Sustainable Technologies
EVALUATION PROGRAM

Procurement Guidance for Parking Lot Snow and Ice Management

Version 2.0

Prepared by:

Toronto and Region Conservation Authority

January 2019

www.sustainabletechnologies.ca

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PUBLICATION INFORMATION

Reports conducted under the Sustainable Technologies Evaluation Program (STEP) are available at www.sustainabletechnologies.ca. For more information about this project or the STEP program, please contact:

Tim Van Seters, M.E.S., B.Sc.
Manager, Sustainable Technologies
Toronto and Region Conservation Authority
5 Shoreham Drive,
Downsview, Ontario
M3N 1S4
E-mail: Tim.VanSeters@trca.on.ca

THE SUSTAINABLE TECHNOLOGIES EVALUATION PROGRAM

The water component of the Sustainable Technologies Evaluation Program (STEP) is a partnership between Toronto and Region Conservation Authority (TRCA), Credit Valley Conservation and Lake Simcoe Region Conservation Authority. STEP supports broader implementation of sustainable technologies and practices within a Canadian context by:

- Carrying out research, monitoring and evaluation of clean water and low carbon technologies;
- Assessing technology implementation barriers and opportunities;
- Developing supporting tools, guidelines and policies;
- Delivering education and training programs;
- Advocating for effective sustainable technologies; and
- Collaborating with academic and industry partners through our Living Labs and other initiatives.

Technologies evaluated under STEP are not limited to physical devices or products; they may also include preventative measures, implementation protocols, alternative urban site designs, and other innovative practices that help create more sustainable and liveable communities.

ACKNOWLEDGEMENTS

Financial support for this project was generously provided by the following organizations:

Toronto and Region Remedial Action Plan
The Region of Peel
York Region
The City of Toronto

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1.0 INTRODUCTION

Contracts for snow and ice management on parking lots are typically oriented towards ensuring that plowing and salting promotes safe conditions throughout the winter, and that interruptions to regular business operations are kept to a minimum. These are important goals, but it is also critical to ensure that snow and ice is managed and applied in a way that minimizes harmful effects on freshwater ecosystems, drinking water, soils, vegetation and wildlife. Applying more salt than is necessary not only harms the environment but also shortens the life of pavements and accelerates corrosion of building and transportation infrastructure. Road salts are necessary, but using too much carries a heavy price tag, both for our environment and built infrastructure.

Property owners, businesses and contractors have control over how much salt is applied through their snow and ice management contracts, and the diligence with which they manage and oversee these contracts. In this document, we describe some of the clauses and conditions that can be included in contracts to promote the responsible use of road salts. A summary of the measures are provided in Table 1, along with estimates of the impact on salt use, and the potential influence these may have on contract costs. Further details and sample clauses that may be included in snow and ice management contracts to ensure the measures are adopted by contractors are provided in Section 2.0.

Table 1: Summary of Salt Reduction Measures and their estimated impact on salt use and contract costs

Measure	Brief Description	Impact on Salt Use Reduction	Contract Cost Implications
Effective Pricing of Services	The pricing structure in winter maintenance contracts should provide incentives for contractors to use less salt	Low to medium improvements relative to contract structures that incentivize greater salt use.	Limited impact; lump sum by season contracts will have lower year to year cost fluctuations
Accurate Salt Delivery	Salt spreading equipment should be calibrated and include automated controls that vary application rates by vehicle ground speed	High impact for closed loop ground speed controllers. Equipment calibration alone can have a medium impact	Low to medium impact depending on the equipment specified
Efficient Application	Pre-wetting and/or anti-icing practices should be employed	Low to medium impact depending on the range of specified practices	Low for pre-wetting; Medium to high for anti-icing
Low Chloride Alternatives	Specify that low chloride road salts be used; ensure conventional road salt meets OPS specifications	Low to medium impact depending on product selected.	Medium to high impact if alternative salts are used; Meeting OPS specifications would not influence cost
Reducing Application Rates	Salt application rates should be reduced where feasible; Salt should not be used as a substitute for plowing.	Medium impact, particularly if reductions are applied both to roads and walkways/patios.	Low impact, if any. By applying more judiciously, the contractor may save money on salt.
Reducing Liability Risk	Maintain accurate and complete records of salting and plowing activities using automated controls	Low to medium impact	Low to medium effect
Well Informed Decision Making	Use supporting tools, such as pavement temperature measurements, to inform appropriate timing and rate of salt application	Low impact	Low impact as these measures can help increase operational efficiency
Professional Training and Certification	Request training and certification of contractors and property managers through the *Smart about Salt* Council.	Medium impact if training is extended to operational staff and property managers	Low impact as training is not expensive

2.0 REDUCING EXCESS ROAD SALT USE THROUGH WINTER MAINTENANCE SERVICE PROCUREMENT PRACTICES

Eight key areas have been identified as measures that are likely to reduce road salt use while maintaining high levels of service and transportation safety. In each of the following sections, the measure is described, followed by a discussion of potential effects of the measure on the amount of salt being applied, and estimated impacts on contract costs. In each section, sample contract clauses are suggested to provide further clarity on how each measure can be incorporated into procurement contracts.[1]

2.1 Effective Pricing of Services

Payment based on the reimbursement of costs or the amount of work accomplished (e.g. miles plowed or pounds of salt applied) does not encourage efficient and effective use of salt.[2] Under these contract pricing structures, the contractor receives compensation in direct proportion to the amount of salt applied and/or the frequency of salt applications. A pricing structure that creates a financial incentive for contractors to apply less salt is preferred. This may be a lump sum by season, a fixed sum per event with extra paid for standby costs, or some combination of these payment options.

2.1.1 Effect on salt use

Relative to a 'salt extra' contract, salt use would be expected to go down using a lump sum or per event contract structure because the incentive to apply more salt is no longer present. The decrease may be significant if the contractor views salt use reduction as a means of increasing profit. Encouragement and promotion of savings associated with salt application reductions during contract negotiations can help influence contractor perspectives in this regard.

2.1.2 Potential impact on contract cost

The impact on contract cost is expected to be low. A lump price per season contract may mean paying more in years with less precipitation and less in years with more. The unit price per event contract will result in variable costs depending on the number of events. In either case, the contractor is not offered an incentive to apply more salt or repeat salting operations during a given event more than is necessary to meet the stated level of service.

Sample contract clauses: Effective Pricing of Services

[Option 1: Unit Price per Event]

The unit prices submitted for each item shall be inclusive of furnishing all materials, equipment, labour, and transportation to perform and complete the work and shall be inclusive of HST.

[1] Most of these contract clauses are copied from existing or previous versions of snow and ice maintenance contracts. See reference section for sources.
[2] VMS, Inc. 2001. Best Practices of Outsourcing Winter Maintenance Services.

Payment shall be in the form of monthly invoices submitted by the Contractor at the unit price tendered for the services provided. Payment shall be considered full compensation for all labour and materials supplied and delivered as part of this Contract. Invoicing shall be inclusive of monthly standby cost, plus winter maintenance services provided for the various storm events. Any liquidated damages incurred by the Contract Administrator will be subtracted prior to payment. The Contractor is not entitled to interest for late payments.

The Contractor is to state the Unit Prices for various types of winter events in Section 14, Form of Tender.

[Option 2: Lump Sum per Season]

The Contractor will be paid for the Fixed Price Work, Ice Melting Services, and Extra Work as follows:

The Fixed Price Work

In consideration of the performance of the Fixed Price Work the Contract Administrator will pay the Contractor a lump sum by way of **[12]** monthly payments, from **[date]** to **[date]**. The Contractor will also invoice the Contract Administrator for items of Additional Work and Extra Work, if any, monthly. All invoices are due and owing within **[thirty (30)]** days of the date thereon and unpaid invoices will attract interest at a rate of **[2]**% per month, **[24]**% per annum.

Should the Contract Administrator default in any payment of a monthly installment of the Fixed Price Work or invoice for Extra Work as aforesaid, the Contractor may give Notice of said default to the Contract Administrator and should said default remain uncorrected for a period of **[(5) five]** days thereafter, the Contractor without further notice to the Contract Administrator may stop work under this Agreement such that all of the Contractor's obligations hereunder will be suspended without limitation, the Contract Administrator will have the sole responsibility to engage a reasonable and effective system to monitor and manage the condition of the Premises, the Contractor will not be responsible for any damages or claims whatsoever relating to or caused in whole or in part by the failure to perform services to the Premises and the Contract Administrator will indemnify and safe harmless the Contractor and its agents and employees from and against any such claims.

Ice Melting Services

The application of Ice Melting Products is included in the Fixed Price work described above.

Additional Work

[Remove this clause if the Fixed Price Work includes all Snowfalls in a given season.]

Snow Clearing for the first **[X]** Snowfalls is included as part of the Fixed Price Work, after which the Contractor will be paid for each additional Snowfall as Additional Work, the sum set out in Section 14, Form of Tender.

Extra Work

It is not intended that the Contractor should perform any work or services not described in or properly inferable from this Agreement. The Contract Administrator may request that the Contractor perform extra work or services ("Extra Work") by **[describe how the Contract Administrator is to contact the Contractor to request that Extra Work be performed]**.

The Contractor will not unreasonably withhold its agreement to perform Extra Work. If the Contractor agrees to perform Extra Work, the Contractor will do so within a reasonable period of time having regard to the timing of the request and the volume of work the Contractor is otherwise committed to. The Contractor will be paid for the performance of Extra Work, including Snow Relocation and Snow Removal, as set out in Section 14, Form of Tender.

2.2 Accurate Salt Delivery

Research has clearly demonstrated that automated salt delivery systems that control application rates by vehicle ground speed can significantly reduce the amount of salt applied. In general, closed loop electronic controllers that measure both truck speed and spreader discharge rates have been found to outperform open loop controllers that measure truck speed only. Regardless of the type of spreader being used, the equipment should be maintained in a good state of repair. Equipment calibration is critical to ensure that the amount of salt targeted for application coincides closely with the actual amount of salt applied.

2.2.1 Potential effect on salt use

In a study by Clear Roads, the use of closed loop electronic controllers resulted in salt savings of up to 47% when compared with manually controlled systems.[3] Calibration of manual spreaders ensures the spreaders are functioning appropriately and applying at the selected rate. This measure alone can reduce salt significantly depending on the pre-calibration condition of the spreader equipment.

2.2.2 Potential impact on contract cost

Less than 10% of parking lot contractors have ground speed controllers. Specifying this requirement may prompt some to change their equipment, but it will also narrow the field of competition, which could result in higher costs. It should be noted, however, that contractors that have made the transition to ground speed controllers are not necessarily charging more for their services because they benefit from other advantages, such as the ability to better track salt use and reduce the amount of salt applied. Maintaining equipment in a good state of repair with tracking abilities can help demonstrate due diligence in the event of a lawsuit, which may translate to lower insurance premiums, both for the property owner and contractor.

[3] Blackburn,B. Fleege, E. and Amsler, D. Calibration Accuracy of Manual and Ground-Speed Controlled Salters, Clear Roads Project CR 2005-02, Wisconson Department of Transportation, United States.

Sample contract clauses: Accurate Salt Delivery

Significant detail can be incorporated if desired. Smaller contracts may require less detail.

General

All winter maintenance equipment must conform to the latest standards as described in the *Highway Traffic Act*.

Equipment Age

All Contractor's vehicles, plows, spreaders and combination units shall be no older than **[10]** years from the current operating year (i.e. in 2013, the vehicles should have been manufactured no later than **[2008]**).

Equipment Specifications

[Option 1: Specifications Not Provided]

The Contractor shall provide adequate equipment to do the work. The amount of equipment to be used, but not the type, must be approved by **[name of municipality or organization]**. The type of equipment proposed for use shall be evaluated with the proposed plan.

[Option 2: Specifications Provided]

The Contractor will provide all of the necessary equipment to undertake pre-wetting and anti-icing procedures. The following provides general specifications for the equipment required to undertake this work. **[Describe specific specifications for the spreader pre-wetting system, anti-icing truck specifications, and other equipment.]**

Spreader Controls

Groundspeed electronic spreader controls have been demonstrated to increase the accuracy of material application rates. Open loop systems adjust the spreader output based on the speed of the vehicle, which is monitored at the speedometer or another sensing point. Closed loop systems take into account both the speed of the vehicle and the discharge rate of the material, by monitoring the liquid flow rate or speed of the auger or conveyer at the discharge point. Closed loop systems have been found to be the most accurate.[4]

To be considered for this contract, all spreader vehicles **[must/should]** be equipped with groundspeed electronic spreader controls. Electronic controllers shall be equipped with a data collection system.

[4] Blackburn,B. Fleege, E. and Amsler, D. Calibration Accuracy of Manual and Ground-Speed Controlled Salters, Clear Roads Project CR 2005-02, Wisconson Department of Transportation, United States.

Units that incorporate global positioning systems (GPS) for automatic vehicle location (AVL), and those that have data logging capabilities are **[recommended/required]** in order to more accurately track winter maintenance activities.

Detailed Specifications for Electronic Spreader Controls for Both Tandem and Single Axle Combination Vehicles

Electronic spreader controls for each dual purpose vehicle must comply with the following specifications in all aspects. Although only the major details of the control system are listed, it is the Contractor(s) responsibility to provide a fully equipped system with compatible components to provide dependable efficient service operated from inside of the cab.

[Modify the following specifications as needed.]

System Components:

The control system shall consist of a programmable microprocessor control console with a LED or LCD display that is easy to read during both day and night operation. The control console shall display to the operator the application rate settings, material selected and indicate any errors. The control system shall include a means to transfer data to a personal computer or to a hand held data transfer mechanism. The data transfer mechanism must have the capability to be connected to a printer directly and thus provide a hard copy of the spread report, or download the data to a personal computer.

Control:

The discharge of material shall be controlled proportional to road speed at the pre-programmed application rate by **[units]**.

The control console shall have the following functions:

1. Spread rate control
2. Spinner speed control
3. Spreader on/off button
4. Blast button
5. Power on/off switch

The control console shall have a self diagnosis capability and display fault codes.

The control console shall be equipped with a visual and audible alarm to inform the operator of a vehicle over speed condition in relation to the system's ability to discharge the programmed application rate.

The control console shall have a PROGRAMMING/CALIBRATION mode separate from the standard OPERATING mode that can be locked out be either a security password, a key or a calibration keyboard.

All operational functions such as material selection, spread rate selection, etc. shall be performed in OPERATING mode only.

The control console software shall be programmed to allow three separate operating modes being MANUAL, OPEN LOOP, and CLOSED LOOP.

The blast function shall be programmed to a fixed application rate or from 0 to 100% of the maximum application setting.

It shall be possible to pre-program ten(10) separate applications rates per material up to a setting of at least **[maximum desired setting]**.

2.3 Efficient Application

The amount of road salt needed to keep parking lots clear of snow and ice can be significantly reduced by using anti-icing (aka direct liquid application) and pre-wetting application techniques. Pre-wetting involves coating dry road salt with a liquid before applying it to the pavement. This helps the salt stick to the surface of the parking lot and speeds the melting of the salt, which means less salt is needed to do the same amount of work.

Anti-icing is the practice of applying a liquid (such as salt brine) or pre-wetted deicer to paved surfaces before the storm arrives. This prevents snow and ice from bonding to the pavement, making them much easier to remove. Anti-icing provides substantial cost savings to municipalities and road authorities because less salt is used, and roadway users benefit through a reduction in the potential for accidents during the winter season. On roads, anti-icing has been found to be effective at application rates as low as 100 pounds per lane-mile, which is equal to 1.57 pounds per 1,000 square feet[5] (refer to Section 7.9.1 Materials Spreading).

Standard road salts used for snow and ice control should also meet Ontario Provincial Standard Specifications (OPSS 2502) for moisture content, texture, and chemistry to ensure optimal performance

2.3.1 Potential Effects on Salt Use

In a study of Ontario roadways, pre-wetted salt was more effective than dry salt in 5 of 7 cases, reducing between 17.9% and 40.0% more snow cover than dry salt.[6]

When compared to conventional deicing, anti-icing typically requires only ¼ of the material and can be done at 1/10th of the cost.[7]

[5] Blackburn, R. R., McGrane, E. J., Chappelow, C. C., Harwood, D. W. and Fleege, E. J., Development of Anti-icing Technology. Strategic Highway Research Program, National Research Council, Washington, D.C.1994.
[6] Fu, L., Sooklall, R., and Perchanok, M.S. 2006. Effectiveness of Alternative Chemicals for Snow Removal on Highways. Transportation Research Record: Journal of the Transportation Research Board, No. 1948, Transportation Research Board of the National Academies, Washington, D.C., 2006, pp. 125–134.

2.3.2 Potential Impact on Contract Costs

While anti-icing can be done at a fraction of the cost of conventional deicing, and both pre-wetting and anti-icing offer significant savings in salt, not all contractors have direct liquid application equipment. Pre-wetting salt also adds cost and is not typically done by smaller outfits. Therefore, requesting that these be added to procurement contracts will likely result in higher costs. The cost is expected to fall over time as brine spreaders become more widely used, and contractors start realizing the substantial salt and labour savings that can be achieved through the use of anti-icing techniques. Costs associated with specifying that salt used conform to OPSS specifications should not impact contract cost.

Sample Contract Clauses: Efficient Application

Materials Spreading

In no case shall the spread pattern formed by the material extend beyond the boundaries of the parking lot. Spreading techniques are outlined in the Salt Institute's Handbook, "*The Snow Fighters*".

Pre-wetting

Pre-wetting is an application method in which a concentrated liquid anti-icing product is added to dry solid salt just before it is applied to the surface of the roadway. The liquid can be added either at the chute or at the spinner. Pre-wetting has been demonstrated to increase the effectiveness of dry road salt, reducing the amount of salt required. The liquid helps the salt stick to the pavement and facilitates melting by speeding the reaction time of dry salt. Pre-wetting should be used where weather and/or road conditions warrant.

Direct Liquid Application (DLA)

Preventing a snow or ice bond to a paved surface is much more efficient than destroying the bond after it has formed, and so preventive strategies should be the top priority.

DLA material should be applied on all roadways prior to the accumulation of frost, snow or ice, followed by plowing and/or spreading operations where weather and/or road conditions warrant. The Contractor shall be responsible to monitor weather and roadway conditions to determine when the conditions are appropriate for application of DLA. DLA, once applied, can be effective for a period of up to three days if not removed by weather. Weather and roadway conditions (air and surface temperature, precipitation, etc.) will vary within the geographic area and as such, the Contractor shall determine, based on the conditions, where and when DLA shall be applied. For example, conditions may be that DLA is required on:

a. all driveway and parking lot areas

b. driveways only

[7] Minnesota Pollution Control Agency et al. 2010. Winter Parking Lot and Sidewalk Maintenance Manual.

c. facilities within a specific geographic area

Salt and Sand Specifications

Salt used for winter maintenance shall conform to OPSS 531 and 2502.

Organic treated anti-icing/de-icing solutions (OTADS) are intended to improve low temperature performance, reduce overall consumption and reduce the effects of corrosion on property and vegetation. For these reasons, base salt (typically NaCl) shall be treated at the source at a 3% ratio with OTADS, that meets the following specifications.

- The product may not contain in excess of the following established total concentration limits. Results are stated as Parts Per Million (ppm)

Cyanide	0.35 ppm	Chromium	1.00 ppm
Arsenic	5.00 ppm	Cadmium	0.10 ppm
Copper	1.0 ppm	Barium	1.00 ppm
Lead	1.00 ppm	Selenium	5.00 ppm
Mercury	0.05 ppm	Zinc	10.0 ppm

- pH – The pH of submitted liquid OTADS shall be 7.0 – 9.5, which is considered neutral.
-OTADS must be Biodegradable and the material shall contain NO additional chlorides.
- The material must contain sufficient organic compounds to produce a final material having a eutectic freeze point of -30˚C or lower.
- The base organic compound must be a sugar beet extract with a minimum of 55% solids with a minimum sugar content of 10%. The sugar must be subjected to a chemical alkaline degradation to a PH value of at least 11 for a minimum of 24 hours followed with an organic acid to lower the PH range to 8.5 to 9.5.

Treated salt shall conform to Table 1 for Gradation as per OPSS 2502, latest revision. Sand shall meet the requirements of OPSS 531 and OPSS 1004.

2.4 Low Chloride Alternatives

A number of low chloride alternatives to road salt are currently available, such as acetates, formates, and organic products made from corn, sugar beets, and other plant materials. Road salt alternatives provide effective snow and ice control and many can be used as anti-icing or pre-wetting agents, delivering the same benefits as liquid salt brine, but with significantly lower chloride content. These products also usually provide melting capabilities at lower temperatures than conventional sodium chloride.

2.4.1 Potential Effects on Salt Use

In the Niagara Region, applying a beet juice compound as an anti-icing and pre-wetting agent to roads has reduced the amount of road salt on the roads by as much as 30%, while also lowering winter road maintenance costs.[8] In a field test of organic deicers performed in the Greater Toronto Area, a 30:70 mixture of beet juice and salt brine was found to be as effective as salt brine alone when used as a pre-wetting agent, and more effective (producing a higher coefficient of friction) than salt brine alone when used for direct liquid application.[9]

2.4.2 Potential Impact on Contract Costs

Alternative products, such as beet juice or calcium magnesium acetates, are more expensive than regular salt. Therefore, requiring alternative products will likely increase the cost of the contract by at least 25%. Specifying that salt meet the OPSS 2502 specification should not have any impact on cost.

Sample Contract Wording: Low Chloride Alternatives

Low-Chloride Materials

A number of alternatives to road salt are now commercially available, including materials that are low in chloride or chloride-free. The Contractor is encouraged to make use of road salt alternatives in order to reduce the amount of chlorides entering the environment.

Acceptable alternatives to road salt include:
List acceptable materials here

The Contractor must obtain the written approval of the Contract Administrator before using any materials which are not specified in Section 7.8.1.

Supply of Materials

Provisions shall be made to ensure that adequate sand and salt will be available for winter usage. All materials necessary for the completion of the work shall be supplied by the Contractor, and the payment provided in the Contract shall be deemed to include full compensation of such materials. The Contractor shall be responsible for ordering, deliveries, checking, rejecting, breakage, theft, unloading and storage of such materials in a manner satisfactory to the Contract Administrator.

The Contractor shall supply a list of suppliers of materials related to the tendered works. The acceptance of a supplier will be at the discretion of the Contract Administrator and persons submitting Tenders may wish to confirm the acceptability of any supplier during the tendering period.

All materials must be from sources that are either on the Designated Sources List, the Aggregate Sources List or approved by the Ministry of Transportation.

[8] Niagra Region, http://www.niagararegion.ca/living/roads/roadsaltreduction.aspx. Accessed July 2013.
[9] Fu, L., Omer, R. and Jiang, C., Field Test of Organic Deicers as Prewetting and Anti-Icing Agents for Winter Road Maintenance, Transportation Research Board: Journal of the Transportation Research Board, Vol No. 2272, Washington, D.C., 2012, pp. 130-135.

2.5 Reducing Application Rates

Knowledge about the amount of salt required to achieve a desired level of service under different weather and pavement conditions is needed to avoid over application of salts on parking lots and roads. In a study of winter maintenance practice in Central and Western Ontario, it was found that parking lot application rates were significantly higher than the road application rates developed by the Ministry of Transportation Ontario (MTO).[10]

Although parking lots may require heavier applications of salt because less traffic is present to disperse the salt, it is widely recognized that rates being applied are often well in excess of what is needed to meet safety standards. Scientifically defensible application rates for parking lots have been developed for Southern Ontario by the University of Waterloo through the *Snow and Ice Control for Parking Lots and Sidewalks* program (www.SICOPS.ca) and in North America, by the Snow and Ice Management Association's Sustainable Salt Institute (Sexton, 2017).

. Since the rates vary widely based on winter conditions and desired level of service, it is not possible to specify how much to apply in all circumstances. Therefore guidance provided in procurement contracts on application rates must be more general in nature, with the aim of ensuring that contractors are at least considering how best to apply at rates that are not in excess of what is required for safety.

Special attention needs to be directed to areas such as entryways, walkways and patios where manual application of salt is required, as these have historically received excessive quantities of salt, in part because the salt is not evenly spread across the areas.

Chemical plowing is a common term used to refer to the practice of applying salt on top of a layer of snow in lieu of both plowing and salting. Specifying the depth of snow accumulation below which anti-icers may be applied is critical to ensure that salt is not used as a substitute for plowing. As a general rule, snow should be plowed prior to salting if more than 1.25 cm has accumulated on the pavement.

2.5.1 Potential Effects on Salt Use

Care taken by Contractors to apply only as much salt is needed and additional scrutiny applied by Contract Administrators to ensure salt is not being over-applied can significantly reduce the amount of salt that is being applied. Simply raising over-application of salt as a potential concern ensures that more attention is paid to the quantity of salt applied, particularly on walkways and entranceways where manual application is required.

Significant reductions of salt on an event basis can be achieved by specifying the depth of snow accumulation at which salt application is no longer appropriate. Over the course of the season, the measure will result in a medium reduction in salt application.

[10] Raqib, O., Mirtorabi, M., Liaqat, Z., and Fu, L. 2013. Monitoring and Analysis of Winter Maintenance Operations for Parking Lots. Paper prepared for publication & presentation at the 93th Annual Meeting of the Transportation Research Board, January 2014. Draft.

2.5.2 Potential Impact on Contract Costs

Reducing the amount of salt applied should save money. Therefore including general cautionary notes regarding application rates should not result in higher contract costs. It is unlikely that contractors would charge more for being subject to a higher level of scrutiny regarding application rates.

Specifying a depth of snow accumulation above which snow plowing is required may add slightly to the cost of the contract because it is cheaper to apply inexpensive salt than to spend extra time on plowing.

Sample Contract Clauses: Application Rates

Application Rates

Sample application rates from various jurisdictions are presented in Appendix 1 for reference.

The rate of materials application depends on a variety of factors, including the weather conditions, surface temperature trend, existing snow or ice cover, traffic volume, and the type of material being applied. The Contract Administrator and the Contractor will determine and agree on a range of application rates for different weather and roadway conditions. The contractor will provide the contract administrator with the salt application rates used on the premises on a monthly basis.

[Option 1: Contractor Responsible For Timing and Quantity of Materials Application]

As part of the Fixed Price Work, the Contractor shall at its sole discretion determine when and in what quantities Ice Melting Products are to be applied to the Premises in accordance with the Drawings and Specifications. In determining whether or not and how to apply Ice Melting Products in any particular circumstance, the Contractor shall act reasonably, shall monitor the weather in the vicinity of the Premises and shall apply the standards and customs of the snow and ice maintenance industry.

In areas where manual application is required, amounts applied must be measured and recorded, and the method of application must ensure an even and optimal spread of salt to minimize over-salting from clumping or overly concentrated application in certain areas.

[Option 2: Contract Administrator Responsible For Timing and Quantity of Materials Application]

The Contract Administrator shall at its sole discretion determine if it wishes to have Salt, Sand, Calcium, or **[name any other products used on site]** (the "Ice Melting Products") applied at the Premises. The Contract Administrator may request that Ice Melting Products be applied by **[describe how Contract Administrator is to contact Contractor to request applications]** and upon receiving a request to apply Ice Melting Products, the Contractor shall respond to the request within a commercially reasonable period of time.

Snow Clearing

Mechanical removal of snow is a key measure for salt conservation. By removing as much snow as possible through plowing, less salt is required to keep the roadway free of snow and ice. The potential for refreeze is also minimized, as less snow and ice is available to dilute the applied chemical.

The following items should be reviewed with all staff engaged in winter maintenance to ensure that care and caution is exercised during the following plowing operations:

a) Drainage structures-catch basins, manholes, etc.

b) Fire hydrants, valve chambers

c) Hydro, telephone and other above and below ground services

d) Around delineators, median markers, signposts, mail boxes, etc.

e) Gates, bollards, fencing

f) Turning and auxiliary lanes

g) On-street parking areas

h) Operating, services and delivery vehicles on site

Salting of premise(s) shall commence no later than the time of 1.25 cm of snow accumulation on the paved surfaces.

2.6 Reducing Risk of Liability

Surveys of snow and ice management contractors have consistently indicated that over application of road salts is closely linked to the fear and long term cost of potential slip-and-fall lawsuits.[11] Following best practices and maintaining accurate and complete records of plowing and salting activities is the best form of defense against these lawsuits. These records may also reduce insurance rates as more and more slip-and-fall suits are successfully defended. Record keeping is also useful for monitoring the effectiveness of winter maintenance activities and identifying areas for improvement, as well as for tracking and assessing the Contractor's progress in the implementation of BMPs.

2.6.1 Potential Effects on Salt Use

Tracking the amount of salt being applied when and where can reduce salt by influencing contractor behaviours and ensuring more efficient operational functions and delivery. Reducing the fear of liability associated with not applying enough is a critical driver of these behavioural changes. The overall effect on salt use in any given year could range between low and medium.

[11] Fu, L., Omer, R., and Liaqat, Z. 2013. A Survey of Current State of Practice for Winter Maintenance of Parking Lots and Sidewalks. Paper submitted for Presentation at 2013 Annual Transportation Research Board Meeting. Draft.

2.6.2 Potential Impact on Contract Costs

Improving the ability to track salt use will require additional equipment and scrutiny by contractors, both of which can increase costs. However, the improved practices help to make operations more efficient, and may be seen as a worthwhile investment into reducing risk and providing the evidence needed to challenge potential lawsuits. If successful, this investment comes with a payback in terms of reduced insurance premiums over the long term. Therefore the potential for contract costs to increase based on tracking requirements alone are expected to be relatively low.

Sample Contract Clauses: Reducing Risk of Liability

The Contractor shall keep and maintain detailed records to track the times service was delivered and upon request, provide this detailed information to the Contract Administrator. It is advised/required that Contractors deploy GPS technology in conjunction with electronic spreader controllers to provide this tracking.

Monitoring and record keeping **[should/must]** include:

a) Location

b) Date and time of treatment

c) Weather conditions (Type of precipitation, air temperature)

d) Pavement conditions (Extent of snow/ice cover)

e) Pavement temperature trends

f) Plowing activities

g) Type and quantity of material placed

h) Snow removal activities (amount removed, disposal location)

i) Observed risk areas that could not be treated and why they could not be treated

A template for documenting winter maintenance activities can be found in Appendix 2.

In addition to winter maintenance activities, the following should also be tracked:

a) Fleet characteristics (Percentage equipped with electronic spreader controllers, Percentage equipped with pre-wetting, Percentage calibrated annually)

b) Staff training

2.7 Well Informed Decision-Making

Making informed decisions about application methods and timing requires the use of supporting tools. Skillful use of local weather forecasts, road weather information systems, internet based radar systems, and infrared thermometers to determine pavement temperature trends can help make decisions that save on salt, time and money[12]

2.7.1 Potential Effects on Salt Use

The use of decision making tools can help provide information allowing for more informed decision making on the timing and amount of salt to apply, and when plowing is required. A modest reduction in salt use can be expected from implementing one or more of these measures.

2.7.2 Potential Impact on Contract Costs

The additional time required to employ decision support tools is offset by salt saving, therefore the potential impact on costs is considered to be low. The decision support tools are widely available and pavement sensors are relatively inexpensive to install.

Sample Contract Clauses: Well Informed Decision Making

Road Weather Information Systems (RWIS)

There are **[X]** RWIS stations in the vicinity of the parking facility, located at:

[List the locations of any RWIS sensors in the area]

To access the RWIS information, the Contractor will require, at his cost, sufficient computer hardware to view and access the internet and an internet service provider account. **[Describe how the Contractor may access RWIS information, and procedures for acquiring passwords (if applicable).]** The availability and accuracy of this information is not guaranteed and shall be confirmed by other available sources.

Local Weather Forecasts

Local weather reports should be monitored closely to ascertain the nature, timing, and duration of winter storms and icing events. The Contractor shall ensure they have the proper resources to independently inform themselves of current weather conditions and forecasts. **[Optional: Include the name and address of a website where local weather forecasts can be accessed.]**

[12] Environment Canada. Case Study #7: Utilizing Technological Advances in the Management of Road Salt Usage in Nova Scotia. http://www.ec.gc.ca/nopp/roadsalt/cStudies/pdfs/7%20-%20Nova%20Scotia%20-%2004%2005%2003.pdf. Accessed August 2013.

Infrared Thermometers

Pavement temperature trends can be measured using portable infrared thermometers. This information improves decisions about the type and amount of material that must be applied. The Contractor is **[required/encouraged]** to use infrared thermometers to monitor pavement temperature trends and inform winter maintenance decisions

Internet-Based Radar

Internet-based radar images can show decision-makers where a storm is in relation to the service area, and help predict the timing of a storm's arrival or departure. The contractor is **[required/encouraged]** to consider internet-based radar images when making operational decisions.

2.8 Professional Training and Certification

Applying the right material in the right amount at the right time in the right place can only be achieved by a knowledgeable contractor. Developing this knowledge requires training and experience. Requesting evidence of this experience for all winter maintenance staff and requiring training and certification through the Ontario *Smart about Salt* Program will help to ensure that the contractor has the skills necessary to implement best practices for road salt use.

Property managers and works staff from businesses is also encouraged to receive training through the *Smart about Salt* program as these staff are responsible for overseeing operations and providing direction on snow storage areas and other critical elements of the winter maintenance plan.

2.8.1 Potential Effect on Salt Use

The diligence of the contractor and property manger in ensuring that plowing and salting are conducted in a responsible manner has a strong influence on the amount of salt applied. More knowlegable and better trained professionals would be expected to exercise greater care and diligence. If training is only undertaken by supervisors, a modest impact on salt use would be expected. If the training extends to front line staff, including drivers, the effect on salt application rates is expected to be more significant.

It is worth noting that in the City of Toronto, the implementation of a road salt management training program for winter maintenance supervisors and operators reduced salt use by almost 37,000 tonnes over two winter seasons and saved nearly $1.9 million dollars[13]

2.8.2 Potential Impact on Contract Cost

Training provides well recognized benefits that are already incorporated within the budget of most reputable contractors. Training to property management and business staff is also provided at a

[13] Environment Canada. Case Study #4: City of Toronto – Salt use Reductions through Employee Training. http://ec.gc.ca/sels-salts/default.asp?lang=En&n=E68EE1F4-1&offset=5&toc=show. Accessed June 2018.

reasonable cost. Extending the training to font line staff may be regarded as an additional expense for some smaller contractors. However, the cost of training is low, and therefore the effect on the overall contract cost is not expected to have a strong influence on quoted prices for services.

The Smart about Salt Council is currently introducing a graduated certification program with lower and higher levels associated with specific requirements for training, equipment standards and record keeping. Specifying the requirement for a higher level of certification in the contract is expected to have a medium effect on contract cost in the early stages of the program roll out.

Sample Contract Clauses: Professional Training and Certification

The Contractor shall train all their operations staff employed under this contract in the proper and timely use of deicing and anti-icing chemicals available along with snow clearing and snow storage techniques to minimize the use of deicing chemicals. The use of liquid anti-icing and pre-wetted deicing materials is encouraged.

To be eligible for this Contract, the Company must provide proof of intent to be certified under the *Smart About Salt*™ Program (www.smartaboutsalt.com) and become a *Smart About Salt* Certified Contracting Company by **[date]**. The *Smart About Salt*™ Winter Salt Management Program, run by the Smart About Salt Council, is a voluntary recognition program about using salt wisely to ensure winter safety, preserve our drinking water and protect the environment. Any Contractor that fails to provide proof of Registration or Certification by the specified date will be disqualified from bidding or continuing with a Contract. Accepted proof of Certification is listing as a Certified Contracting Company on the *Smart About Salt* Website or written acknowledgement of Registration or Certification from the *Smart About Salt Council*.

Currently, there are two training sessions planned for **[date]** in **[place]** and **[date]** in **[place]**. The Contract Administrator will pay the costs for successful completion and accreditation of at least **[four (4)]** staff members of the successful Contractor. **[If the Contract Administrator does not wish to cover the costs of Contractor Training, remove this provision.]**

3.0 REFERENCES

The contract clauses provided in this procurement guidance document are based on wording from existing snow and ice maintenance contracts and request for tenders, as well as best practice guidance from the following sources:

Landscape Ontario. *Snow and Ice Maintenance Contract between Owner and Contractor*.

The Corporation of the City Of Woodstock. 2011. *Tender for Winter Maintenance Services: Project #75010.*

The Regional Municipality of Niagara. 2009. *The Regional Municipality of Niagara Request For Tender for Winter Maintenance Water & Wastewater Facilities: Tender Number #2009-T-21.*

Region of Waterloo. *Section B Scope of Work: Generic for All Locations.*

The Corporation of the Town of Richmond Hill. *TW-42-09*.

Environment Canada. 2004. *Best Management Practices for Salt Use on Private Roads, Parking Lots and Sidewalks*.

Minnesota Pollution Control Agency, Fortin Consulting, Inc., Circuit Training and Assistance Program, Minnetonka, University of Minnesota, Minnesota Department of Transportation, Scott, Minnesota Local Technical Assistance Program, Envirotech Services, Inc., Cadwell Lawn Care and Landscaping, General Growth Properties, Inc., and Mississippi Watershed Management Organization. 2010 Revised Edition. *Winter Parking Lot and Sidewalk Maintenance Manual*

Ontario Good Roads Association. *Salt Management Plan Template*.

Sexton, P. C., 2017. *Sustainability Analysis of the Commercial Winter Management Industry's Use of Salt*. Master's thesis, Harvard Extension School.

Toronto Parking Authority. *Winter Maintenance for TPA Parking Lots. Snow plowing, salting and removal.* 2015.

Transportation Association of Canada. 2013. *Syntheses of Best Practices for Road Salt* Management: 9.0 *Winter Maintenance Equipment and Technologies*.

VMS, Inc. 2001. *Best Practices of Outsourcing Winter Maintenance Services*.

APPENDIX 1: SAMPLE APPLICATION RATES

Road salt application rates currently used by other jurisdictions within and outside of Ontario are presented below. These rates have been provided as examples of what other jurisdictions are specifying, and may not be appropriate for a given application. Rates typically specified on municipal roads and highways are typically much lower than on parking lots. The effectiveness of a given application rate is dependent on several factors including precipitation type and depth, air and pavement temperature, humidity, dew point, sun exposure, the type of paved surface, and the volume of traffic. These application rates should be modified according to the conditions observed at the parking lot and the knowledge and experience of the contractor.

Anti-Icing

Tables 5 and 6 present application rate guidance for anti-icing using liquids, developed by the Minnesota Pollution Control Agency and the Niagara Region. Application rates vary based on the type of precipitation and the type of liquid being applied.

Table 5: Direct Liquid Application (DLA) Guidelines (L/100 m^2)

CONDITION	**APPLICATION RATE (L/100 m^2)**		
	$MgCl_2$	**Salt Brine (NaCl)**	**Other Products**
Minnesota			
Regularly scheduled applications	0.8 – 1.6	1.2 – 2.4	Follow manufacturers' recommendations
Prior to frost or black ice event	0.8 – 1.6	1.2 – 2.4	
Prior to light or moderate snow	0.8 – 1.6	1.2 – 3.3	
Niagara Region			
Prior to frost	N/A	1.71 – 2.28*	N/A
Prior to snow or freezing rain**	N/A	2.28 – 3.5*	N/A
CAUTION: Too high an application rate may result in slippery conditions or tracking.			

*Spread the liquid across 2/3 of the driving surface.

**Liquid anti-icing in anticipation of snow and/or freezing rain should be completed as close to the beginning of the precipitation as possible to a maximum of eight (8) hours.

Table 6: Direct Liquid Application (DLA) Guidelines (gallons/1,000 ft^2)

CONDITION	APPLICATION RATE (gallons/1,000 ft^2)		
	$MgCl_2$	**Salt Brine (NaCl)**	**Other Products**
Minnesota			
Regularly scheduled applications	0.2 – 0.4	0.3 – 0.6	Follow manufacturers' recommendations
Prior to frost or black ice event	0.2 – 0.4	0.3 – 0.6	
Prior to light or moderate snow	0.2 – 0.4	0.3 – 0.8	
Niagara Region			
Prior to frost	N/A	0.4 – 0.6*	N/A
Prior to snow or freezing rain**	N/A	0.6 – 0.9*	N/A
CAUTION: Too high an application rate may result in slippery conditions or tracking.			

*Spread the liquid across 2/3 of the driving surface.
**Liquid anti-icing in anticipation of snow and/or freezing rain should be completed as close to the beginning of the precipitation as possible to a maximum of eight (8) hours.

The DLA for frost shall not be completed if any of the following criteria are expected:

- Pavement temperature is expected to remain above 2° centigrade continuously for the next 72 hours
- Pavement temperature is lower than -10° centigrade during the application
- Pavement temperature is expected to fall below -15° centigrade at any time within the next 24 hours
- Non-freezing rain is forecast in the next 24 hours
- Snow or ice has already accumulated on the road surface

The DLA in anticipation of snow and/or freezing rain shall not be applied if:

- The pavement temperature is lower than -10° centigrade or is expected to be below -10° centigrade between the time of application and the start of precipitation
- Snow and/or ice has already accumulated on the road surface

Deicing

Table 7 presents application rate guidance used in the Niagara Region for varying weather and pavement conditions. Pre-wetted salt is to be applied in such a way as to ensure the maximum amount of material remains on the road. This is usually accomplished by applying a strip not less than 3.5 m wide, down the centre of a two-lane driveway or laneway and between lanes in a parking area at the rates shown in Table 7. Where pre-wetting equipment is unavailable, dry salt may be used at the rate of 1.85 – 2.42 kg/100 m^2 (3.8 – 5.0 lbs/1,000 ft^2). On elevated sections of driveway and parking areas, the salt shall be kept as high up on the pavement as possible to allow the brine to flow across the driveway or parking area.

Salt is spread after the beginning of precipitation when moisture is present to hold the salt in place.

The spinner shall be used to apply pre-wet salt on pavements with:

- surfaces made of open friction course material; or
- distorted cross fall; or
- no cross fall.

In these situations, the brine cannot flow across the pavement, and consequently a narrow strip will not be effective. Under freezing rain conditions, spread over 1/3 of the driving surface.

The recommended application rates are based on on-board pre-wetting with liquid applied at a minimum of 5% and maximum of 30% by mass of the dry material rate, where the total dry equivalent of liquid and dry rock salt is equal to the rates shown in Table 7.

"Light snow" refers to snowfall where plowing operations are not yet necessary (or anticipated), but there is a need to apply salt. "Heavy snow" refers to snowfall where plowing will be required during the storm event.

The variable application rates are a guideline only. Where these rates are not achieving the required results, re-application, or increasing rates to the standard (1.85 – 2.42 kg/100 m^2) shall be considered.

When using the variable chart, ensure consideration is given to weather forecasts, pavement conditions, and pavement temperatures. Use relevant information from RWIS, and infrared thermometers and visual assessment.

Specific attention shall be given to potentially hazardous locations, such as: hills and run-off areas, curves, intersections, and shaded areas. These locations are potentially hazardous because they could be slippery when the rest of the surface area is not, or they are areas which may require braking.

Table 7: Best Practices for Variable Salt Application Rates with On-Board Pre-Wetting

Precipitation	**Units**	**Road Surface Temperature Range**		
		Warmer than -5°C	-5°C to -10°C	-10°C to -18°C
Frost	kg/100 m^2	0.7	1.0	1.0
	lbs/1,000 ft^2	1.4	2.0	2.0
Light snow	kg/100 m^2	1.0	1.43	1.85
	lbs/1,000 ft^2	2.0	2.9	3.8
Heavy snow	kg/100 m^2	1.85	1.85	2.42
	lbs/1,000 ft^2	3.8	3.8	5.0
Freezing rain	kg/100 m^2	1.85	2.42	2.42
	lbs/1,000 ft^2	3.8	5.0	5.0

Tables 8 and 9 contain guidelines for parking lot application rates from the Minnesota Pollution Control Agency's Winter Parking Lot and Sidewalk Maintenance Manual. These rates are based on road application guidelines (Minnesota Snow & Ice Control Field Handbook, Manual 2005-1). Develop your

own application rates by adjusting your current rates incrementally downward toward these guidelines. Where temperature categories overlap, select the rate most applicable to your situation.

Table 8: Deicing Application Rate Guidelines for Parking Lots and Sidewalks (kg/100 m^2)

Pavement Temp (°C) and Trend (↑ ↓)	Weather Condition	Maintenance Actions	Application Rate in kg/100 m^2			
			Salt Prewetted/ Pretreated with Salt Brine	Salt Prewetted/ Pretreated with Other Blends	Dry Salt	Winter Sand (abrasives)
> -1° ↑	Snow	Plow, treat intersections only	0.37	0.24	0.37	Not recommended
	Freezing rain	Apply chemical	0.61	0.49	0.73	Not recommended
-1° ↓	Snow	Plow and apply chemical	0.61	0.49	0.73	Not recommended
	Freezing rain	Apply chemical	0.73	0.61	0.85	Not recommended
-1° to -4° ↑	Snow	Plow and apply chemical	0.61	0.49	0.73	Not recommended
	Freezing rain	Apply chemical	0.73	0.61	0.85	Not recommended
-1° to -4° ↓	Snow	Plow and apply chemical	0.61	0.49	0.73	Not recommended
	Freezing rain	Apply chemical	0.85	0.73	1.10	1.59
-4° to -7° ↑	Snow or freezing rain	Plow and apply chemical	0.85	0.73	1.10	1.59 for freezing rain
-4° to -7° ↓	Snow	Plow and apply chemical	0.98	0.98	1.34	Not recommended
	Freezing rain	Apply chemical	1.22	0.98	1.46	1.59
-7° to -9° ↑	Snow	Plow and apply chemical	0.98	0.98	1.34	Not recommended
	Freezing rain	Apply chemical	1.22	0.98	1.46	1.59
-7° to -9° ↓	Snow or freezing rain	Plow and apply chemical	1.22	0.98	1.46	1.59 for freezing rain
-9° to -18° ↑↓	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	1.46	Not recommended	2.44 spot treat as needed
<-18°	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	2.20	Not recommended	2.44 spot treat as needed

Table 9: Deicing Application Rate Guidelines for Parking Lots and Sidewalks (lbs/1,000 ft^2)

Pavement Temp (°C) and Trend (↑ ↓)	Weather Condition	Maintenance Actions	Application Rate in lbs/1,000 ft^2			
			Salt Prewetted/ Pretreated with Salt Brine	Salt Prewetted/ Pretreated with Other Blends	Dry Salt	Winter Sand (abrasives)
> -1° ↑	Snow	Plow, treat intersections only	0.75	0.5	0.75	Not recommended
	Freezing rain	Apply chemical	1.25	1.0	1.5	Not recommended
-1° ↓	Snow	Plow and apply chemical	1.25	1.0	1.5	Not recommended
	Freezing rain	Apply chemical	1.5	1.25	1.75	Not recommended
-1° to -4° ↑	Snow	Plow and apply chemical	1.25	1.0	1.5	Not recommended
	Freezing rain	Apply chemical	1.5	1.25	1.75	Not recommended
-1° to -4° ↓	Snow	Plow and apply chemical	1.25	1.0	1.5	Not recommended
	Freezing rain	Apply chemical	1.75	1.5	2.25	3.25
-4° to -7° ↑	Snow or freezing rain	Plow and apply chemical	1.75	1.5	2.25	3.25 for freezing rain
-4° to -7° ↓	Snow	Plow and apply chemical	2.0	2.0	2.75	Not recommended
	Freezing rain	Apply chemical	2.5	2.0	3.0	3.25
-7° to -9° ↑	Snow	Plow and apply chemical	2.0	2.0	2.75	Not recommended
	Freezing rain	Apply chemical	2.5	2.0	3.0	3.25
-7° to -9° ↓	Snow or freezing rain	Plow and apply chemical	2.5	2.0	3.0	3.25 for freezing rain
-9° to -18° ↑↓	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	3.0	Not recommended	5.0 spot treat as needed
<-18°	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	4.5	Not recommended	5.0 spot treat as needed

The Ministry of Transportation Ontario (MTO) salt application rates for roadways, converted to units relevant for parking lots, are provided in Table 10. Research has shown that application rates for parking lots are usually higher than the MTO rates for roads.

Table 10: Ministry of Transportation Ontario (MTO) Deicing Application Rates for Roads

	Units	**Dry Salt Application Rate**
Low	kg/100 m^2	1.70
	lbs/1,000 ft^2	3.5
Medium	kg/100 m^2	1.96
	lbs/1,000 ft^2	4.0
High	kg/100 m^2	2.22
	lbs/1,000 ft^2	4.5

APPENDIX 2: SAMPLE ACTIVITY LOG

This activity log can be used to accurately measure winter maintenances activities and monitor the implementation of best practices. **[Tailor as needed according to circumstances.]**

RECORD OF WINTER MAINTENANCE	
General	
Location	
Treatment start date and time	
Treatment end date and time	
Name of operator	
Weather conditions	
Air temperature	
Relative humidity (%)	
Dew point	
Sky (Ex: sunny, cloudy, etc.)	
Date and time of event start	
Date and time of event end	
Type of precipitation (Circle all that apply)	Snow / Rain / Snow / Freezing rain / Sleet / Hail / Other:
Total precipitation (mm)	
Pavement conditions	
Extent of snow/ice cover	
Pavement temperature trend	
Maintenance activities	
Timing of application	Anti-icing / De-icing
Type of material applied	
Reason for applying	
Application rate	
Describe snow clearing activities	

Amount of snow removed	
Disposal location	
Areas of special concern	
Observed risk areas that could not be treated	
Reasons for not treating risk areas	
Observations	
Observations at the time of treatment	
Observations during the event	
Observations after the event	

Source: Minnesota Pollution Control Agency. 2010 Revised Edition. Winter Parking Lot and Sidewalk Maintenance Manual.

Research has shown that application rates for parking lots are usually higher than the MTO rates for roads. Within the effective temperature for NaCl, rates typically range from 2.3 to 7.4 kg/100 m^2 (5 to 15 lbs/1000 sq. ft) with an average industry rate based on monitoring of approximately 6.1 kg/100 m^2 (12 lbs/1000 sq. ft) (see Sexton, 2017).