Interim Progress Report

Optimum Salting for Parking Lots and Sidewalks

Prepared for

Landscape Ontario Horticultural Trades Association
7856 Fifth Line South
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By

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1 Introduction

Every year, Canada spends over $1 billion to clear snow and ice on public and private roads, parking lots and sidewalks. This includes the use of over 5 million tonnes of salts for deicing and anti-icing operations. While use of salts is essential to ensure the public safety and mobility and the nation's economic vitality, release of such large quantities of salts could cause significant environmental side effects such as damages to the soil, water, plants and wildlife. Salt is also a significant factor contributing to the corrosion of bridges, buildings and vehicles, increasing their maintenance costs by billions of dollars.

Because of these significant financial, environmental, and social implications, considerable research and development efforts have been devoted to the improvement of winter maintenance methods, products, and technologies over the past decades. However, most of the past efforts have focused on roadway maintenance with little research on those for parking lots and sidewalks although the latter takes a significant share of salt usage (20~30%). There are few defendable and uniform guidelines on what snow and ice control methods, materials, and application rates should be adopted for these facilities. The few available guidelines are either short of recommending application rates (Environment Canada, 2004) or derived rates straight from those for roads which often have drastically different functional requirements and environmental conditions. This lack of uniform salting guidelines, in combination with the private owners' desire to minimize their business risk and legal exposure, has resulted in excessive quantities of salts being applied in these areas.

2 Research Objectives

The primary goal of this research project is to develop a better understanding of the conditions that influence the effectiveness of various commonly used deicing and anti-icing treatments for parking lots and sidewalks, and to develop knowledge for optimum selection of materials, application rates and techniques. The specific objectives of the project include:

- To determine the condition parameters that affect the performance of rock salts, brines, and alternative chemicals for deicing and anti-icing treatments.
- To determine the optimum application forms and rates for deicing and anti-icing treatments of parking lots and sidewalks over the expected range of pavement and environmental conditions.
- To develop models that can be used to forecast pavement surface conditions, such as residual salts, snow and ice cover, and friction, under specific weather events and treatment schedule.
- To develop guidelines and decision support tools for snow and ice control of parking lots and sidewalks, including material selection, salt application rates and treatment strategies.
- To synthesise best practices related to parking lot maintenance service policy and standards, material selection and application rates, deicing and anti-icing operations.

3 Project Tasks (2011)

Following the work plan detailed in the research proposal, the project for Year 1 (2011) has following three major tasks:

- Reviewing literature
- Conducting field testing of dry salt
- Survey contractors for the state of practice and establishing off-site data collection system

Detailed progresses on these tasks are described in the following sections.

4 Literature Review

A review of existing literature was conducted to understand the state of the art in winter maintenance of transportation facilities. Various online and printed resources have been scanned to find relevant materials on the subject.

It has been found that municipalities and universities in the US and other parts of the world have been involved in some similar studies that aim to streamline the process of parking-lot and side-walk maintenance during the winter (see appendix A for a list of these studies). However, most of these efforts have been in the form of training programs for contractors and maintenance personnel that aim at educating them with maintenance practices that would reduce not only environmental impacts but also operating costs. There are only a few resources recommending salt application rates for parking lots and sidewalks. The recommended rates are almost exclusively adopted from those used in highway snow and control. To our knowledge, no systematic field studies have been conducted to develop salting guidelines for various forms of snow and ice control strategies specifically for parking lots and sidewalks.

A review on the existing technologies for parking lot maintenance is also being conducted. This includes pavement and air temperature measurement, vehicle locator systems such as automatic vehicle location (AVL) along with newer ground-speed based spreaders that enable an even spread of salt despite the speed variability of the spreader.

A study of the trend of slip and fall accidents in Ontario is also underway. Slip and fall injury data is being collected along with the type of demographic, storm severity and general level of service at the site where the accident occurred.

Results of the literature review will be detailed in the final project report.

5 Field Testing and Results (2011)

The performance of salts or other chemicals for snow and ice control is affected not only by the treatment variables (e.g. type or brand of deicer, application rate, or method), but also by many other factors such as pavement temperature, type of pavement and surface contaminants, expected precipitation, residual chemicals from previous applications and other environmental factors like cloud cover etc. To determine how these factors influence the deicing performance of chemicals, a field test with semi-controlled settings was initiated. The following sections detail the test site, testing method and preliminary results.

5.1 Test Site

A three day inspection was conducted at different sites at The University of Waterloo to determinetheir traffic usage, pavement type and external factors like shades that might have an effect on the maintenance activities and the level of service for that location. This step is to ensure that the selected test sitesare sufficiently representative and can be divided into uniform test sections.

After closely examining a number of sites, parking lot C located next to the University avenue was selected, as show in Figure 1. The lot has a capacity of approximately 400 stalls and four main drive aisles. It is considered to be one of the most heavily used parking lots at the University of Waterloo. High usage and closeness to the University made it the ideal candidate for the test site. The four drive aisles are designated at the test sections for experimenting different application rates.

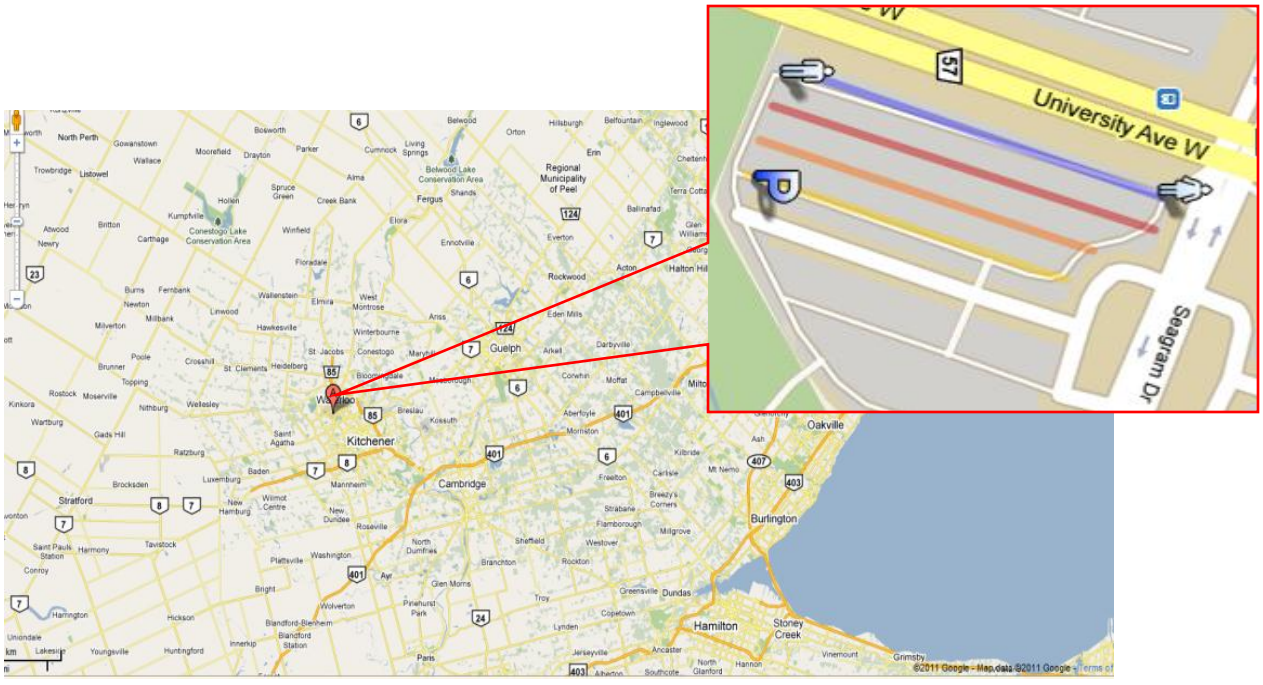


Figure 1: Test Siteat the University of Waterloo

5.2 Salt Application Control

To determine the performance of different salt application rates at the same test site, arrangements were made with the University of Waterloo maintenance and services office to apply salt at different rates on different sections of the selected parking lot. Having different rates on the same location under the same storm events enabled a fair performance comparison on a much finer granularity as all variables relating to storm intensity, traffic and other environmental factors were approximately the same .

Each of the four sections of the selected site was divided into two unequal segments, as shown in Figure 2. The smaller segment (40 feet in length-indicated by solid line) was reserved for manual salting whereas the longer segment (indicated by dashed line) was salted using the newly acquired automated ground speed based salt spreader. Manual and automated salt spreading rates were kept the same within each section and varied across the four sections. Manual and automated application sections were then visually inspected to validate the amount of material put down by the automated system against the precisely measured manual application.

Three applications rates were tested, including 7, 10 and 12 kg/100m^2. Table 2 shows the rates applied along with the corresponding sections.

Figure 2: Salt Application Methods

Table 2: Salt Application Rates Tested

Lane	Material Kg/100m² (lbs/1000ft²)
1	7 (15)
2	10 (20)
3	12 (25)
4	(not used this season)

5.3 Data Collection

Figure 3 shows a flowchart of the data collection procedure. After the start of each event, the lot is first plowed after a certain amount of snow accumulation. The test sections are immediately inspected after plowing to check if they have similar initial conditions before salting. Initial data collection is followed by manual and automated salting of the lot. The lot is then periodically visited and observed till a desired level of service is achieved.

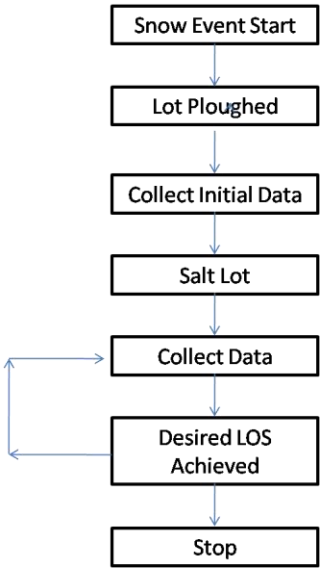


Figure 3: Data Collection Procedure

For each observation visit, the following condition data are collected:

- Snow cover and thickness (visual observation plus digital camera)
- Presence of ice sticking to the pavement (visual observation plus digital camera)
- Presence of salt from previous salting operation (visual observation plus BOSO20 salinity meter)
- Pavement and air temperature (infrared and probe type thermometer)
- Blowing or drifting snow(visual observation)
- Friction level (T2GO friction meter)

Appendix B listed the various data collection equipment used in this field test. A sample of the data collected after a regular visit to the parking lot can be found in Appendix C. Additional weather related data were downloaded from MTO's RWIS (road weather information systems) website using the closest RWIS stations (one is located on HWY 8 near Cambridge and the other on HWY 7 near Guelph).

5.4 Some Preliminary Results

A total of four snow events, stretched over seven days, were covered after the start of the project in Feb. 2011. Details of these events and data collection runs are summarised in Table 3.

There were some issues with both the salinity meter and friction equipment; as a result, the team was not able to obtain sufficient amount of reliable measurements on residual salt and friction level, precluding their use as indicators for evaluating the performance of the different application rates. As a result, trend of visual snow coverage, as identified from video records, is used as the only performance indicator for the subsequent analysis. To facilitate the comparison, a pavement snow and ice coverage rating scheme is proposed to represent the qualitative characteristics of snow coverage. Table 4 shows the pictorial definition of this rating scheme with an index value of 0 representing the worst condition of being complete snow coverage and 5 the best condition of being bare wet.

Table 3: Summary of Snow Events

EVENT DATE	EVENT CONDITIONS	Total Precipitation (cm)	Air Temp (°C)	Surface Temp (°C)	No of Test Runs
February 3, 2011	Snow Covered Sunny, not snowing	12.8	~ -10	~ -9	4
February 4, 2011			~ -4	~ -7	2
February 24, 2011	Icy – Melted by 9:00am	2	~ -5	~ -2	1
March 11, 2011	Very Slushy / Snow Covered	0.6	~ 4	~ 4	3
March 23, 2011	Continuous snow fall, clear / No snow / follow up on March 23 event.	12.6	~ 3	~ 3	2
March 24, 2011			~ -2	~ -5	2

Table 4: Condition Rating Scheme

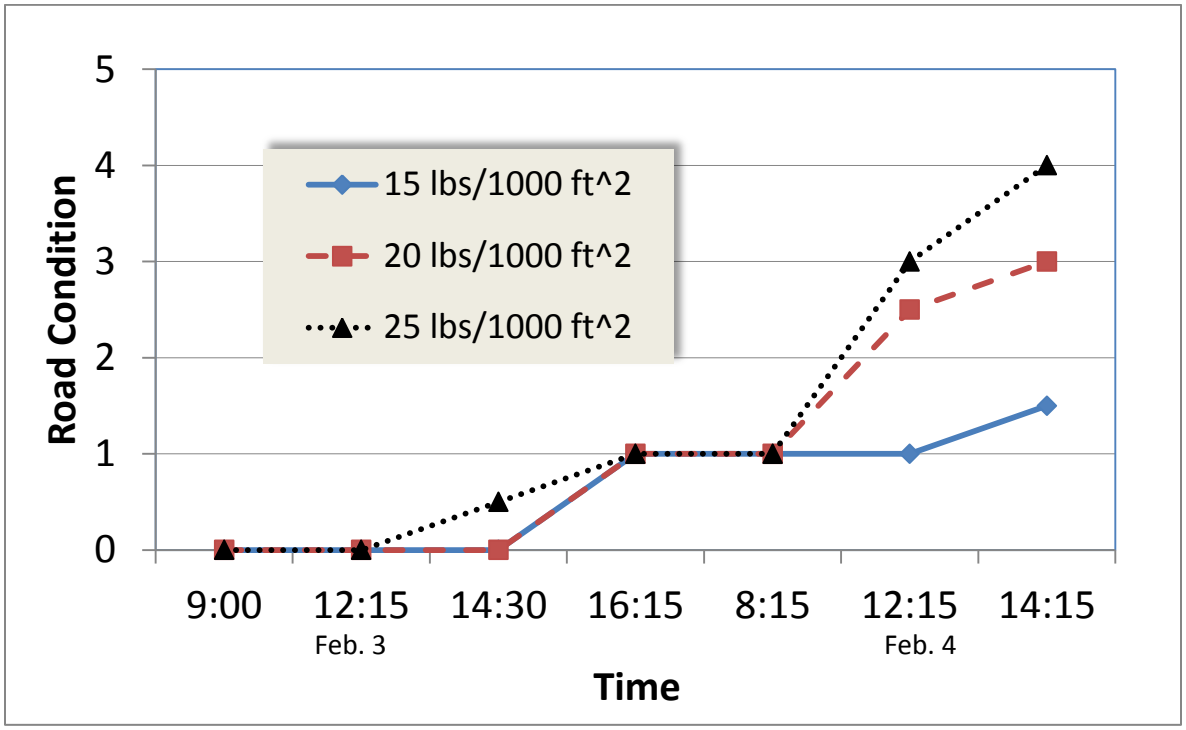
Condition Rating	Snow Cover State	Illustration
0	Completely snow covered	
1	Tracks unclear	
2	Tracks bare	
3	Slush	
4	Patches	
5	Bare wet	

Figure 4 shows the deicing performance of salt as related to salt application rate over two snow events. The two events were vastly different in terms of temperature: one (Feb. 3-4) was extremely cold with air temperature below -10 °C and the other relative warm temperature fluctuating around zero degree Celsius. The following observations could be made from these results:

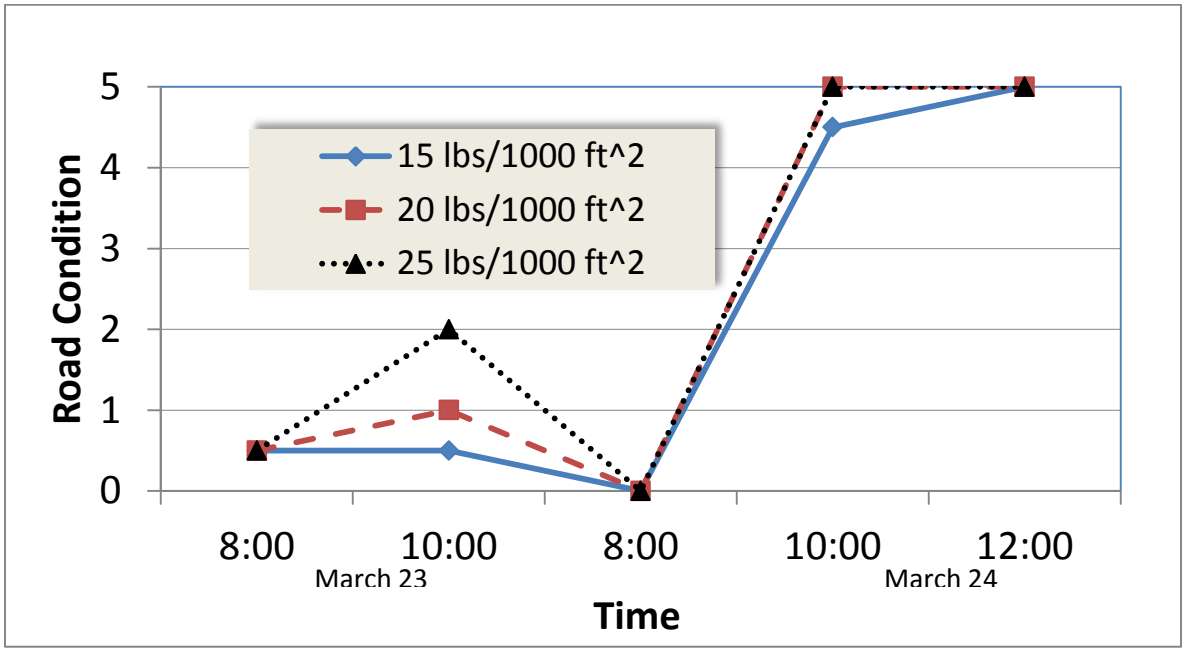
- When the temperature is below the practical lowest effective temperature of salt (~ -7 °C), the performance differences between the different application rates were extremely small, as shown in the left part of Figure 4-a which was observed on Feb. 3 with a temperature below -7 °C. This result makes intuitive sense, confirming that the effect of salt is limited no matter how much salt is used;
- When the temperature is around the practical lowest effective temperature of salt, better performance was achieved by applying larger amount of salt, as shown in the right part of Figure 4-a. However, under warmer conditions, as in the case of March 23-24 (Figure 4-b), the difference between the different rates again became small, suggesting that a lower rate should be considered under these conditions. The same patterns were observed on the other two events, both of which had high temperatures.

5.5 Remarks

The experimental setup to micro examine the performance of different de-icing materials under real conditions has been set up and tested. The setup along with the mentioned pavement condition monitoring equipment has proven useful to collect a rich dataset of road surface conditions along with material application, usage and other environmental factors. The collected data can then be used to generate detailed condition specific models and determine the optimum snow-control techniques specifically for parking lots.



a). Test results of Feb. 3/4



b) Test results of Mar. 23/24

Figure 4: Deicing Performance versus Application Rates

6 Survey of the State-of-the-Practice and Off-site Data Collection

6.1 Survey of Parking Lot Snow and Ice Control Practice

To better understand how bulk of the parking-lot maintenance contractors operate, a survey is to be carried out on an Ontario wide survey of various small, medium and large maintenance contractors. The primary purpose of the survey is to collect information about parking lot maintenance industry and current practice. This information will be used to provide input to the field test in determining the types of materials, the ranges of application rates, and the variety of snow and ice control strategies currently being used.

A prototype online survey system has been developed (Appendix D) and tested on a pilot survey of three maintenance contractors. The survey focuses on the following specific areas:

- ***Material Application, Rates and Types***
  With little or no formal guidelines and procedures to follow, parking-lot maintenance is subject to a large variation in material types and application rates. The survey focuses on enlisting the main materials (chlorides, bio based materials) that are used by contractors for snow and ice removal. The survey also covers material application rates so that the current level of practice amongst the maintenance contractors can be gauged.

  The pilot survey indicated that contractors are aware of the variety of snow melting chemicals available in the market and the need to use different materials under different circumstances. Traffic and temperature have been identified as the main performance factors; however, cost economy and availability dominate all others.

- ***Maintenance Methodology and Need for Training and Awareness Sessions.***
  Maintenance contractors are asked about their maintenance methodology and common practice regarding when to plow, salt or sand. Unlike highway maintenance, property maintenance contractors follow vastly different maintenance strategies, mostly relying on the experience of the personnel rather than maintenance guidelines.

  Other factors affecting maintenance decisions include type of contracts, demands of the clients, and various logistical factors such as equipment availability, distance from salt depot, time of day, work load etc.

  It has been observed from the pilot survey that the mainstream contractors are well aware of the maintenance training programs that are out there. Some contractors admitted attending international maintenance conferences and workshops that introduce new maintenance practices and materials. However, the current training programs available in Canada are not up to the standards and do not add to their existing knowledge. It was suggested that the focus of training workshops should be towards introducing new technologies and practices rather than telling the contractors what they already know.

- ***Type of Equipment (salters, plows, etc.)***
  The type of equipment can make a potentially large difference in time, cost and material efficiency of a maintenance operation. The survey focuses on collecting information on the range of equipment that is in use. It has been observed that there is a large variety in the type of equipment being used. Smaller contractors tend to have older and low capacity units whereas bigger contractors have high capacity equipment. A list of the type of different salters, sanders etc. is currently being put together.

- ***Use of Latest Technology (RWIS, ground speed based spreaders)***
  Some mainstream contractors are already using information from RWIS along with AVL and temperature sensors to aid in maintenance operations. Ground speed based salt spreaders are not common but those who have used them report considerable increase in salt efficiency. The survey will help identify the extent that these technologies are being used.

- ***Type of Contracts***
  One of the main considerations in parking lot maintenance is the contract type. For example, a contractor could include salt costs in the contract or charge the client separately of the salt usage. As expected, the later type tends to cause contractors putting down more salt. However, given the current low prices of salt, it may still be more cost-effective for contractors to chemically melt the salt even when they have to cover the salt costs.

- ***Variation in Customer Demands***
  The type of customer/contract also largely dictates the maintenance practice of the contractors. It has been seen that government/corporate/military contracts tend to have high expectations and demands compared to others. There is consensus on the idea that often times demands for higher levels of service would result in less efficient use of salt.

- ***Insurance and Legal Issues***
  Slip and fall law suits are the biggest concern for all contractors. There is consensus on the opinion that large amounts of excess salt are being inefficiently used in order to avoid accidents and law suits. This not only results in a high maintenance cost but also causes damage to the environment.

- ***Hurdles in Adopting Sustainable Practices***
  Fear of law suits and lack regulatory action are the major hurdles for contractors to adopt sustainable practices. Many believe they wouldn't adopt efficient salt usage practices when there is little or no incentive of doing so.

- ***Willingness to Cooperate With Other Agencies and Promoting Sustainability***
  Many of the larger contractors are willing to share maintenance and material usage information. The main motivation behind this is to come up with a set of baseline levels of service and best practices which could help in defending law suits.

6.2 Off-site Maintenance Data Collection System

Field testing is always limited in terms of the kinds of conditions that it can cover. To address this limitation, this research project will incorporate an off-site data collection program that would involve a group of contractors to provide us their maintenance operations and condition tracking data. Appendix E shows a prototype information system that will be used for this task. After having conducted a pilot survey of several maintenance contractors within Ontario, a common eagerness to share maintenance and material application data was observed. The main motivation for maintenance contractors to be involved in such data collection and archiving activities is to be a part of a program that is working towards standardizing parking lot maintenance practices. Every contractor that adds to the pool of maintenance data and also abides by the set regulation can potentially be given a high rating which would help in attracting more business.

For regulation agencies, the collected data can be used to monitor salt usage trends through the province. These trends can help better understand areas where the greatest inefficiencies exist.

From a research perspective, the collected data can be validated against the micro tests conducted at the University to confirm if the applied rate is within a safe margin of what would be considered a reasonable range for a given set of conditions. After sufficient provincial wide data have been collected, it can be used to produce maintenance baselines that are rich enough to cover variations in weather along with other lot specific variables such as type of pavement, demographic etc.

6.3 Remarks

The research team has interviewed several contractors to understand the current practices in parking-lot maintenance. This process will continue in the following months, which will help determine the root causes of inefficiencies in usage of salt and devise appropriate remedies.

With a massive number of maintenance contractors spread all over the province, a web based system is the only viable solution for maintenance data collection. With contractors ranging from small business with a few basic trucks and plows to large companies with AVL equipped rate controlled spreaders, the system needed to be flexible enough to accommodate all types of data.

7 Next Step

The project was started in Feb., 2011 and as a result it is still at the initial stage with majority of the tasks to be completed over the next 2~3 years. The following is a revised work plan for this project:

- **May-Dec, 2011**: Complete state-of-the-practice survey and sign up contractors for off-site data collection
- **Sept-Dec, 2011**: Prepare new field test on both dry salt and liquid salt
- **Jan-Mar, 2012**: Conduct field test on deicing operations using both dry salt and liquid salt

- **May-Dec, 2012**: Data processing and analysis; prepare the second Interim Report
- **Sept-Dec, 2012**: Prepare field test on organic deicers
- **Jan-Mar, 2013**: Conduct field test on deicing operations using both dry salt and liquid salt
- **May-Dec, 2013**: Data processing and analysis, prepare the final Report and guidelines

Acknowledgements

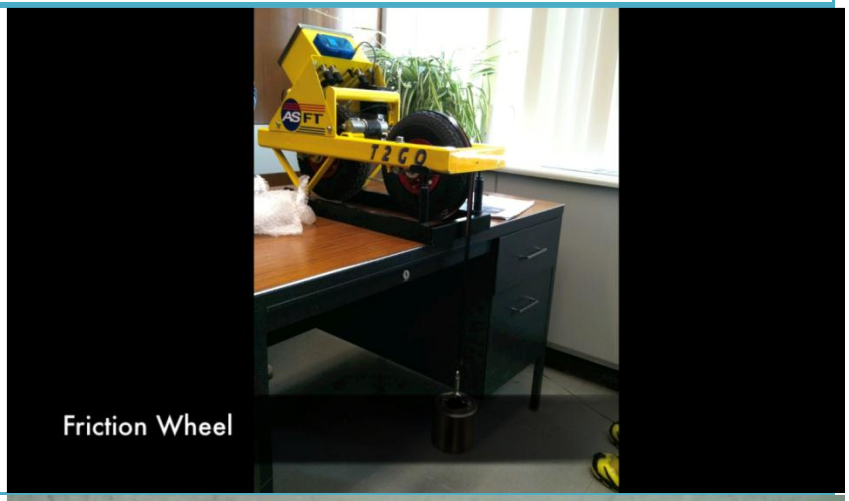
- Michael Steward, Kylee McIntosh and Kathy Hui (co-op students from the University of Waterloo) - involved in the field testing, data collection and processing
- Robert Roszell – provided valuable service in coordinating with the sponsors and contractors
- All sponsors (LO, MTO, OGRA, SIMA, TRCA, University of Waterloo …)

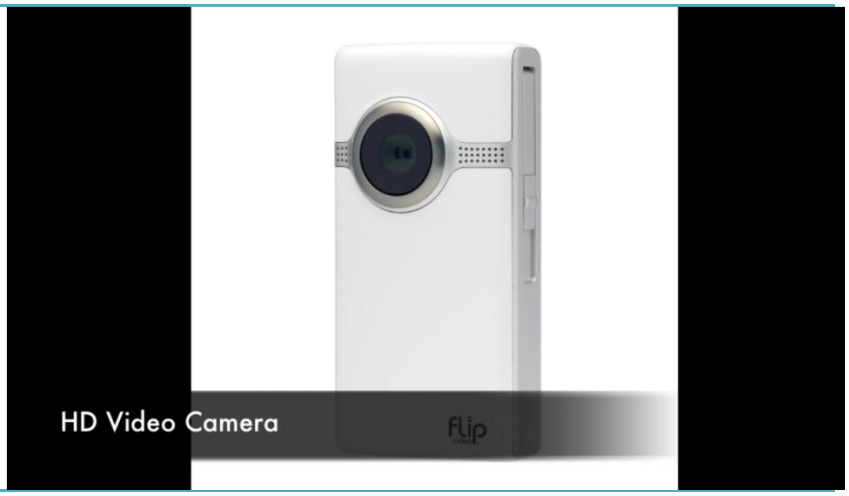
Appendix A: Reviewed Publications

Description:	Weblink:
Snow and Ice Control Manual for Transportation Facilities by L. David Minsk	http://books.google.ca/books?hl=en&lr=&id=IJZuqhCOeW8C&oi=fnd&pg=PP11&dq=snow+and+ice+control&ots=R3PwDlEFk1&sig=cAsUeBpzgjsyjMAaKYw3uxrdKPE#v=onepage&q&f=true
Town of Arnprior: Policy for winter control (Minimum Standards)	https://docs.google.com/viewer?url=http%3A%2F%2Fwww.arnprior.ca%2Fpdf%2Fwintercontrolpolicy.pdf
Environment Canada: Best practices for salt use on private roads, parking lots and sidewalks	https://docs.google.com/viewer?url=http%3A%2F%2Fwww.ec.gc.ca%2Fnopp%2Froadsalt%2Freports%2FParkingLot%2FEN%2Fparkinglot_E.pdf
City of Geneva: Public works department – Snow and ice control policies	http://www.geneva.il.us/departments/publicworks/snowice.htm
Magic salt case studies	http://www.esdeicing.com/Case_Studies
NCHRP – Snow and ice control: Guidelines for materials and methods	http://books.google.ca/books?hl=en&lr=&id=PRq2CxurLgcC&oi=fnd&pg=PP1&dq=snow+and+ice+control&ots=9ygy4l3iZN&sig=fz36pE2Qci5QojL6yT7bey_vYHU#v=onepage&q&f=false
Managing roadway snow and ice control operations by David Keummel	http://books.google.ca/books?id=I3gxuwTE5_MC&pg=PA7&lpg=PA7&dq=parking+snow+and+ice+control+regulations&source=bl&ots=knzPYmeDel&sig=na3N7zmWfZ415JWG1xCUoqbP9-0&hl=en&ei=u_iITd27CKjh0gH90bT3DQ&sa=X&oi=book_result&ct=result&resnum=7&ved=0CD0Q6AEwBg#v=onepage&q=parking%20snow%20and%20ice%20control%20regulations&f=false
Ice Control Technologies with 20% Brine on Highways	http://trb.metapress.com/content/rl6g78823255h205/fulltext.pdf

Pre-Wetted Salt Dosage Advice by Gordon Lewis	http://www.highways.gov.uk/knowledge_compendium/assets/documents/pre-wetted_salt_dosage_advice_FV1_doc.pdf
Performance and Impacts of Current De-cing and Anti-icing Products: User Perspectives versus Experimental Data (page 11 graph)	http://www.westerntransportationinstitute.org/documents/reports/4W1095_TRB08.pdf
StatsCan:Number of dangerous goods reportable accidents, by facility, annual (accidents)	http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&searchTypeByValue=1&id=4090004
Slip and fall statistics	http://hspsupplyinc.com/stats.htm
Workplace slip and falls	http://www.noskidding.com/ns_slipsandfallscanada.htm
Slip and fall statistics	http://www.circlecitysnowandice.com/services.html

Appendix B: Data Collection Equipment

Data Being Collected	Equipment	Illustration
Road Surface Friction	T2GO friction Tester	
Surface and air temperature	Infra-red and Probe Thermometer	
Residual salt	SOBO Road Salinitymeter	

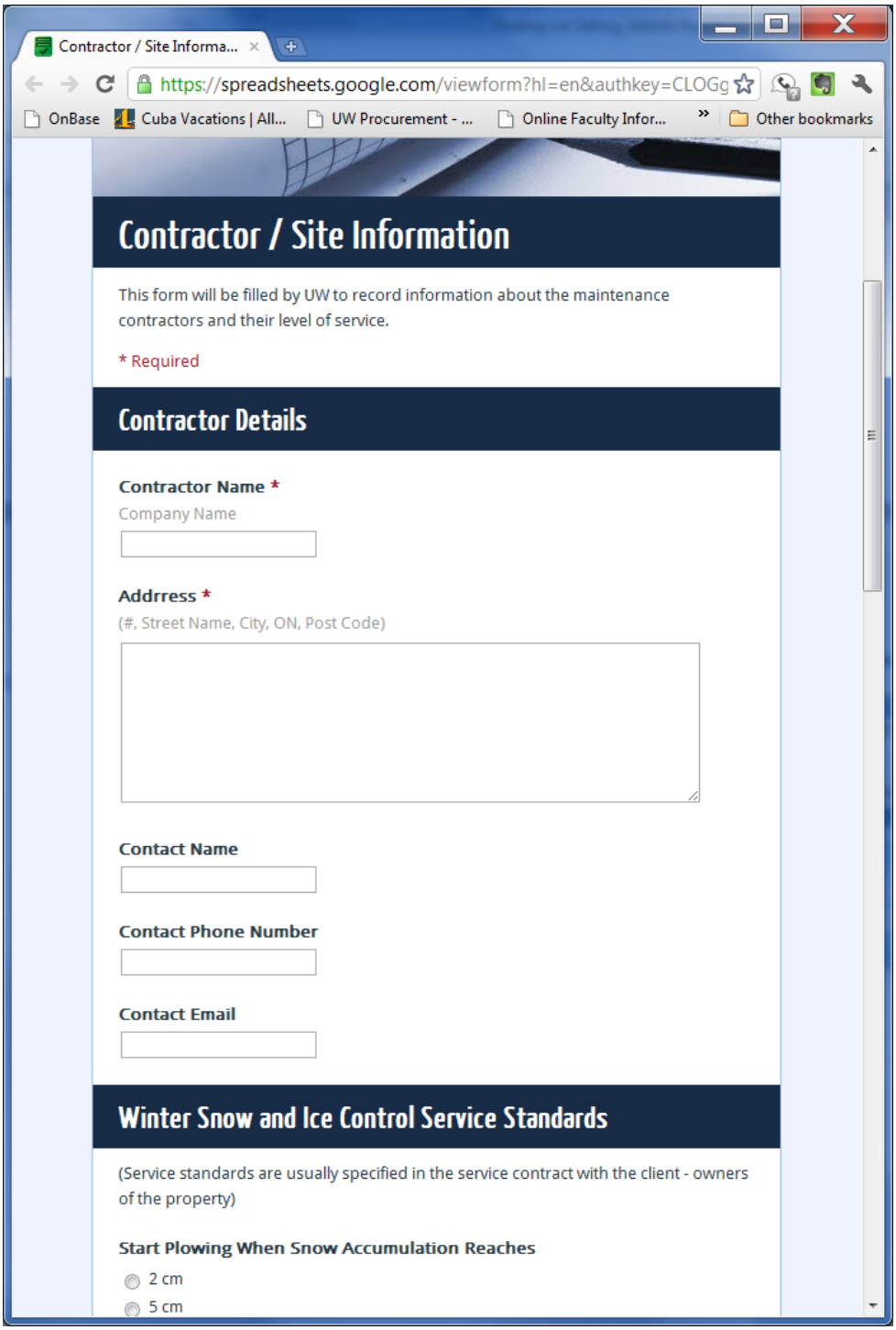
Surface and Environmental Conditions	Manual Observation and HD video	

Appendix C: Sample Data Collection Form

<table>
<tr><td>Date:</td><td>February 11, 2011</td></tr>
<tr><td>Time:</td><td>11:00 AM</td></tr>
<tr><td>Event Conditions:</td><td>Wet slushy snow</td></tr>
<tr><td>Temperature:</td><td>2 C</td></tr>
<tr><td>Salinity (gms/m²) :</td><td>
<table>
<tr><td>Lane 1</td><td>13</td><td>9</td><td>12</td><td>6</td></tr>
<tr><td>Lane 2</td><td>15</td><td>15</td><td>11</td><td>10</td></tr>
<tr><td>Lane 3</td><td>3</td><td>5</td><td>4</td><td>3</td></tr>
<tr><td>Lane 4</td><td>6</td><td>4</td><td>7</td><td>5</td></tr>
</table>
</td></tr>
<tr><td>Friction(average):</td><td>
<table>
<tr><td>Lane 1</td><td>32</td></tr>
<tr><td>Lane 2</td><td>25</td></tr>
<tr><td>Lane 3</td><td>32</td></tr>
<tr><td>Lane 4</td><td>40</td></tr>
</table>
</td></tr>
<tr><td>Special Conditions:</td><td>-Above freezing temperatures
-Slush causing loss of traction
-No precipitation
-Medium traffic load
-Cloud Cover</td></tr>
<tr><td>Lane 1</td><td>  </td></tr>
<tr><td>Lane 2</td><td>  </td></tr>
</table>

Lane 3	
Lane 4	

Appendix D: Survey Form – Contractor and Practice



Appendix E: Maintenance Operations and Condition Tracking Form

Appendix F: Project Website

www.sicops.ca