Chloride Impact Study

FINAL REPORT

Brantam Developments Inc.

Project Name:
Chloride Impact Study
Renwick Subdivision
Komoka, Ontario

Project Number:
KCH-21004499-A0

Prepared By:
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Date Submitted:
July 19, 2021

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Date Submitted:

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1. Introduction

1.1. Overview

EXP Services Inc. (EXP) was retained by Brantam Developments Inc. to undertake a Chloride Impact Study in support of the proposed Renwick Subdivision located in Komoka, Ontario, hereinafter referred to as the 'Site'.

The Site is located at Part of Lot 4 Concession 3 (Geographic Township of Lobo), Municipality of Middlesex Centre, Ontario at the northwest corner of Komoka Road and Oxbow Drive in the community of Komoka. The Site is approximately 20.5 ha in size and is presently an agricultural field. The Site is bounded by residential houses to the northeast along Komoka Road, commercial and residential area to the southeast and agricultural fields to the southwest and northwest. The Site is also bounded by CP Railway tracks to the north and south. The current development plan includes multi-family town homes, an apartment complex and a stormwater management (SWM) pond. The proposed development plan is included as **Attachment 1**.

A hydrogeological assessment is being completed on the Site, and this Chloride Impact Study is based upon the groundwater chemistry results obtained during the investigation, as well as the proposed stormwater management and site plans. This report should be read in conjunction with the Hydrogeological Assessment (EXP, 2021).

1.2. Purpose

A Chloride Impact Assessment was recently requested by the Ministry of Environment, Conservation and Parks (MECP) in order to satisfy the conditions for Draft Plan Approval. This Chloride Impact Study has been completed to satisfy this requirement, which includes the calculation of salt loading from de-icing operations into the groundwater to ensure that groundwater chloride concentrations will conform to the Reasonable Use Concept (RUC) Guidelines established by the MECP. The assessment presented considers the following:

1) Water Quantity: Ensure aquifer recharge is maintained or enhanced post-development;

2) Water Quality: Ensure that the ultimate steady-state concentration of chloride in the groundwater will not exceed the MOE's RUC;

3) Hydrogeologic Impact Assessment: Identify the Regional and Site geology and hydrogeology and evaluate potential groundwater impacts in relation to the applicable source water protection governing Acts/Policies;

a) Clean Water Act (MOE, 2006); and,

b) Approved Source Protection Plan, Upper Thames River Source Protection Area (TSRSPC, 2015).

In addition, reference was made to the Road Salt Management and Chloride Reduction Study completed by Stantec in 2005 (Stantec, 2005).

Given the winter season in Ontario, there is widespread use and storage of road salt. At typical concentrations in drinking water, sodium and chloride are not risks to human health; however, at concentrations greater than 20 milligrams per litre (mg/L), sodium intake can present a health issue for some people. Source Water Protection Tables of Drinking Water Threats and circumstances (swpip.ca) identify sodium and chloride as contaminants that could make their way into surface and groundwater from road salt application, storage and handling.

The purpose of this study is to assess impacts to the groundwater system (both quality and quantity), and if necessary, mitigate the impacts by proposing enhanced development technologies and construction techniques. To address the groundwater quality, a hydrologic model was analysed to determine infiltration rates and then a mass balance was completed to quantify potential winter salt application impacts (chloride) to the existing groundwater quality per the RUC criteria.

1.3. Reasonable Use Concept (RUC)

The assessment of road salt and its impact on groundwater quality can be made by estimating the total chloride levels post-development due to road salting activities and comparing the estimated value with specific target criteria for chloride concentrations. The Ontario Drinking Water Standard (ODWS) for chloride of 250 mg/L generally defines the upper limit of acceptability. In recent years the MECP's RUC has been adopted for various studies conducted to assess the impact of road salt on groundwater quality per the Region of Waterloo's document entitled *Draft Protocol for Evaluating Road Salt Impacts to Groundwater Using the Reasonable Use Concept,* dated January, 2008. For the purposes of this Chloride Impact Study, reference will be made to the protocols established in this widely accepted January 2008 document.

The RUC establishes limits for the allowable concentrations of contaminants based on background groundwater quality and the reasonable use of groundwater on adjacent property. The limits are set such that there would not be any significant effect on the use of the groundwater on the adjacent property. As a result, the quality of groundwater may not be degraded by an amount in excess of:

- 50% of the difference between background and the Ontario Drinking Water Objectives for non-health related parameters (e.g. chloride), or
- 25% of the difference between background and the Ontario Drinking Water Objectives for health-related parameters (e.g. lead).

The RUC has been incorporated in Regulation 232/98. The RUC has been included directly as performance specifications for the site-specific design approach. In cases where the reasonable use of groundwater is other than drinking water, for example where background groundwater quality is poor, the RUC guideline allows alternative concentration limits to be set. These alternative limits would be determined on a case-by-case basis.

For this Site, the maximum background chloride concentrations from monitoring well BH2/MW of 39 mg/L was used. The full water quality results can be referenced in the Hydrogeological Assessment (EXP, 2021).

The RUC is calculated for a parameter based on the following expression:

$$Cm = Cb + x\ (Cr - Cb)$$

Where:

Cm = concentration of a parameter which complies to the RUC at the downgradient boundary

Cr = maximum acceptable concentration of a parameter (Cl = 250 mg/L)

Cb = background concentration of the parameter (39 mg/L) prior to any man-made contamination

For health-related parameters x = 0.25, and for non-health related parameters x = 0.5

Therefore,

$$Cm = 39\ mg/L + 0.5\ (250\ mg/L - 39\ mg/L)$$

Cm = **144.5 mg/L**

Thus, given the Ontario Drinking Water Standard (ODWS) for chloride is 250 mg/L and the background chloride concentration in the groundwater has been averaged to be 39 mg/L, the **RUC concentration of chloride in groundwater is 145 mg/L.**

2. Chloride Impact – Mass Balance Analysis

To quantify potential winter salt application impacts (chloride) to the existing groundwater quality, a conservative mass balance analysis was completed for the proposed development.

The mass balance analysis approach used in this analysis is considered a conservative evaluation since it does not include any dilution from groundwater already present in the system, any flow through dilution effects, or any off-site effects. All these effects would result in additional dilution of the chloride concentrations.

As the runoff from the development will be collected and channeled through storm sewer systems, the assumed percentage of infiltration is 28%, as per the Region of Waterloo Guidelines (January 2008).

The results of the mass balance analysis are summarized in Table 1 below.

Table 1. Mass Balance Calculation without Mitigation

Mass Balance Calculations – Secondary Roadway (Municipal Maintenace)	Value	Total
Length of Roadway (km)	2.26	
Annual Salt Application Rate – Secondary Road (22 tonnes/two-lane-km/year) (1)	22	
Total Salt Applied (Roadways) (tonnes/yr)		49.7
Mass Balance Calculations – Parking Lots and Roadways (Private Maintenace)		**Total**
Area of Paved Surfaces (parking lots) (m^2)	7,303	
Annual Salt Application Rate (events/year)	37	
Salt Applied (g/m^2/event) (1)	50	
Total Salt Applied (tonnes/year)		14
Mass Balance Calculations – Total Site		**Total**
Total Salt Applied (tonnes/year)	63	
Infiltration Rate into Subsurface (%)	28	
Total Estimated Infiltration Volume per year (m^3/yr) (2)	72,691	
Molecular Weight Ratio of Sodium to Chloride	0.606	
Estimated Total Groundwater Chloride Concentration (mg/L) (3)		**148**

Notes:

(1) The road salt application rates are based on values presented in the Region of Waterloo Report: *Road Salt Management and Chloride Reduction Study Phase 2: Evaluation of Chloride Reduction Options*, Stantec Consulting Ltd., 2003. These rates are considered conservative since they do not include the 25% target reduction or take into consideration more recent application loading data.

(2) Refer to Water Balance Completed as part of the Hydrogeological Assessment (EXP, 2021)

(3) The amount of additional chloride input to the groundwater is based on dilution calculations and the molecular weight ratio of sodium to chloride in the total volume of salt (0.606).

Results from the mass balance analysis indicate the total additional chloride input to the subsurface from the proposed development areas is approximately **148 mg/L**, which is slightly above the RUC limit of **145 mg/L**.

3. Mitigative Measures

The estimated post-development groundwater chloride concentration of 148 mg/L is above the RUC limits of 145 mg/L. The following mitigative measure is recommended for the proposed development to address potential groundwater quality impacts:

- Salt Risk Management Plans (SRMP) to be prepared for the proposed development.

3.1. Salt Risk Management Plans

For the roadways through the individual development and residential blocks, it is likely that snow removal and ice control will be undertaken by a private winter maintenance service provider. As such it is recommended that a site specific SRMP be required and implemented as part of the future development of these sites. The purpose of the Salt Management Plan will be to reduce the impact of all winter maintenance activities involving salting practices on the surface water and groundwater resources. The SRMP should outline operational practices and strategies and should considerations for:

- Awareness;
- Planning;
- Equipment;
- Application;
- Snow Removal;
- Site Drainage;
- Salt Storage; and
- Record Keeping.

An example Salt Risk Management Plan is included as **Attachment 2**.

The example SRMP includes a recommendation for a road salt application limit of 45 g/m^2 (4.5 kg/100 m^2) per event, as opposed to the standard application rate of 50 g/m^2. As it is understood that the primary roadways will be maintained by the Municipality of Middlesex Centre, this salt application reduction is only applicable to the parking lot areas and the multi-family block roadways within the proposed development. Based on the reduced application rate of 45 g/m^2, an estimated groundwater chloride concentration of **144 mg/L** could be expected at the property boundary, which is below the estimated RUC limit of **145 mg/**L, as shown in Table 2 below.

Table 2 also presents the estimated results for a road salt application limit of 29 g/m^2 (2.9 kg/100 m^2) per event. This road salt application rate of 29 g/m^2/event is based on values presented in the Region of Waterloo Report: Road Salt Management and Chloride Reduction Study Phase 2: Evaluation of Chloride Reduction Options, Stantec Consulting Ltd., 2003. These results are presented only as a reference point.

Table 2. Mass Balance Calculation with Salt Mitigation

	Salt Application 45 m/m^2/event		**Salt Application 29 m/m^2/event**	
Mass Balance Calculations – Parking Lots and Pavement (Private Maintenance)	Value	Total	Value	Total
Area of Paved Surfaces (parking lots) (m^2)	7,303		7,303	
Annual Salt Application Rate (events/year)	37		37	
Salt Applied (g/m^2/event)(1)	**45**		**29**	
Total Salt Applied (tonnes/year)		12		6
Mass Balance Calculations – Total Site		Total		Total
Total Salt Applied (tonnes/year) – Private Roads	12		6	
Total Salt Applied (tonnes/year) – Total Site		49.7		49.7
Infiltration Rate into Subsurface (%)	28		28	
Total Estimated Infiltration Volume per year (m^3/yr)(2)	72,691		72,691	
Molecular Weight Ratio of Sodium to Chloride	0.606		0.606	
Estimated Total Groundwater Chloride Concentration (mg/L)(3)		**144**		**130**

Notes:

(1) The road salt application rate of 29 m/m2/event is based on values presented in the Region of Waterloo Report: *Road Salt Management and Chloride Reduction Study Phase 2: Evaluation of Chloride Reduction Options*, Stantec Consulting Ltd., 2003. These rates are considered conservative since they do not include the 25% target reduction or take into consideration more recent application loading data.

(2) Refer to Water Balance Completed as part of the Hydrogeological Assessment (EXP, 2021)

(3) The amount of additional chloride input to the groundwater is based on dilution calculations and the molecular weight ratio of sodium to chloride in the total volume of salt (0.606).

4. Recommendations

It is recommended that:

- A Salt Risk Management Plan be prepared and formalized with the Municipality of Middlesex Centre for the Site. An example Plan has been provided as **Attachment B**.
- That the maximum salt application rate of **45 g/m^2/event,** or an alternative equivalent mitigation, be incorporated into Site Plan Agreement for each multi-family block.
- A monitoring program should be implemented during post-development of the Site in order to monitor the downgradient chloride concentrations within the groundwater and surface water. Key components to be considered in the monitoring program include modifications to winter maintenance procedures, and road salt application rates and total annual salt applied.

5. Conclusions

Based on the foregoing analyses, it is concluded that:

1. Based on a conservative mass balance analyses completed for the proposed development, the anticipated average post-development groundwater chloride concentrations of 148 mg/L exceeds the RUC limit of 145 mg/L when considering a road salt application of 50 g/m^2.
2. Reductions in salt application rates from 50 g/m^2 to 45 g/m^2 would reduce the expected chloride concentration in groundwater at the Site boundary from 148 mg/L to 144 mg/L, which is below the RUC limit of 145 mg/L.
3. The mass balance analysis performed in this study is considered to be a conservative evaluation since it does not include any dilution from groundwater already present in the system, any flow through dilution effects, or any off-site effects, all of which would result in additional dilution of the chloride infiltration.
4. A Salt Risk Management Plan should be prepared and formalized with the Region for the Site, in addition to a monitoring program for the Site.

6. References

Thames-Sydenham and Region Source Protection Committee (TSRSC). 2015. Approved Source Protection Plan, Upper Thames River Source Protection Area. September 17, 2015.

Ministry of the Environment and Energy, 1994, Incorporation of the Reasonable Use Concept into MOEE Groundwater Management Activities, GUIDELINE B-7.

Ministry of the Environment (MOE). 2008. Technical Rules: Assessment Report, Clean Water Act, 2006

Regional Municipality of Waterloo. 2008. Draft Protocol for Evaluating Road Salt Impacts to Groundwater Using the Reasonable Use Concept (DOCs #409317, Version 1.0).

Stantec Consulting Ltd. 2005. Road Salt Management and Chloride Reduction Study Phase 2: Evaluation of Chloride Reduction Options. Prepared for the Regional Municipality of Waterloo. December 2005.

7. Experience & Qualifications

EXP Services Inc. (formerly Trow Associates Inc. founded in 1957) provides a full range of environmental services through a full-time Earth and Environmental Services Group. EXP's Environmental Services Group has developed a strong working relationship with clients in both the private and public sectors and has developed a positive relationship with the Ontario MECP. Personnel in the numerous branch offices form part of a large network of full-time dedicated environmental professionals in the EXP organization.

This report was prepared by Hagit Blumenthal, M.Sc., P.Geo. Ms. Blumenthal has experience in conducting hydrogeological assessments. Ms. Blumenthal is a hydrogeologist and environmental geoscientist with more than 8 years' experience in the environmental field, and is a licensed Professional Geoscientist (P.Geo.) in Ontario. She obtained a Master of Science (M.Sc.) in 2010 from the University of Waterloo and has worked in the Hydrogeological and Environmental fields since then.

This assessment was reviewed by Ms. Heather Jaggard, M.Sc., P.Geo. Ms. Jaggard is a hydrogeologist and environmental geoscientist with more than 9 years in the environmental field and is a licensed Professional Geoscientist (P.Geo.) in Ontario. She obtained a Master's of Science (M.Sc.) in 2012 from Queen's University in Kingston, and is a Qualified Person (QP) registered with the Ontario MECP. She has worked in the Hydrogeological and Environmental fields since that time. In her professional career for the past few years, Ms. Jaggard has completed numerous hydrogeological assessments and modelling works for land development sites. Environmental site assessments and preparation of submissions for PTTW have been part of her routine assignments.

8. General Limitations

The information presented in this report is based on a limited investigation designed to provide information to support an assessment of the current environmental conditions within the subject property. The conclusions and recommendations presented in this report reflect Site conditions existing at the time of the investigation. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent. Should this occur, EXP Services Inc. should be contacted to assess the situation, and the need for additional testing and reporting. EXP has qualified personnel to provide assistance in regards to any future geotechnical and environmental issues related to this property.

Our undertaking at EXP, therefore, is to perform our work within limits prescribed by our clients, with the usual thoroughness and competence of the engineering profession. It is intended that the outcome of this investigation assist in reducing the client's risk associated with environmental impairment. Our work should not be considered 'risk mitigation'. No other warranty or representation, either expressed or implied, is included or intended in this report.

The comments given in this report are intended only for the guidance of design engineers. The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not afforded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in this report

This report was prepared for the exclusive use of **Brantam Developments Inc.** and may not be reproduced in whole or in part, without the prior written consent of EXP, or used or relied upon in whole or in part by other parties for any purposes whatsoever. Any use which a third party makes of this report, or any part thereof, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. EXP Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Appendix A – Proposed Development Plan

KOMOKA ROAD

BLOCK 177 OPEN SPACE (0.415 ha)

BLOCK 178 OPEN SPACE (1.138 ha)

BLOCK 171
MEDIUM DENSITY (0.615 ha)

STREET 'D'

STREET 'B'

STREET 'A'

STREET 'C'

STREET 'E'

R7.50m R (TYPICAL)

BLOCK 173
MEDIUM DENSITY
(1.090 ha)

BLOCK 169 MEDIUM DENSITY (0.414 ha)

BLOCK 170
MEDIUM DENSITY
(1.451 ha)

RESERVE
BLOCK 168

BLOCK 176
WALKWAY
(0.014 ha)

BLOCK 175
STORMWATER MANAGEMENT
(0.888 ha)

BLOCK 174
MEDIUM DENSITY
(0.541 ha)

BLOCK 179 OPEN SPACE (0.497 ha)

0.3m RESERVE
BLOCK 180
(0.001 Ha)

OXBOW DRIVE

CANADIAN NATIONAL RAILWAY

PAVEMENT AREA= 16372.27
1.64 ha

RENWICK SUBDIVISION

PAVEMENT AREA PLAN

SCALE 1: 1800
DATE: JUNE 24, 2021

ARCHIBALD, GRAY & McKAY ENGINEERING LTD.
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PLAN • SURVEY • ENGINEER

Plot date: Jun 24, 2021 G:\CLIENT\1389\1\CAD 2019\1389-1 BASE.dwg

Appendix B – Example Salt Risk Management Plan

Road Salt Risk Management Plan
Renwick Subdivision

Part of Lot 4 Concession 3, Komoka,
Municipality of Middlesex Centre, Ontario

1.0 Introduction

The proposed development is located at the northwest corner of Komoka Road and Oxbow Drive in the community of Komoka, Ontario, and hereinafter referred to as the 'Site'. The legal description of the Site is listed as Part of Lot 4 Concession 3 (Geographic Township of Lobo), Municipality of Middlesex Centre. The Site is located within a Significant Groundwater Recharge Area (SGRA) and a Highly Vulnerable Aquifer (HVA), both with a vulnerability score of 6, which is considered Low Risk. The Site is not located within a Wellhead Protection Area (WHPA), and as such, the Site is considered to have Low Risk potential for contamination of source water. Although the Site is not classified as a High Risk area for Source Water Protection, The Ministry of the Environment, Conservation and Parks (MECP) requested this Chloride Impact Study and Road Salt Management Plan be compiled.

The Risk Management Plan (RMP) presented herein provides measures for the management of road salt on Site driveways, parking lots and sidewalks to minimize potential risks from road salt releases and protect employees and visitors to the Site from falls and other potential hazards associated with accumulate ice and snow.

2.0 Objective

The objective of the salt RMP is to provide measures for the effective management of road salt at the Site that minimizes potential risks to the Municipality's HVA and SGRA and is protective of the safety of individuals during ice causing winter time conditions. The specific objective is the implementation of measures that control or prevent the bonding of ice/snow to pavement or concrete (effective salt management).

3.0 Applicability

This salt RMP is applicable to the Renwick Multi-Family Block developments, and eventual maintenance staff or contractors associated with the properties that are undertaking snow and ice management at the Site.

4.0 RMP Components

The RMP presents general measures for the management and use of road salt at the site which encompasses the following components

- Awareness
- Planning

- Equipment
- Application
- Snow Removal
- Site Drainage
- Salt Storage
- Record Keeping

4.1 Awareness

General

All Maintenance staff and contractors engaged in snow/ice management operations for the Multi-Family Block roadways and site parking areas are to be made aware of the importance of implementing best management practices in relation to HVA and SGRA vulnerability to road salt use. Maintenance staff and contractors are to be made aware of the benefits of an effective salt management strategy as it relates to the control of winter maintenance and material costs, preventing and reducing corrosion damage to structures and utilities and damage to vegetation.

Considerations

- Maintenance staff or contractors engaged in snow and ice control should be trained or be knowledgeable on the storage, handling and application of road salt to minimize use.
- Maintenance personnel and contractors should be trained or a knowledgeable to assess weather conditions (i.e., temperature, type and extent of precipitation), and surface conditions to implement the best/most appropriate strategy (e.g. anti-icing, de-icing) for a given set of conditions.
- All individuals operating de-icing equipment should have the necessary training or experience especially in controlling application rates of road salt and salt containing materials to minimize releases to the environment.
- Prior to each winter season, the maintenance manager should meet with maintenance staff and or/the contractor engaged in snow and ice control operations to re-iterate the importance of applying best management practices related to assessment of conditions and event planning, material handling and application, and equipment operation and maintenance.

4.2 Planning

General

Storm event pre-planning relates to the evaluation of expected weather conditions to identify the measures that should be implemented as they related to approach (anti-icing versus de-icing) materials, quantities and application rates, placement and timing.

Considerations

- Review weather forecasts and radar images to identify the type of precipitation event - snow, frost or freezing rain - and when the event may be expected.
- Implement surface specific and condition specific measures.
    - Implement anti-icing measures in advanced of a storm to prevent surface bonding of ice or snow

  - Use abrasives with lower salt content (i.e. to prevent freezing and particle clumping) such as sand where conditions permit.
  - Use condition specific quantities of road salt or related agents (i.e. lesser amounts/lower for frost events and greater amounts for freezing rain events)
  - Use broadcast spreaders for parking lots and driveways and drop spreaders for walkways.
  - Plow snow where accumulations are expected to exceed 2 cm.
- Monitor treated surfaces for residual chemical presence to avoid unnecessary use of road salt or road salt containing products.
- If possible, monitor asphalt and concrete surfaces temperatures to determine if road salt or a related agent is required or if temperatures are too cold for application of road salt or the related agent.
- Apply road salt or a related chemical agent after plowing only if the pavement temperature is above the agent specific freezing point and where there is remnant ice or snow that could not be removed by a plow.

4.3 Equipment

General

Proper equipment maintenance and calibration should be used to minimize road salt or salt containing material usage.

Considerations

- Mechanical equipment should be used for snow removal and snow and plough blades set to the lowest possible clearance.
- Spreaders should be equipped with appropriate controls to adjust spreading rates for specific conditions.
- Spreading equipment should have on/off operator controls to avoid excess release of materials.
- Spreaders should have necessary controls to disperse materials across target areas only.
- Combination plow and spreaders should be used for more efficient snow removal and road salt or salt containing material spreading.
- Broadcast spreaders should be used on parking lot areas and a drop spreader for the sidewalk areas
- Spreaders should be calibrated following manufacture requirements and the calibration check before and during the operational season to confirm spreading rates.
- Spreading equipment should be inspected before and during the operational season.
- If possible, salt should be pre-wetted to enhance the activation time of the salt
- Pre-wetting tanks should be design to prevent spillage of entire tank contents in the event of a failure.
- Liquid product spray trucks should be equipped with a spray bar for the roadway and parking lot areas.

4.4 Application

The potential release of road salt to the subsurface of the Site is to be controlled through practices related to weather condition and surface assessment, anti-icing and de-icing, material selection and use and application rates.

Considerations

- Alternative methods and materials should be used and road salt or road salt containing product use avoided altogether where possible.
- Use mechanical methods to remove accumulate snow and ice and slush including plow equipped trucks, snow blowers and power brooms.
- Where conditions permit, use sand as an abrasive in place of solid salt. To prevent freezing and clumping, sand may be mixed with a small amount of salt, which should not exceed 3 to 5% by volume. Sand and salt should be mixed by mechanical means to obtain a homogeneous mixture.
- Use liquid agents for anti-icing instead of road salt. Apply liquid anti-icing agents on dry pavement in advance of a light snow or frost but not in advance of freezing rain or sleet where dilution of product is likely to occur. Apply anti-icing treatments under appropriate conditions as summarized as follows:

Table 1: General Conditions for Using Anti-Icing Agents (1).

Agent	Lowest Temperature (°C)	Application Rate (2)	Comments
Road Salt	-9	2.9 kg/100 m^2	Apply for dry snow
Liquid Salts	-7	3.2 L/100 m^2	Apply for wet snow

Notes:
(1) ITSS Lab, Department of Civil & Environmental Engineering, University of Waterloo, "Optimal Snow and Ice Control of Parking Lots and Sidewalks", January 2015.
(2) Specific application rates are to be determined from an assessment of storm event and surface conditions.

Kg = kilograms

L = litres

m^2 = square metres

- Use pre-wetted salt either by mixing a liquid with salt at the spreader or chute or adding liquid to a solid stockpile or pre-treating stockpiles to reduce salt use
- Do not use specific products/ materials below their freezing point temperatures, where they become ineffective:
    - rock salt (sodium chloride) – less than -10°C
    - Brine (23% by volume sodium chloride) less than -7°
- Application rates for de-icing should be adjusted for conditions in relation to snow type (e.g. lose or packed snow or ice), traffic, type of surface and pre-wetting.
- Road salt should be applied at specific rates for surface (parking stalls, roadways/ramps, sidewalks), temperature and snow and ice conditions.
    - Salt and sand mixtures at lower temperatures
    - Lower rates under frost or light snow

- Higher rates under colder temperatures and heavier snows
- Apply specific amounts to know areas

General application rates for asphalt surfaces under different temperature and snow conditions are summarized in the following table

Table 2: General Application Rates for Dry and Wetted Road Salt De-icing [(1)].

Temperature Range	Application Rate (kg/m^2) [(2,3)]			
	Loose Snow	Fresh Snow	Packed Snow	Freezing Rain and ice
-1 to -3	1.0 / 0.8[(4)]	1.3 / 1.1	2.0 / 1.6	10.6 / 8.4
-4 to - 6	2.5 / 2.0	3.3 / 2.6	5.0 / 4.0	26.4 / 21.1
-6 to - 9	5.8 / 4.6	7.7 / 6.2	11.6 / 9.2	62.6 / 49.3

Notes:
(1) ITSS Lab, Department of Civil & Environmental Engineering, University of Waterloo Optimal Snow and Ice Control of Parking Lots and Sidewalks, January 2015.
(2) Estimated application rates based on a snow thickness of up to 2 cm and a 3 to 4 hour return time to bare pavement.
(3) Specific application rates will vary with storm event and surface conditions.
(4) The first number is the application rate using dry road salt and the second number is the rate using wetted salt.

- Application equipment should be properly maintained and where possible calibrated.
- Logs should be maintained documenting all application events and equipment maintenance calibration.
- Salt materials should be inspected before for clumping and clumps removed
- Experienced contractors aware and knowledgeable of salt inputs should be employed

4.5 Snow Removal

General

Melting snow is a potential source of salt either from on Site or off Site ice management activities and should be managed to minimize salt releases.

Actions

- Snow should be plowed and stored in such a manner to minimize the requirement for Off-Site removal and the potential concentration of road salt in melted snow.
- Snow should be stored on the low side of pavement to direct melt waters away from pavement or salt vulnerable areas.
- Snow should be stored in areas where melt water is not being directed towards parking and roadway areas to prevent re-freezing and additional salting operations.
- Melt water should be directed to the perimeter swales/ditches.
- Snow removed from the Site should be transported to a proper snow disposal facility.
- Salt or salt containing products should not be added to promote rapid melting of snow.
- Mechanical agitations or spreading may be used to promote melting.
- Snow should be stored in sun exposed areas to promote melting.
- Snow should not be store over drains.

4.6 Site Drainage

General

Directing surface water flows away from asphalt surfaces to prevent ponding or puddle formation and the creation of areas prone to ice formation is a proactive measure to minimize road salt use. The grades of the Site parking areas are designed to direct surface water flow to perimeter ditches/swales, where it is to conveyed to the storm water management. These measures are to be maintained to avoid unnecessary use of road salt or related products on ponded areas.

Considerations

- Parking lot grades are to be constructed and maintained as per the Site surface features design/drainage plan, where drainage is directed away from pavement areas.
- Drainage from roof downspouts should be directed away from pavement areas.
- Underground utility corridors should be constructed in a manner that avoids the creation of undulations susceptible to ponding.
- Periodic maintenance inspections of parking lots and driveways for ponding should be conducted and records of such inspections maintained.
- Ponded water should be dispersed using power brooms or leaf blowers.
- Snow should be piled on low areas or on the back side of curbs such that melt water is directed away from pavement areas (see snow removal).
- Should areas of noticeable ponding developed, repairs should be made to these areas as directed by a paving engineer in a timely manner during the next repair season.
- Repair low areas where puddles may form and which may be prone to freezing.

4.7 Salt Storage

General

Storage of salt, sand/salt mixtures or liquid agents are potential source of uncontrolled releases and as a best practice should be prohibitive at the Site.

Considerations

- On-Site handling of road salt by contractors should be prohibited.
- If road is stored On-Site, practices to be followed should include:
    - Storage in a permanent enclosed structure constructed with a pad of impervious asphalt or concrete.
    - Site drainage should be directed away from road salt or salt containing product areas.
    - Spreading equipment should be loaded on pads constructed of impervious asphalt or concrete and should not be overloaded.
    - Immediate cleanup and return of all spilled materials to the storage shed/building and documentation of cleanup activities.
    - Stored salt should consist of non-aggregate materials free of clumping.
    - Road salt should be stored in original container or in secondary containers/bins and not stockpiled.
    - Logs should be kept of salt and salt containing product transfers including any material spillage and the measures taken to control and clean up the spills or to contain and recover spilled materials.

- Liquid product storage tanks should be protected from potential vehicle collisions and provided with secondary containment or located in an accessible area that provides for prompt product recovery.
- Spreading equipment should not be cleaned or washed on Site and such activities should only be undertaken at facilities where salt containing wash waters are collected.
- Annual and periodic inspections of the salt storage enclosure and tanks should be conducted for pad cracks and other signs of deterioration. Repairs to pads and tanks should completed where possible in a prompt manner and should be inspected and reviewed by the Site maintenance manager or by person designated by the manager with appropriate training and experience to undertake such reviews. Inspection observations and repairs to pad, tanks etc. should be logged.

4.8 Record Keeping

General

Records and logs should be kept documenting the salt management practices and the effectiveness of such practices in meeting the Site objectives.

Considerations

Related documentation should include but not be limited to

- Equipment calibration and maintenance records.
- Employee training
- Contractor Agreement
- Daily logs documenting:
    - Date and type of treatment
    - Weather conditions including type of precipitation, air temperature, thickness of snow cover, asphalt conditions
    - Snow removal activities including plowing, blowing, sweeping
    - Materials and quantities used
    - Unusual conditions – areas not treated or problem areas.

5.0 References

ITSS Lab, Department of Civil & Environmental Engineering, University of Waterloo, “Optimal Snow and Ice Control of Parking Lots and Sidewalks”, January 2015.

Transportation Association of Canada, Syntheses of Best Practices. 10.0 Salt Use on Private Roads, Parking Lots and Walkways, April 2003.

LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the hydrogeological investigation undertaken as of the date of the Report. Should changes occur which potentially impact the hydrogeological condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of EXP may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by EXP. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and EXP's recommendations. Any reduction in the level of services recommended will result in EXP providing qualified opinions regarding the adequacy of the work. EXP can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the test pit results contained in the Report. The number of test pits necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to EXP to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to EXP by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. EXP has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to EXP.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to EXP by its client ("Client"), communications between EXP and the Client, other reports, proposals or documents prepared by EXP for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. EXP is not responsible for use by any party of portions of the Report.

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Where EXP has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by EXP have utilize specific software and hardware systems. EXP makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are EXP's instruments of professional service and shall not be altered without the written consent of EXP.

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