities must be practical and must not impose undue maintenance requirements.
- On site snow storage for parking facilities should be placed in the low area of the site to prevent melt water from flowing across the site and refreezing on surfaces that still contain frost.

For more details on snow storage, refer to **Book 8: Snow Storage and Disposal**, Syntheses of Best Practice, Road Salt Management, by the Transportation Association of Canada, available at: http://www.tac-atc.ca/sites/tac-atc.ca/files/site/doc/resources/roadsalt-8.pdf

3.6.3 Snow Fences

Consider the use of snow fences to address blowing snow in the open areas of your road network.

Consider the following before proceeding with the installation of a snow fence:

- Prevailing wind direction
- Physical features of the site (topography, road alignment, structures, vegetation)
- Snow storage capacity

The Strategic Highway Research Program offers an excellent set of technical guidelines for the design and placement of snow fences. We encourage you to reference their **Snow Fence Guide**, SHRP-W/FR-91-106 for detailed instructions, at: https://www.extension.iastate.edu/forestry/publications/PDF_files/SHRP-H-320.pdf

3.6.4 Living Snow Fences

Living snow fences involve planting vegetation such as trees near roadways to inhibit snow from blowing onto neighbouring roads. Alternatively, arrangements can often be made with farmers to allow several rows of corn stalks adjacent to the road to be left standing over the winter to act as a living snow fence.

Along with several other municipalities, Peel Region has run a successful Living Snow Fence Program in partnership with local farmers and residents for a number of years. Information about Peel's program can be found at www.peelregion.ca/pw/transportation/residents/living-snow-fences.

3.7 Water Quality Monitoring

Our surface and groundwater resources are sources which serve our municipal drinking water systems. For this reason, it is important for us to understand the condition of these resources. Monitoring the quality of surface water and groundwater allows for an understanding of the condition of streams, lakes, and aquifers, allows for the comparison of how these conditions vary from one region to another; whether conditions are changing over time; how natural features and human activities affect those conditions; and where those effects are most pronounced (World Meteorological Association, 2013).

The Province of Ontario has established provincial water quality monitoring programs which are generally implemented by the 36 conservation authorities. The information already collected from these programs can help to characterize the quality of water in the lakes, rivers, and aquifers which are in the general vicinity of your municipality. The locations of sampling sites included in the Provincial Water Quality Monitoring Network can be found at: https://www.ontario.ca/environment-and-energy/map-provincial-stream-water-quality-monitoring-network . Similarly, the water quality of aquifers monitored through the Provincial Groundwater Monitoring Network can be found at: https://www.ontario.ca/environment-and-energy/map-provincial-groundwater-monitoring-network.

When these provincial sites were selected, it was to provide a coarse understanding of the state of water quality in the Province. To enhance the information provided by these networks, many conservation authorities have additional water quality monitoring sites to further characterize the condition of water resources within their jurisdiction. Therefore, it is advised that there be contact with conservation authority staff to understand to what extent the results obtained through their monitoring networks have shown that the application, handling and storage of road salt has impacted the aquifers, rivers, and lakes in and around your municipality.

The information generally collected through a water quality monitoring program fall within two categories: field parameters (usually measured with a field probe or meter) and analytical results (measured by an accredited laboratory). For the purposes of determining the impact of the application, handling and storage of road salt on water resources, the parameters of interest will include pH, specific conductance, chloride, sodium, and total dissolved solids. Measuring the presence and concentration of the parameter bromide, should also be considered as it can assist in distinguishing a source when the contamination may be coming from something other than the salt storage facility. The parameters listed above would be part of the suite of information collected by your conservation authority to characterize the condition of sites which are part of the provincial networks.

After establishing contact with your local conservation authority, you may find that not enough information is available about the facilities and practices with your municipality. For example, your municipality might have a salt storage and handling facility for which there is interest in determining whether there is runoff from this site. In such cases, it would be advisable to establish a targeted monitoring program on a much finer scale. Note that not all areas in Ontario have conservation authorities. Some municipalities may seek support from local environmental organizations.

Before initiating a targeted monitoring program, it is important to define the 'goals' of this investigation. The definition of goals will help you determine the types of parameters to be measured, the frequency, and the locations of monitoring sites. Some of the monitoring objectives you might want to identify could include:

- The identification of water quality problems;
- To determine compliance;
- To ascertain whether there are point sources of contaminants; and
- To support program development.

For example, the installation of groundwater monitoring stations (test wells) in key locations within your Issue Contributing Areas, including your Works Yards, as well as near salt storage and monitoring surface water quality in stormwater runoff areas, can aid in the determination of the extent of any impacts and effectiveness of any mitigation measures taken. A best management practice would be to monitor shallow groundwater quality using up-gradient and

down-gradient monitoring wells if applicable. Groundwater monitoring should be completed for new facilities prior to the site being commissioned to provide baseline information for potential future comparisons.

To ensure that you have created a program that will provide you with the answers to the questions you are hoping to address, your municipality should consider reaching out to professionals such as water quality specialists, engineers, and geoscientists.

3.8 Parking Lots

As with road networks, the mechanical removal of snow by plow or shovel remains the most effective method on parking lots. Studies by the Lake Simcoe Region Conservation Authority and the University of Guelph, have shown that 30-80% of the road salt applied in urban watersheds could be on parking lots. It is recognized that better planning and management of road salt related activities is needed for parking lots as well.

3.8.1 Application Rates

Unlike roads, there are no industry accepted standards for salt application rates on parking lots. This applies to private facilities as well as municipally owned facilities such as sports arenas, libraries, water and wastewater treatment plants, etc. A suggested starting point for determining salt application rates in parking lots would be to adopt the rates recommended by the Snow and Ice Management Association, shown below. Adjustments can then be made according to on site conditions at the time. Also, consider the factors shown in Table 9 to determine appropriate application rates.

- 250-300 lbs/ac (28 – 34 g/m^2) for pre-treating surfaces prior to or upon accumulation of ½ inch or less, and maintaining after each snow clearing cycle.
- 500 – 600 lbs/ac (56 -67 g/m^2) for deicing lots after clearing snow.

Table 9: Factors to Determine Salt Application Rates in Parking Lots

Factor	Comment
Surface Temperature	Vehicle mounted infrared thermometers can be used to monitor surface temperature.
Surface Type	Black asphalt holds heat better than concrete.
Type of Precipitation	Wet snow at temperatures closer to the freezing point holds more moisture and requires more salt than snow at colder temperatures.
De-icing Products Available	Premium de-icing products have a much lower freezing point and therefore can melt snow more effectively so less salt may be required. Refer to materials information in section 2.4
Time of Day	Night time temperatures are generally colder than day time.
Time of Year	Surface temperatures are warmer in November than in February.
Residual De-Icing Material	If the parking lot was salted the day before and there was no additional melting, more salt will not be required.
Site Specific Features	Adjust the application rate as required.

3.8.2 Method

Before undertaking any winter maintenance on the site, first establish the following**:**

1. Create a site plan that shows:
    - Hard surface locations and area measurements
    - Walkways
    - Entrances and exits
    - Accessible parking stalls and ramps
    - Loading zones
    - Snow storage areas
    - Green space
    - Areas requiring special attention, such as potholes, cracks, downspouts discharging onto hard surfaces. Correct these or note them before the winter season to prevent problems.
2. Mark off areas requiring no service (e.g. green areas, sections under construction, etc.).
3. Consider installing a snow fence, if possible.
4. Review the weather forecast.
5. Determine surface temperatures using an infrared thermometer.
6. Plow and/or shovel first.
7. Choose appropriate de-icing materials and application rate as per 3.8.1.
8. Clean up over-applied salt.
9. Record the following:
    - Before and after site conditions
    - Material quantities applied
    - Surface temperatures
    - Current weather forecast
    - Staff and equipment time

3.8.3 Personnel

Operators should be trained on:

- Salt Science
- Limitations of Salt
- Weather basics
- Environmental concerns
- Plowing/shoveling techniques
- Safety
- Record keeping
- Calibration of equipment
- Identification of hazard areas

Facility managers should be trained on:

- Salt Science
- Limitations of salt

- Environmental concerns
- Site evaluation

Note that the Smart About Salt certification training covers all of the above topics.

3.8.4 Site Considerations

Every site has physical issues that need to be identified and corrected before winter to minimize excess salt usage and to reduce liability. Examples include:

- Potholes
- Cracks
- Downspouts that empty onto hard surfaces
- Melt water from snow piles placed on the high side of site
- Doors positioned into prevailing winds (subject to blowing snow issues)
- Areas that need to be blocked off if they cannot be safely maintained
- Other site specific features.

Note that often these areas are maintained by contractors who are trained to apply the appropriate amount of road salt, and this helps avoid over application by others.

3.9 Road Salt Storage Practices

Road salt should be stored indoors on an impermeable (asphalt or concrete) pad. The pad should drain water away from the storage facility, be free of cracks or other escape routes for drainage, and have features to control for spillage or drainage.

The basic principles of road salt storage are:

- Keep it dry
- Keep it covered
- Prevent salt loss and spillage
- Keep it contained

Similarly, brine tanks should be housed on an impermeable pad with sides high enough to contain the contents of the tank in the event of a spill or leak.

Tanks and hoses should be inspected pre and post-season for leaks and cracks. Pipes and valves should also be inspected pre and post-season and maintained.

3.10 Annual Review of Salt Management Plan

Start the process by reviewing and adjusting your Salt Management Plan (SMP) annually. Consider the 'good practices' laid out in this document, as you fine-tune your SMP. Being aware of current best available practices is helpful, as is comparing notes with neighbouring and similar sized municipalities. Monitor and evaluate SMP implementation, to help identify gaps between policy and practice.

A convenient, no-cost option to assist you in this process is the **Winter Planner Add-On** to OGRA's *Winter Web App*. Contact Fahad Shuja fahad@ogra.org for more information or assistance in accessing the application from OGRA's website www.OGRAapps.com.

3.11 Risk Management Plans for Road Salt Application, Handling and Storage of Road Salt, and Snow Storage

As source protection plan policies are being implemented across Ontario, local Risk Management Officials (RMOs) are negotiating risk management plans (RMPs) with landowners to address certain threat activities, as required under the *Clean Water Act, 2006*. Some source protection plan policies outline specific measures to include in the RMP, while others are less specific thus allowing the RMO to use professional judgment and discretion.

The RMPs being negotiated to address road salt related activities (application, handling and storage, and snow storage) include measures such as:

- Any existing risk management measures already in place
- The measures most suitable to reduce the risk posed by the activity
- Provisions for consideration of the following:
  - Vulnerable areas
  - Water courses
  - Storage facilities (permanent and temporary) for salt
  - Site drainage.
- Protocols and emergency measures to be followed in the event of a spill and any other measures deemed necessary to reduce the risk of a release to the environment
- Requirements for appropriate training of any personnel applying road salt
- The timing of plan implementation
- Monitoring and reporting requirements
- A provision that the RMO is to be notified of any changes in operation such that the RMP can be updated; and
- A provision in reference to Section 60 of *Clean Water Act, 2006* O. Reg. 287/07 indicating that the RMP may not be transferred to another person without the written consent of the RMO.

3.12 Additional Proposed Approaches to Salt Management within Issue Contributing Areas

The working group discussed additional approaches that municipalities may wish to consider:

- Municipalities, particularly those in urban areas, may wish to consider seeking Council approval to reduce the posted speed limit on roads within ICAs. This would have the effect of adjusting the committed Level of Service and consequently the volume of chemicals entering the environment in these highly vulnerable areas. It should be noted that because deicing material can be dragged by the traffic for approximately half a kilometer into the next zone, the designation of a stretch of road for such a strategy should be at least three or four kilometers long.
- In addition, this strategy should be accompanied by a vigorous public awareness campaign, including prominent signage indicating the location of "***Drinking Water Protection Zones***", information explaining the reasons for the adjustment distributed via property tax bills or municipal utility bills, public consultation meetings, and information on the municipality's website.
- Realigning roads to eliminate super elevated curves

- Raising roads higher than the adjacent topography
- Cut grass and vegetation in the right-of-way short to prevent it from catching blowing snow.

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Appendix A: Level of Service and Minimum Maintenance Standards

Level of Service

A municipality's Level of Service is a statement of policy that has been approved by Council, and sets out what the municipality will do to meet public expectations with respect to the maintenance of its road network and related infrastructure, taking into account its available resources and local historic experience with similar events.

Minimum Maintenance Standards versus Level of Service

Minimum Maintenance Standards versus Level of Service Ontario Regulation 239/02 as amended from time to time, provides municipalities with a defence against claims. In order to use the defence provided in section 44(3)(c) of the Municipal Act 2001 a municipality via their record keeping must prove that at the time an action arose the alleged default was covered by the standard and that the service provided by the municipality met or exceeded the standard. A municipality does not need to adopt MMS as policy to use the defence; it is record keeping that is important for a municipal defence and proves whether or not the standard was met. The MMS are a statutory defence whereas a LOS policy is a goal/target. In theory, neither the MMS nor LOS policies are legally enforceable "standards", but if a municipality is sued, failure to comply with the same will be considered by the Courts in determining the question of negligence.

A Level of Service policy (LOS) sets an obligation for the municipality to make reasonable efforts to achieve same, and the municipality must put itself in a position, by proper record keeping, to demonstrate that fact. If a municipality, for financial or other reasons, is incapable of compliance with the MMS and sets itself a level of service that falls short of the MMS, the protection of the MMS will be lost and the municipality will be required, if it is to have any hope of avoiding liability, to demonstrate that its level of service was reasonable in the circumstances. It is recommended that legal counsel be involved in the development of any LOS that does not meet the standards set out in the MMS. The preference would be for a municipality to develop their own LOS. The LOS document may embody all or a portion of MMS.

(Source: A Guideline for Developing a Level of Service Policy, Ontario Good Roads Association, 2014, www.ogra.org)

Appendix B: The *Clean Water Act, 2006* Issue Contributing Area Maps

Appendix B: The *Clean Water Act, 2006*

Maps: Issue Contributing Areas for Sodium and Chloride

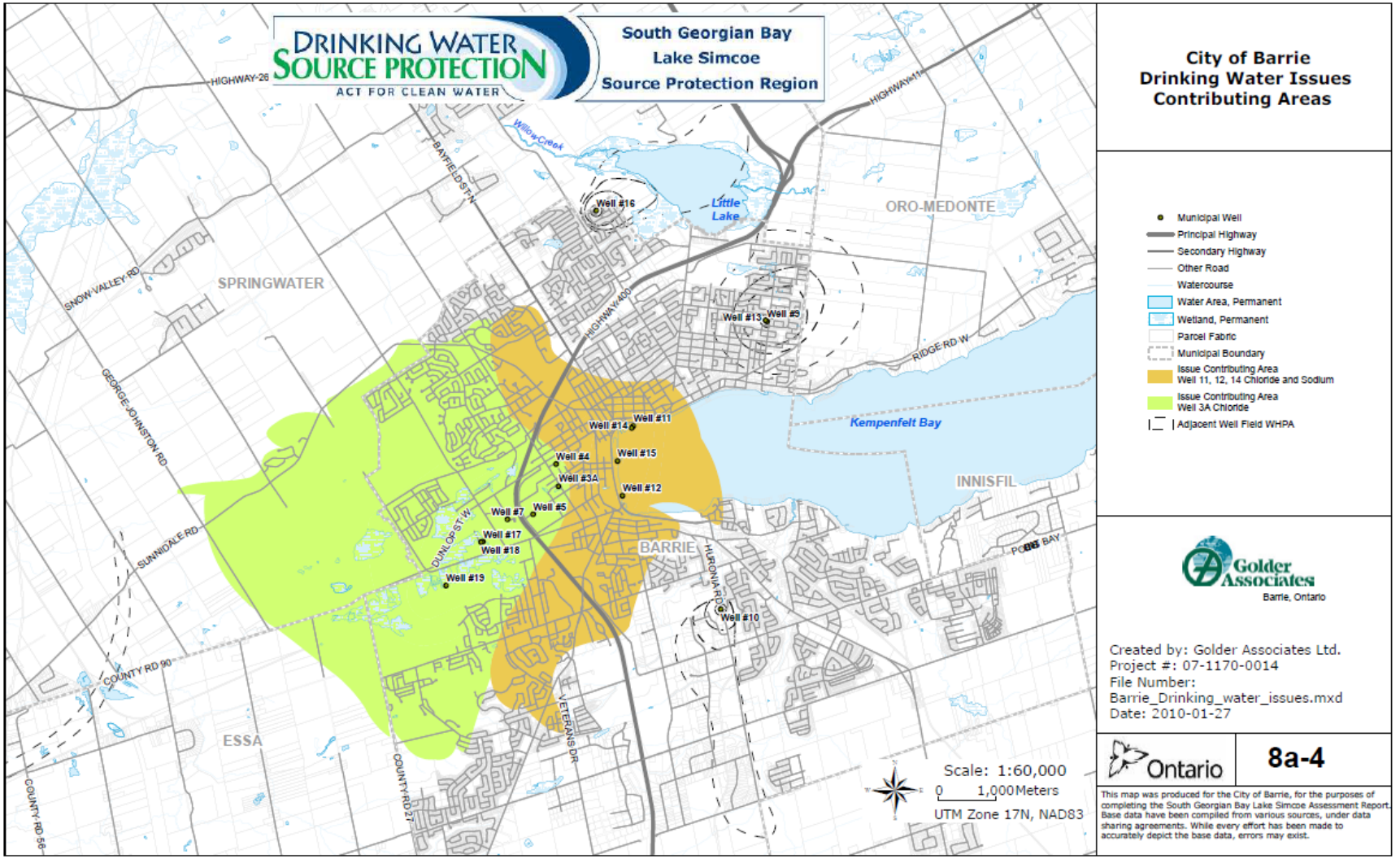

Figure B1. City of Barrie Issue Contributing Area

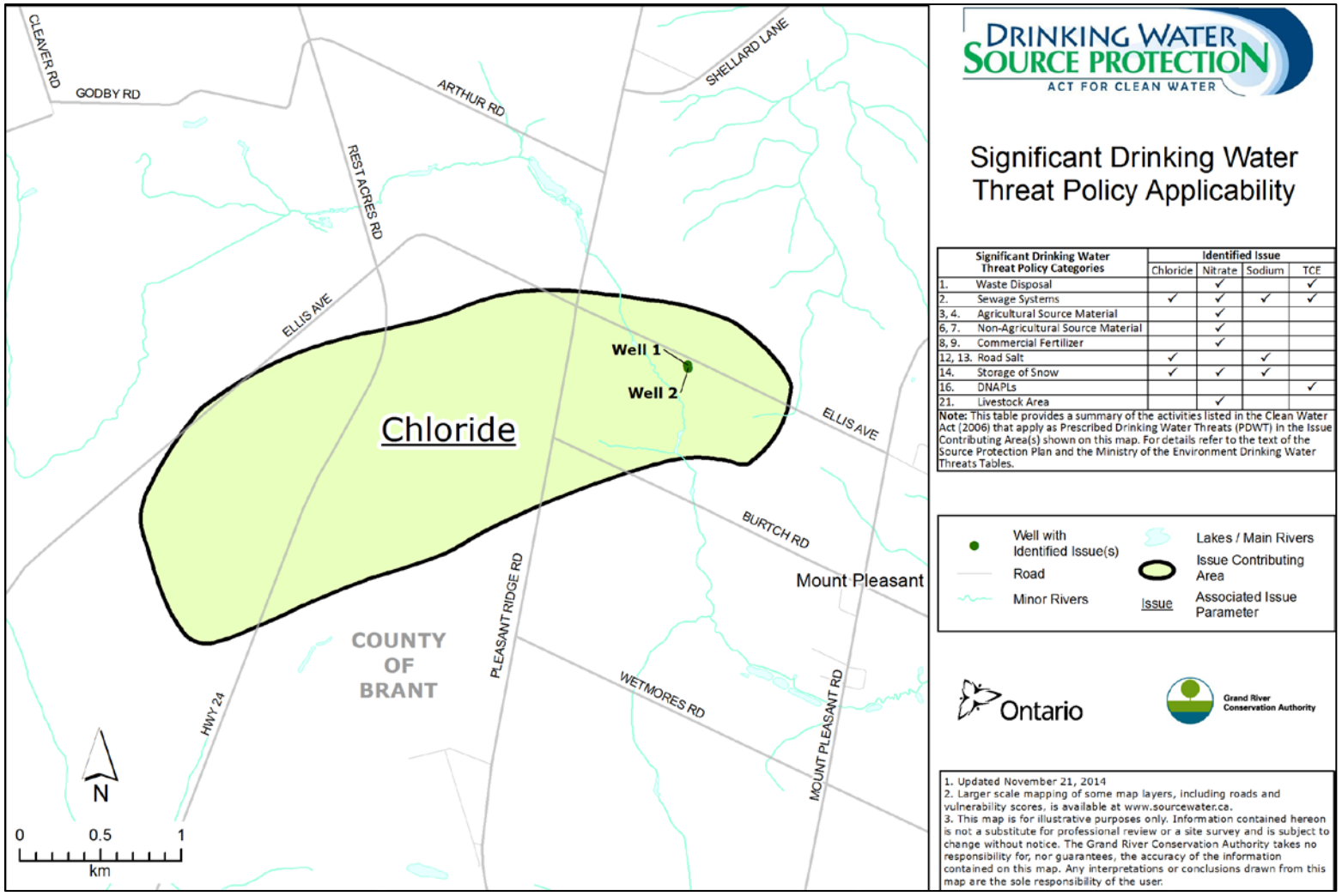

Figure B2. Mt. Pleasant Issue Contributing Area

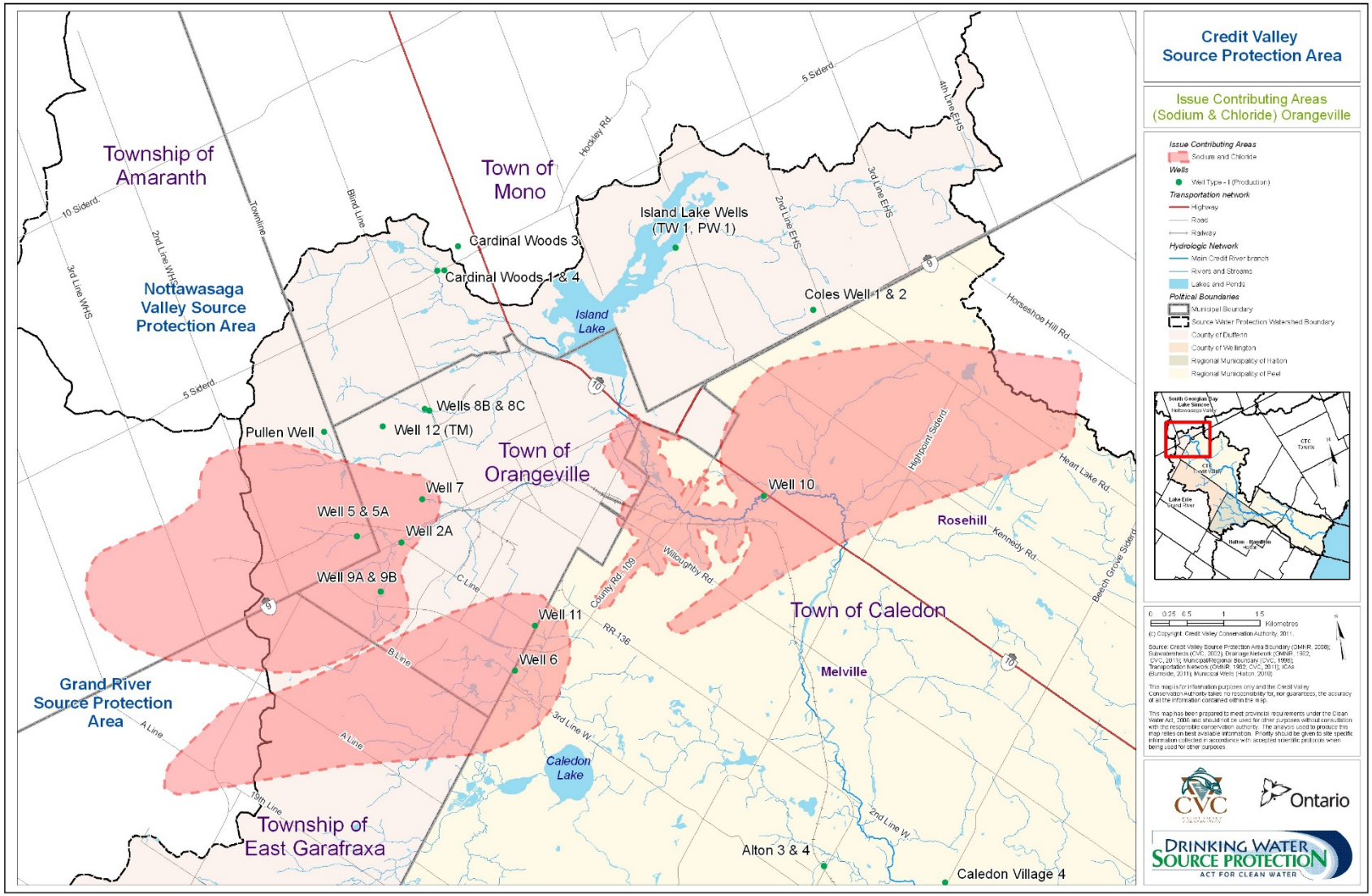

Figure B3. Orangeville Issue Contributing Area

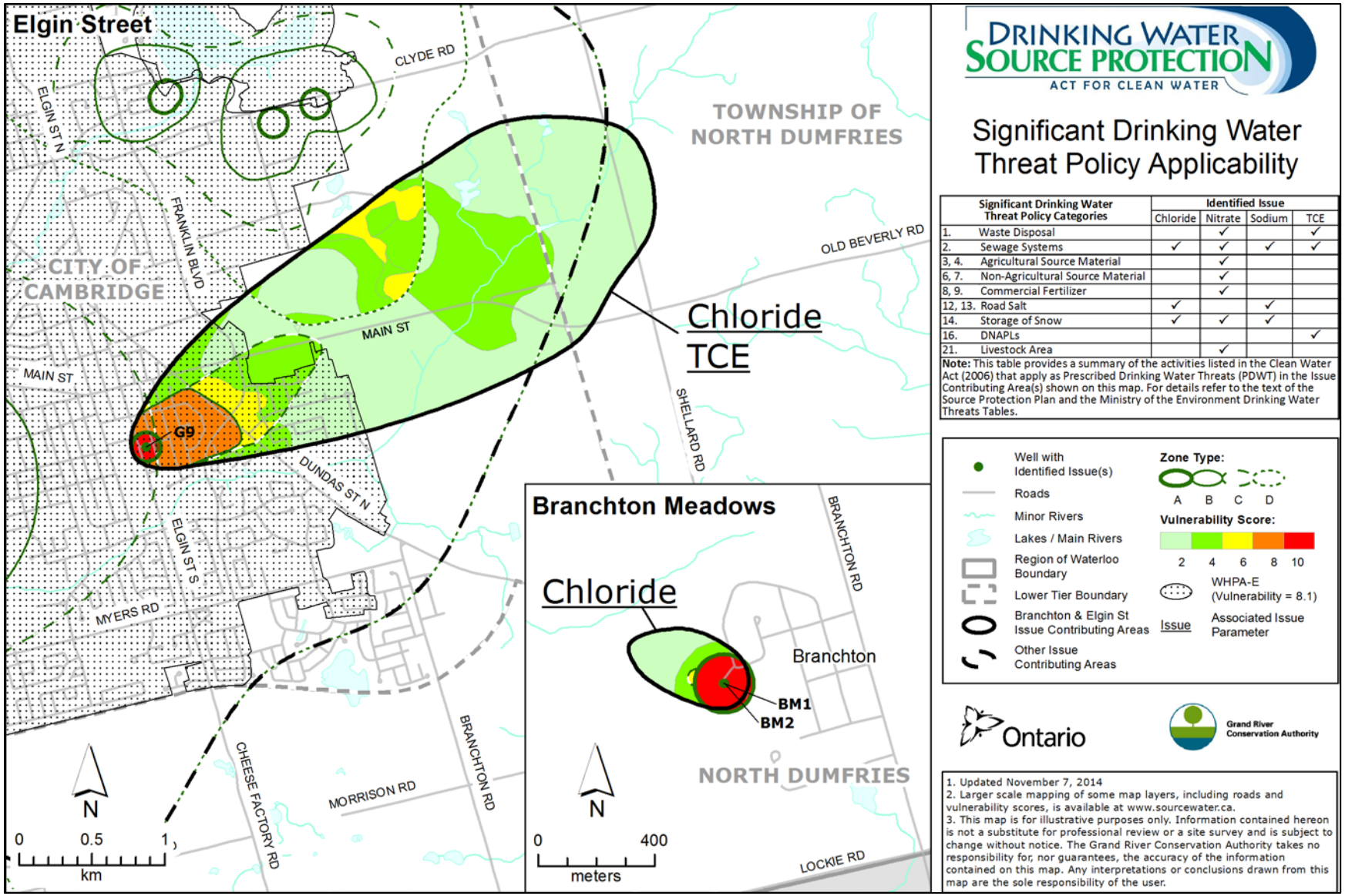

Figure B4. Elgin Street and Branchton Meadows Issue Contributing Areas

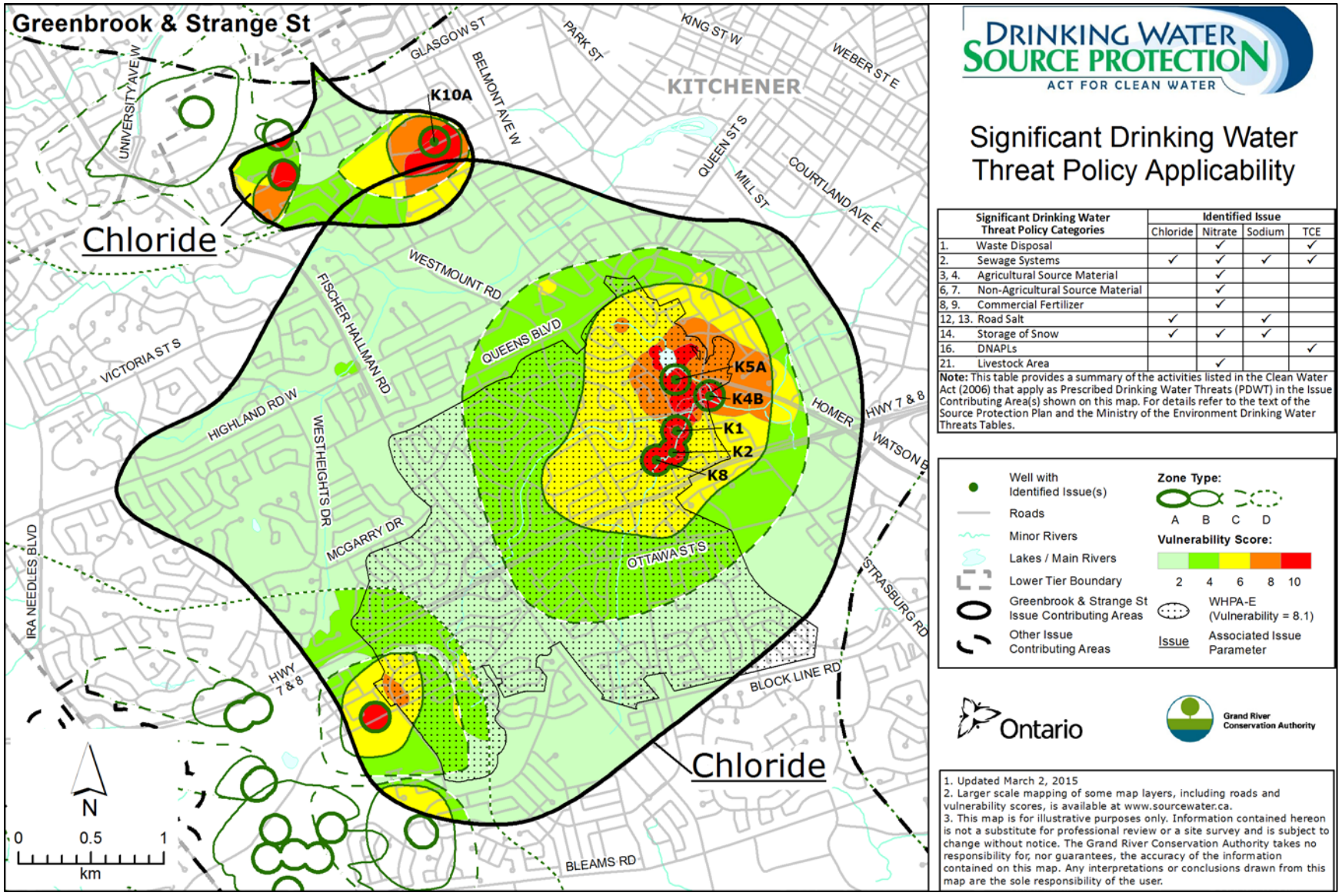

Figure B5. Greenbrook and Strange Street Contributing Area

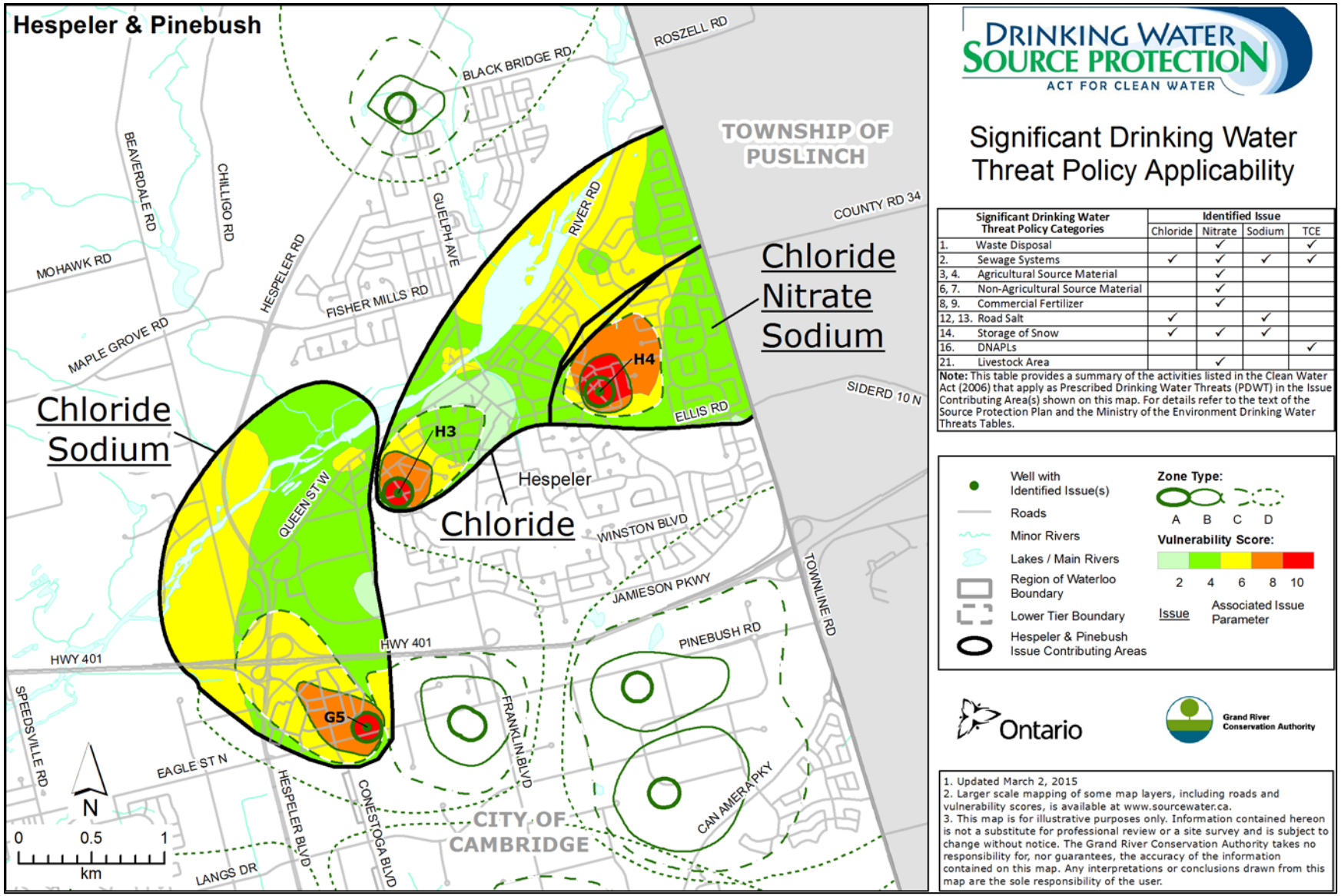

Figure B6. Hespeler and Pinebrush Contributing Area

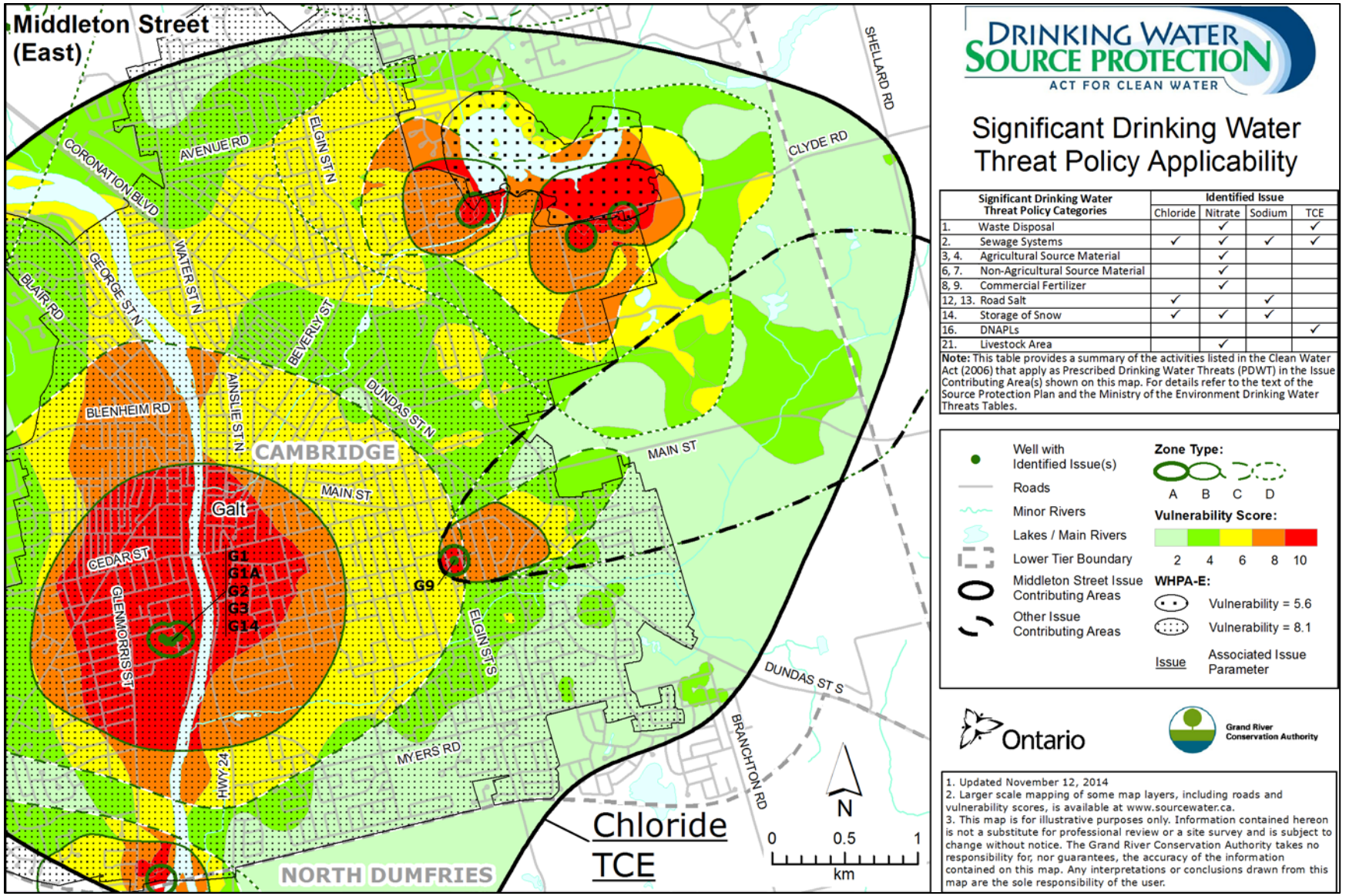

Figure B7. Middleton Street (East) Contributing Area

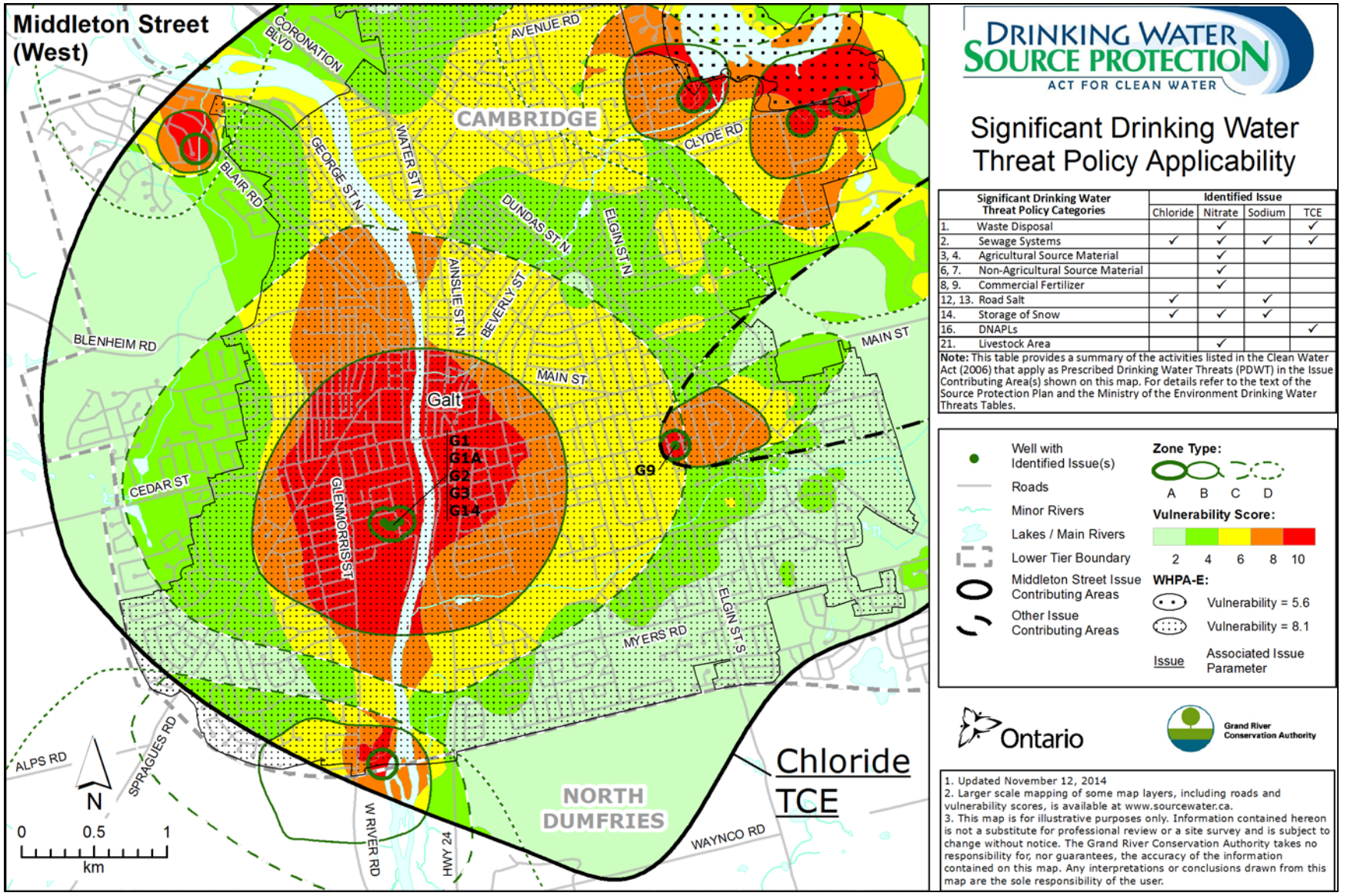

Figure B8. Middleton Street (West) Issue Contributing Area

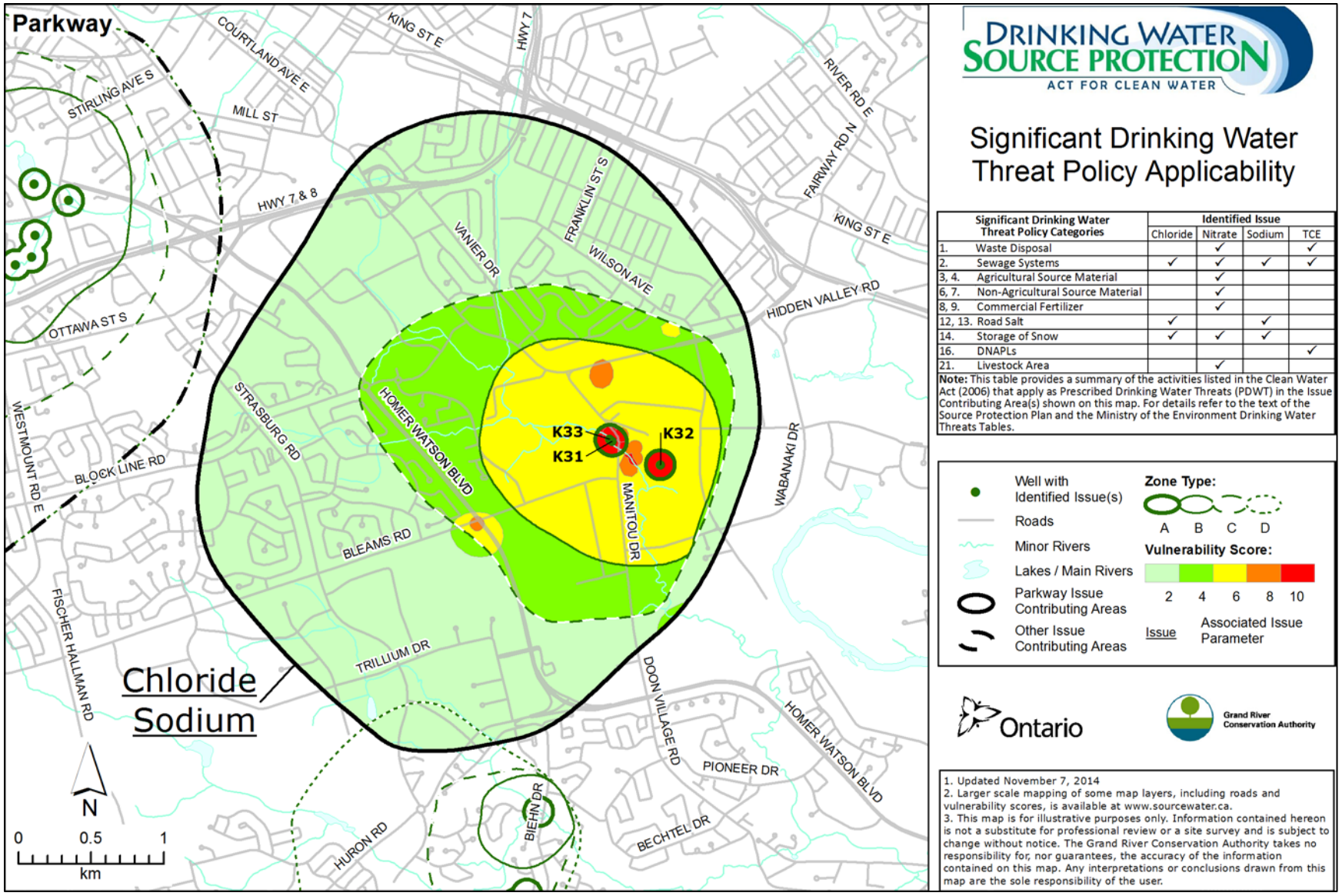

Figure B9. Parkway Issue Contributing Area

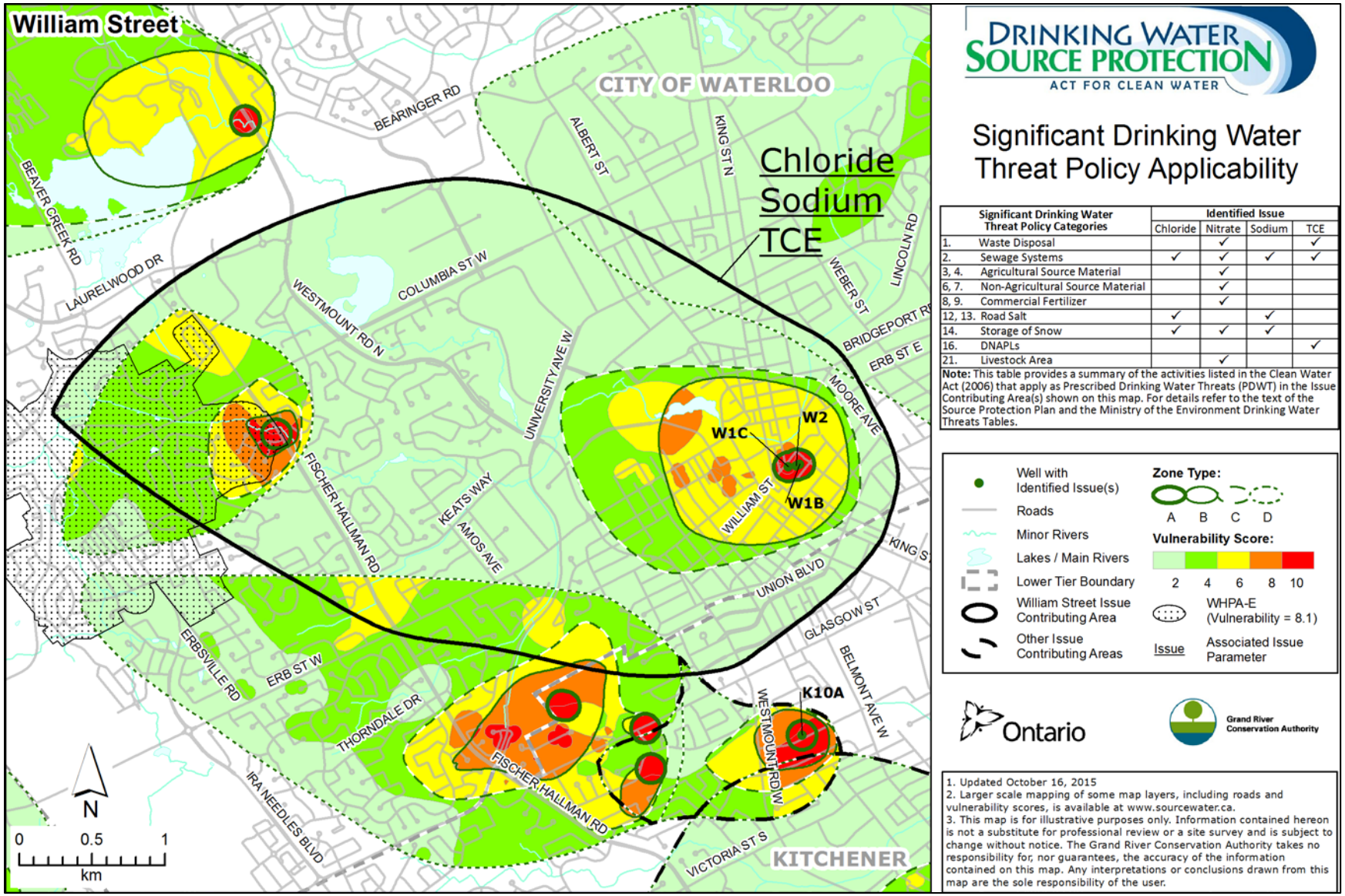

Figure B10. William Street Issue Contributing Area

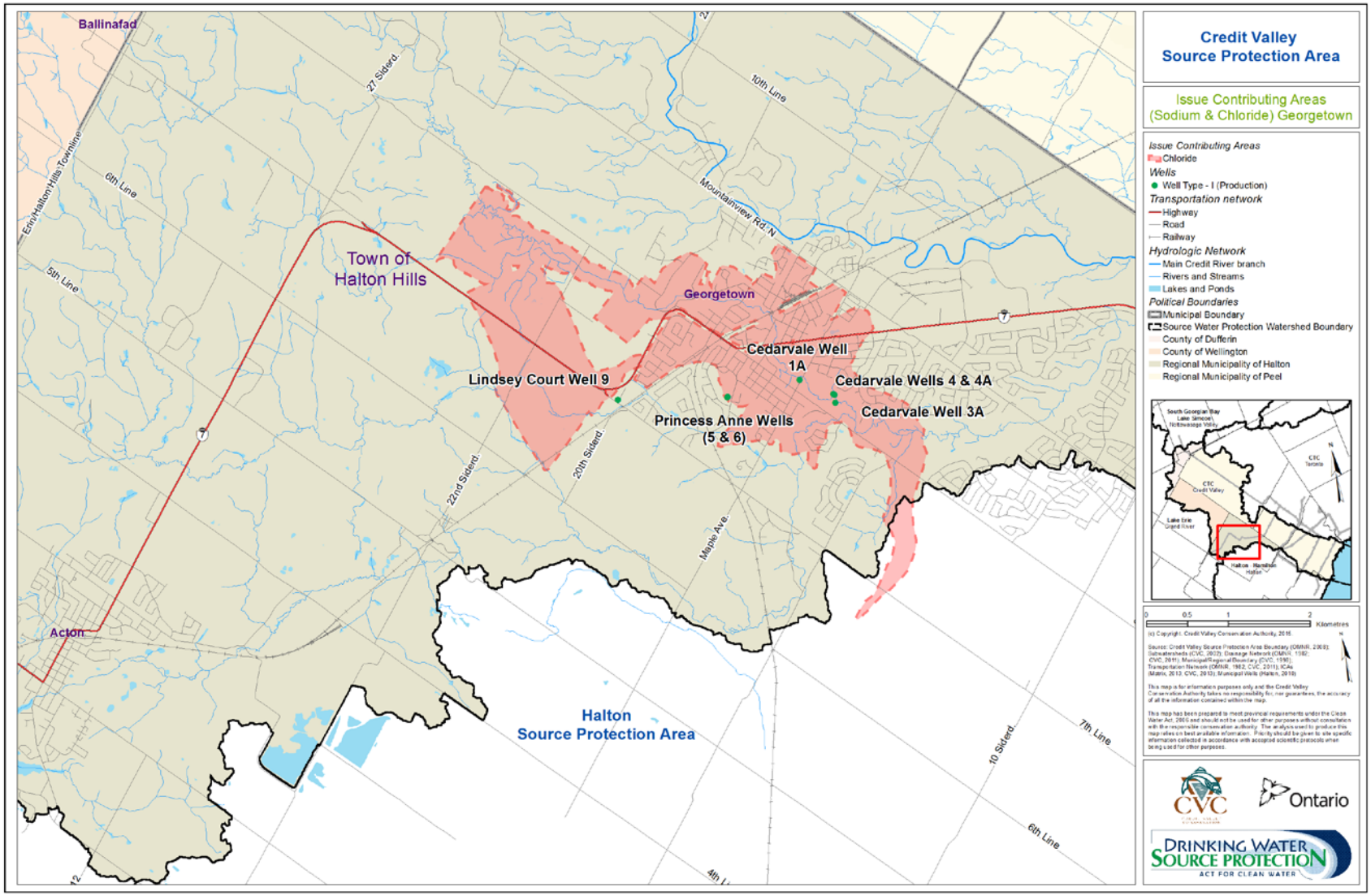

Figure B11. Georgetown Issue Contributing Area

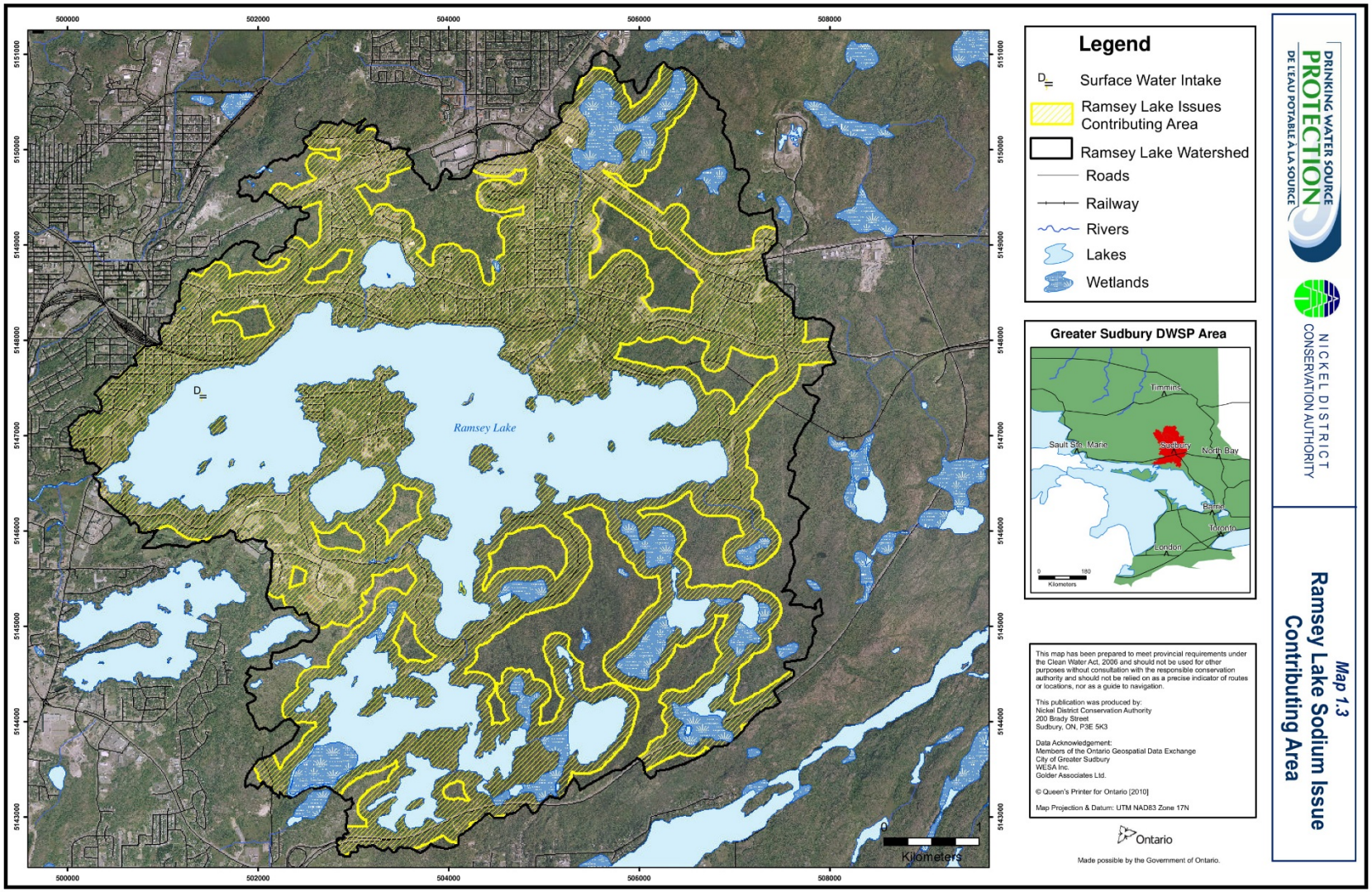

Figure B12. Ramsey Lake Issue Contributing Area