DE-ICING DALHOUSIE

ASSESSING CURRENT SALT MANAGEMNET PRACTICES AT DALHOUSIE

J. Morrissy
C. Hiscock
S. McGill
C. Armstrong
L. Miller

ABSTRACT:

The use of salt has been shown to have a number of adverse environmental implications. After an extensive five year study, conducted by Environment Canada, road salts containing inorganic chlorides, should be added to Schedule 1 of the list of toxic substances within the 1999 Canadian Environmental Protection Act (CEPA). There are a number of viable alternatives to common salt, which have been garnering increased interest. Our project therefore aimed to research the environmental effects of excessive salt use, analyze the practicality of alternative ice-removal practices that could be undertaken at Dalhousie, explore the feasibility of the current ice-removal practices employed on campus and suggest areas for improvement. The average volume of salt which was collected per square meter for each of parking lots, sidewalks, and entrances of buildings on Dalhousie's Studley campus was found to represent the amount of salt applied excessively. Based on the journal research of alternative materials to common road salt (NaCl), it was concluded that calcium magnesium acetate (CMA) is the most environmentally friendly material but it is also the most costly. The most economic material is NaCl, however there are a number of adverse environmental effects on terrestrial wildlife, vegetation and aquatic ecosystems. Based on the results of the study we concluded that there are no economically viable de-icing alternatives to salt for Dalhousie University.

TABLE OF CONTENTS

INTRODUCTION

BACKGROUND INFORMATION

In accordance with by-law S-300, effective November 22 1997, Dalhousie University is legally responsible for the complete removal of snow and ice from any section of sidewalk which abuts their property. This must be done within twelve hours following the end of a snowfall, or within six hours of daylight, whichever comes first (HRM, 2008). To maintain the safety and integrity of its sidewalks during the winter months, Dalhousie University primarily employs the use of sodium chloride (common salt), as a de-icing agent, on the sidewalks. The chemical nature of the salt lowers the freezing point of the ice/snow from 0°C to roughly -5° C and is, therefore, a highly effective tool at both removing and preventing the accumulation of unwanted snow and ice (Environment Canada, 2004a).

The use of salt, however, has been shown to have a number of adverse environmental implications. An extensive five year study, conducted by Environment Canada, examining the effects of road salts on the surrounding environment, found that road salts were responsible for the contamination of ground and surface water, as well as a number of adverse health effects on terrestrial vegetation and wildlife (Environment Canada, 1999).

BASIS FOR PROJECT

Following the results of the study, road salts containing inorganic chlorides should be added to Schedule 1 of the list of toxic substances within the 1999 Canadian Environmental Protection Act (CEPA) (Environment Canada, 1999). With these advancements Environment Canada was forced to draft a road salt management plan to limit the environmental impacts of the salt. However, the salt management code of practice excludes private or institutional property owners, which use less than 500 tones of salt per year. Therefore, Dalhousie University has no legal obligation to alter its de-icing practices, despite the known environmental implications (Environment Canada, 2004b).

There are a number of viable alternatives to common salt, which have been garnering increased interest, as the adverse environmental effects of salt become established among government policy makers. Some of these alternatives include Calcium Chloride, Acetate Magnesium and other, less harmful chemical compounds (Vancouver City Council, 1998). Many other cities and institutions have opted to reduce their impact by limiting the quantity of salt used on their roads and sidewalks by employing alternative salt management programs. Considering the Dalhousie campus is located within a public neighborhood and frequented by thousands of people on a daily basis, it is essential that all of the alternatives to road salt and other strategies to reduce the use of salt on sidewalks are adequately considered.

There was a study, similar to our own, conducted by a group of students in 2004, which came to the conclusion that there were no economically viable alternatives to using common salt on the sidewalks of Dalhousie University and that all reasonable measures to reduce the amount of salt on the sidewalks were being pursued. However, there were a number of areas within their study which could have been improved upon, especially in relation to the methods used for data collection and its analysis. Moreover, our study will be essential to verifying the validity of the previous study. One cannot be certain the results of a study are valid unless the results are reproducible using alternative methods (Palys, 2008). Considering the known environmental implications, further study into the effects of excessive salt use on Dalhousie University's property is of great importance. Our project, therefore aims to research the environmental effects of excessive salt use, analyze the practicality of alternative ice-removal practices that could be undertaken at Dalhousie, explore the feasibility of the current ice-removal practices undertaken at Dalhousie and suggest areas for improvement.

METHODS

DESIGN OF STUDY

In order to achieve the objectives of this research project, our group utilized a deductive approach to conduct the study. This approach allowed our group to describe the current salt practices in use at Dalhousie University and as well as explore the environmental implications and possible alternatives. The primary research tools/methods employed were a literature review, salt measurement via quadrat/transect techniques, and interviews.

HUMAN SAMPLE

We decided to focus primarily on the core actors; actors who are continuously involved in Dalhousie's ice management processes. Therefore, our human sampling was purposive; people were intentionally sought because they met some criterion for inclusion in the study (Palys, 2008). We also employed the use of the "snowball technique", wherein the interviewees are asked to identify other actors of interest to be interviewed (Palys, 2008).

The actors included in this sample were the director of Environmental Health and Safety, Raymond Ilson; Mike Murphy, the manager of Environmental Sciences; Mike Wilkinson, who is part of the Dalhousie Grounds Service and Horticulture; Milton Graves, professor of earth sciences; John Choptiany, teaching assistant for ENVS 3502 and a member of the custodial staff. We were unsuccessful in contacting Ocean Contracting, the company outside of Dalhousie who is responsible for the snow removal of parking lots, and and Jeffrey Lamb, the Director of Facilities Management.

LOCATION SAMPLE

The sample locations were selected by stratified random sampling, wherein population is divided into a number of stratum (Palys, 2008). The grouping variable was the infrastructure type, because they employ varying salt management practices. Groups were divided into building entrances, sidewalks, and parking lots. By utilizing probabilistic sampling techniques, a representative sample of the population's relative attributes was most likely to be obtained (Palys, 2008).

INSTRUMENTATION

A priori document analyses utilizing peer-reviewed journals and electronic resources was conducted to examine the environmental effects of excessive salt use, salt management practices, and alternative methods to road salt. *A priori* document analysis allowed for a more effective and comprehensive literature review. *A posteriori* literature research was also undertaken; as we carried out this project additional relevant information pertaining to our research objectives were uncovered.

Questionnaires were administered to each of our actors involved in the study. When possible, these questionnaires were administrated in a face to face environment however there was an instance where this was not possible. Instead, the questionnaire was administrated via email. As a group we believe that self administered questionnaires was the best option because, as Palys (2008) states, self administered questionnaires allow the interviewer to clarify ambiguities that may arise. These types of questionnaires also allow the respondent to answer in privacy and they also result in a higher response rate when compared to mail out questionnaires (Palys, 2008).

Quadrats were another tool we used to conduct our research. The quadrats measured an area of $1m^2$ and were used in order to obtain a percent cover analysis. The quadrats were also used to set the parameters/boundaries in which the salt would be collected and measured. By making use of these two methods (estimation of percent cover; measurement of salt) we reduced the mono-operational bias. This bias was reduced because we used alternative methods to measure the variable of interest (Palys, 2008). The quadrats allowed us to pinpoint locations whereby salt use could be deemed excessive. GIS and GPS technology were employed to generate our sixty stratified random samples. This eliminated any personal or location sample biases because the sample sites were randomly generated using this technology and not purposively sought.

RELIABILITY AND VALIDITY

In our study a reliability strategy known as inter-rater reliability was employed. If you've adequately specified what a particular construct means, other researchers should be able to read your explanation and replicate the results (Palys, 2008, p.60). When assessing percent cover, photographs of each quadrat was taken. Each member of the group then individually estimated the coverage in each of the sixty quadrats. This helped ensure inter-rater reliability because the biases of measurements were reduced by means of averaging the results.

According to Palys (2008), in order to demonstrate validity you must show that your particular operationalization accomplishes the purpose for which you intend to use it (p. 62). In our study an operationalization for the construct of excess salt was the ability to collect and measure salt from within the quadrat transect. If we could not measure the salt within a quadrat, than the quadrat did not contain excess salt. By defining our construct excess salt as being the amount of salt we could quantifiably measure from a quadrat, our group has successfully chosen a relevant criterion in which the construct is embodied and that our operationalization is indeed related to the specified criterion. This is otherwise known as convergent validation (Palys, 2008).

One thing worth noting however, is that because we employed the snowball methodology for our interviews, our study may fail the test re test reliability (Palys, 2008). The results of such a study may vary if our study was to be replicated in the future.

PROCEDURES

A PRIORI RESEARCH

As it was previously mentioned in the Instrumentation section *a priori* document analyses, which utilized peer-reviewed journals and electronic resources, was conducted on the environmental effects of salt use. Information comparing different de-icing methods was also analyzed based on cost, potential damages, and temperatures at which each material is most effective. Another integral area of this study was to research alternate materials and methods of dispersal. Case studies of various regions whereby salt management plans were already in practice were also analyzed.

MEASURING SALT

The average amount of salt used on sidewalks, parking lots, and in front of buildings was measured by taking random samples, using a quadrat with an area of $1m^2$ (1m X 1m). This was deduced qualitatively by using percent cover analysis. Percent cover was assessed by taking photographs of each quadrat and later having each member of the group individually estimate the coverage. This, as mentioned previously, helped ensure inter-rater reliability, whereby the bias of the measurements will reduced by averaging the results (Palys, 2008). The salt within the quadrat was collected and measured using a graduated cylinder, organizing the amounts for each stratum into a table (Appendix B). A total of fifteen locations were frequented twice a week. The grouping variable of this study was infrastructure type because different infrastructures employ varying salting and snow removal techniques. The sample locations were selected by stratified random sampling and were generated randomly using GIS technology. These generated co-ordinates were located in real time by using GPS technology and by programming the desired co-ordinates into the handheld device (Appendix B). For the purpose of this study, excessive salt was defined by the amount of salt that could be physically collected and measured.

INTERVIEWING PROCESS

Face-to-face interviews were conducted. The interviewer first introduced himself and explained the purpose of the interview. The interview questions, as noted in *Appendix D*, acted as vital tools to obtain qualitative and quantitative data, relating to the current feasibility of Dalhousie's present salt removal practices. Questions also explored the potential effects on the environment and possible alternatives. The interview questions were dependent on the person being interviewed, so as to maximize the amount of relevant information from each source. Closed-ended, categorical, and ranking scale type questions were avoided. Instead, open-ended questions were used, thereby allowing respondents to provide more descriptive and subjective responses.

At the end of each interview the interviewee was asked whether or not s/he was aware of anyone else who may have been capable of providing our group with information relevant to our topic of interest. As mentioned earlier, this method is known as the snowball technique (Palys, 2008). After all pertinent information from the interviews was collected, an analysis of the responses was undertaken in order to aid our study.

LIMITATIONS AND DELIMITATIONS

Limitations can be defined as restrictions in the study over which you have no control (Wright, 2009). The issue of time was the primary limitation in our study. Some interviews could not be arranged given certain time constraints and given more time, the study could be examined in greater detail. A second limitation would be that some of our core actors did not respond to the emails our group sent out. As a result, this placed constraints in relation to what information we could obtain, thus limiting the amount of information gathered.

Delimitations can be defined as limitations on the research design deliberately imposed (Wright, 2009). The most obvious delimitation would be that of our spatial boundaries. Our group limited the study strictly to Dalhousie's Studley campus. Another limitation deliberately imposed would be in relation to our stratum (parking lots, sidewalks, building entrances), as we deliberately chose these to be our area of study/concern.

RESULTS

JOURNAL RESEARCH

Document analyses on the environmental effects of salt usage and alternative de-icing methods utilizing peer-reviewed journals and electronic resources was undertaken on the environmental effects of salt use, alternative de-icing materials and case studies of various regions whereby salt management plans were already in practice.

THE ENVIRONMENTAL EFFECTS OF ROAD SALT

The following is a summary of the environmental effects of road salt within the *Priority Substances List Assessment Report for Road Salts* conducted by Environment Canada (1999):

TERRESTRIAL ECOSYSTEMS

Within the hydrological cycle a portion of the precipitation that falls as rain or snow will flow over impervious surfaces, such as roadways and into ditches, wetlands lakes or other bodies of surface water. However, a significant portion of the overland flow will also infiltrate the soil into the subsurface ground water system. If the infiltrating precipitation has comes into contact with road salts the solution will likely contain significant quantities of salt due to the highly soluble nature of the inorganic sodium chloride in water. The dissociated chloride ions and sodium ions will then migrate with the infiltrating precipitation into the groundwater system.

A study conducted by Howard and Haynes (1993) in the greater Toronto area found that 55% of the salt applied to roads was deposited within the subsurface water system. The rate of infiltration of surface water into the ground water system is largely dependent on the quantity of precipitation and the geological characteristics of the soil. Based on the clay content of the soil and the corresponding exchangeable sodium ratio of the soil in Nova Scotia, groundwater in Halifax is especially sensitive to road salt contamination (Figure 1).

The contamination of groundwater can have a number of implications for terrestrial wildlife which consume the water. It has been 10% of species are adversely affected by concentrations of salt that exceed 240 mg/L and can even be lethal to highly sensitive species. Terrestrial birds, especially herbivorous and granivorous species are highly susceptible to salt poisoning. There have been two reported cases of bird kills of more than a thousand birds directly related to their consumption of salt via contaminated groundwater and directly from the road surface.

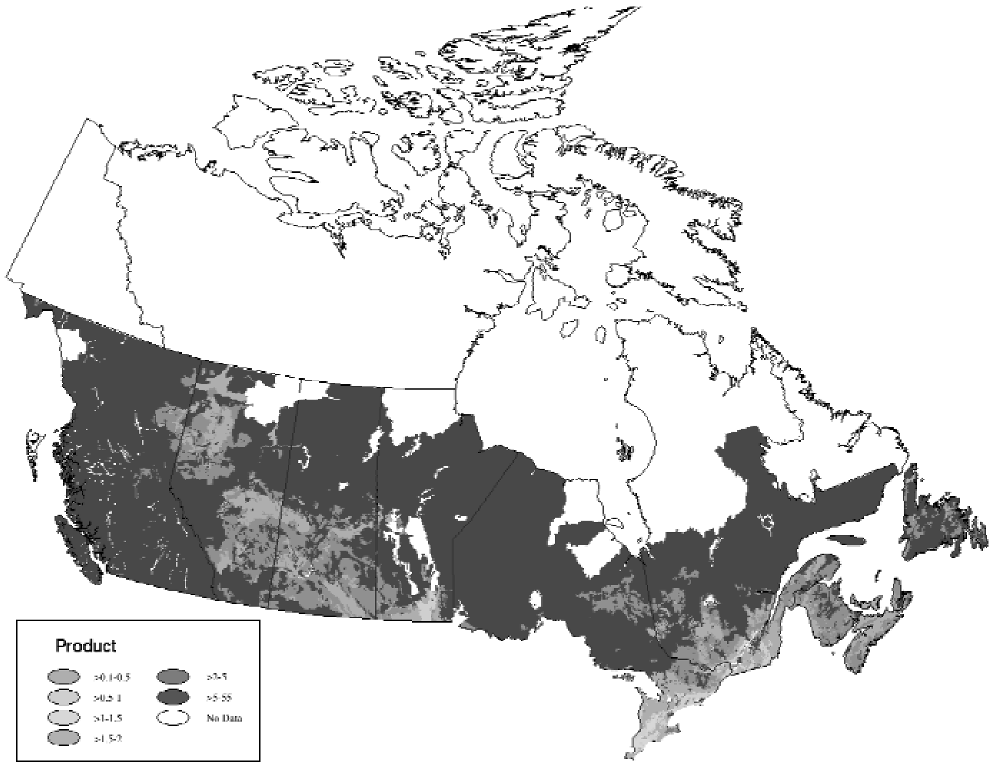

Figure 1. A pictorial representation of the areas that are most sensitive to excessive road salt application based on the clay content of the soil and the corresponding exchangeable sodium ratio. Lighter shades indicating a higher sensitivity with darker shades indicating a more resilient environment. (Morin *et al*., 2000)

Furthermore, there are also a number of adverse effects on terrestrial vegetation. Sodium chloride inhibits the osmotic balances and nutrient absorption processes of the plants producing drought-like symptoms. At higher levels, plants can be affected directly by the toxicity, resulting in tissue death. A study conducted by Beckerson *et al.* (1980) found that 40% species traditionally used in Canadian landscapes are sensitive to road salt. Moreover, sensitive plants can be adversely affected up to 80m from the edge of the road.

AQUATIC ECOSYSTEMS

Cities and other urban environments are increasingly sensitive to road salt contamination, in that; they are often in close proximity creeks, streams, rivers and other aquatic ecosystems. Aquatic ecosystems including bacteria, fungi, protozoans, zooplankton, benthic invertebrates, fish and amphibians are highly sensitive to road salts. Studies have shown that species diversity will decline rapidly within fresh water ecosystems with increasing salinity by altering the density of the water and reducing its capacity for vertical mixing (Figure 2).

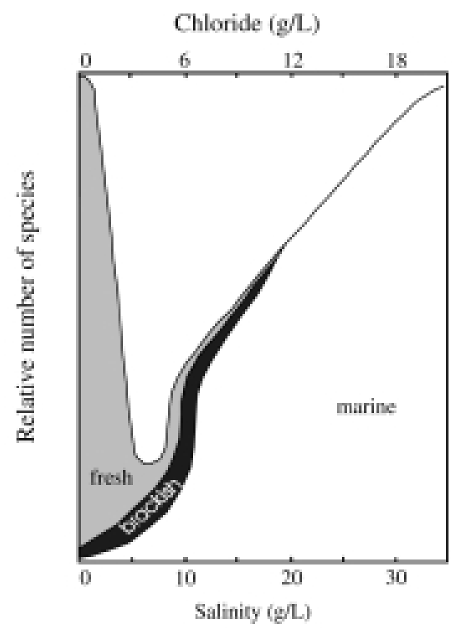

Figure 2. A graphical representation of species diversity across a salinity gradient (from Wetzel, 1983)

Recently, Keizer *et al.* (1993) conducted a study investigating the water quality of 51 lakes in the Halifax/Dartmouth Metro Area, relative to data collected in April of 1980. They found the most significant difference to be a two-fold increase in the conductivity of the lakes, due to high concentrations of sodium chloride.

ROAD SALT MANAGEMENT PLANS

Salt is necessary to provide safe winter driving conditions, and though alternatives are available salt is the most efficient when evaluated according to cost and effectiveness. Injury road accidents are lowered by 88% when salt is used for de-icing (Salt Institute 2009). However, proper use is important because salt use can be harmful to plants, animals, birds, fish, lake and stream ecosystems, and ground water (Red Deer 2009). In 2001 Environment Canada produced a report recommending that salt be added to its list of toxic substances under the Canadian Environmental Protection Act (Red Deer, 2009).

The Government of Canada did not list salt as a toxic substance; however it did take steps to recognize the need to develop a policy related to salt use. For this reason Environment Canada released a document entitled *Code of Practice for the Environmental Management of Road Salts* in 2004. The purpose of this report was to “help municipalities and other road authorities better manage their use of road salts in a way that reduces the harm they cause to the environment while maintaining road safety” (Road Salts, 2007). The Code of practices applies to any organization that uses a minimum of 500 tonnes of salt a year. The focus of the code of practices is on salt storage, salt use, and snow disposal, as they relate to road de-icing (Road Salts, 2007). The ultimate recommendation of the code of practices was that all qualifying authorities prepare a Salt Management Plan (SMP).The plan should build on existing work, be flexible and responsive to local conditions, improve continuously, include monitoring and evaluation, and should work cooperatively with road authorities (Road Salts 2004). The potential benefits according to Environment Canada are:

- Reduction of salt use
- Reduction of winter maintenance costs
- Potential improvement to road safety
- Reduction of costs related to remediation of contaminated sites and groundwater
- Reduction of potential liability for damages to private or commercial properties

Increasingly, cities and municipalities in Canada are recognizing the benefits of utilizing an SMP. These plans outline best practices procedures which are designed to minimize the adverse affects of salt to the environment while still providing an appropriate level of road safety.

One of the first authorities in Canada to produce and implement a salt management plan was the city of Toronto. Though Toronto recognizes the adverse environmental effects of salt used as a de-icer, their SMP allows them to continually minimize the amount of salt entering the environment. For sidewalk clearing Toronto uses mechanical clearing beginning after 7.5 cm has accumulated. After ploughing, a 50/50 salt/sand mixture is applied to melt ice and provide grit and traction. The Toronto SMP outlines operational practices and strategies for each of 23 different activities (Appendix C). These practices and strategies include activities such as electronic spreader controls, equipment washing, records keeping, weather forecasting, training, and technology reviews. Through constant review and implementation of best practices relating to these activities Toronto is striving to fulfill its mission to “optimize the use of de-icers on Toronto's roads and sidewalks while striving to minimize salt impacts to the environment" (Toronto, 2002).

The city of Red Deer, Alberta, is located between Calgary and Edmonton and has a population of 80,000 (Red Deer, 2008). Like Toronto, this small city recognizes the importance and usefulness of having an SMP. The city has developed an SMP that "sets out the policies and procedures for ensuring that The City of Red Deer continuously improves the management of road salt in its snow and ice control operations" (Red Deer, 2009). Like Toronto they have outlined a best practices policy for a number of activities. Wise road salt management is informed by advanced weather forecasting stations, traffic and roadway information, safety reports, and historical collision reports. A salt /sand mixture is used and the blend is adjusted depending on the specific conditions at the time. A Salt brine mixture that is 23% salt is used for pre-wetting the salt/sand mixture to make it more effective. Red Deer also uses this salt brine for anti-icing practices to inhibit bonding of ice and snow with the road (Red Deer, 2009). Storage is also covered in Red Deer's SMP in order to limit the amount of salt that is entering the environment from storage activities. The city is building new storage facilities that will prevent wind erosion, runoff from rainwater, and seepage into the groundwater (Red Deer, 2009)

ALTERNATIVE DE-ICING PRODUCTS

There are a number of alternative de-icing products to common road salt. They include calcium magnesium acetate (pellet de-icer made from dolomite limestone and acetic acid), abrasive material (sand, ash or cinders), magnesium chloride and calcium chloride. Each of these products has both advantages and disadvantages. None of them can absolutely replace salt as de-icer but each is good under certain temperature and environment condition.

Calcium magnesium acetate (pellet de-icer made from dolomite limestone and acetic acid) as a de-icer has the following advantages: it is eco-friendly, less acidic and boosts soil permeability. However, it is about 30 times more expensive and less effective in colder temperatures.

Abrasive materials (sand, ash or cinders) are a possible alternative to salt, however they are not considered de-icers. Abrasive materials are far less expensive than salt, as they are recyclable and environmentally neutral. They are more effective in colder temperatures than salt, though it is more effective in harsh weather abrasive materials have some drawbacks. Abrasive materials do not dissolve ice and require reapplication to be rendered viable and effective. Moreover, it has to be physically removed from gutters at the end of winter.

The substance magnesium chloride is also one of the alternative products to salt. It tends to be effective as low as -25^{0}F. It causes fast reactions at lower temperatures compared to other products and less corrosive than salt (sodium chloride) and calcium chloride. However, it costs twice as much as salt and must be kept in a dry area.

Another substance that is used as alternative de-icer to salt is calcium chloride. Calcium chloride is efficient at temperatures as low as -59^{0}F. It does not leave any visible residue when dry as compared to salt. It does not have any known effects on the soil texture. Also, it has faster and quicker reaction power than the mentioned alternatives. It costs about 10 times the price of salt, but 20 times less than calcium magnesium acetate (Delahaut, 1999; Johnson & Sucoff, 2000).

Table 2. Comparison of de-icing materials in terms of cost and environmental effects (Delahaut, 1999).

SUBSTANCE	Lowest effective temperature (degree Celsius)	Approximate cost	Degree of potential plant damage	Potential for water contamination	Degree of potential soil damage
Salt (NaCl)	-9	$20-40 per ton	Moderate- high	Yes	High
Abrasive materials (sand, ash, cinders)	All temperatures	$6-16 per ton (sand)	None	None	None
Calcium magnesium acetate (CMA)	-27.78	$600 per ton	None	None	None. Can increase soil permeability
Calcium chloride (CaCl)	-50.56	$150 per ton	Very high. Highly corrosive.	Yes	None
Magnesium chloride (MgCl)	-31.20	$50 per ton	Low. Less corrosive than CaCl and NaCl	Yes	Low

EXPERIMENTAL DATA

The GIS-generated map of Dalhousie's Studley campus indicating sampling sites can be found in Appendix A. There were 20 sample sites for each of the three strata (entrances of buildings, sidewalks, and parking lots) making a total of 60 sample sites.

A table for each stratum displaying information such as the coordinates of each sample site, the date each sample was taken, the percent cover of salt, and the volume collected in each square metre can be found in Appendix B.

The percent cover at the entrances of buildings and on sidewalks were found to be much higher than on parking lots (Figure 3, Figure 4).

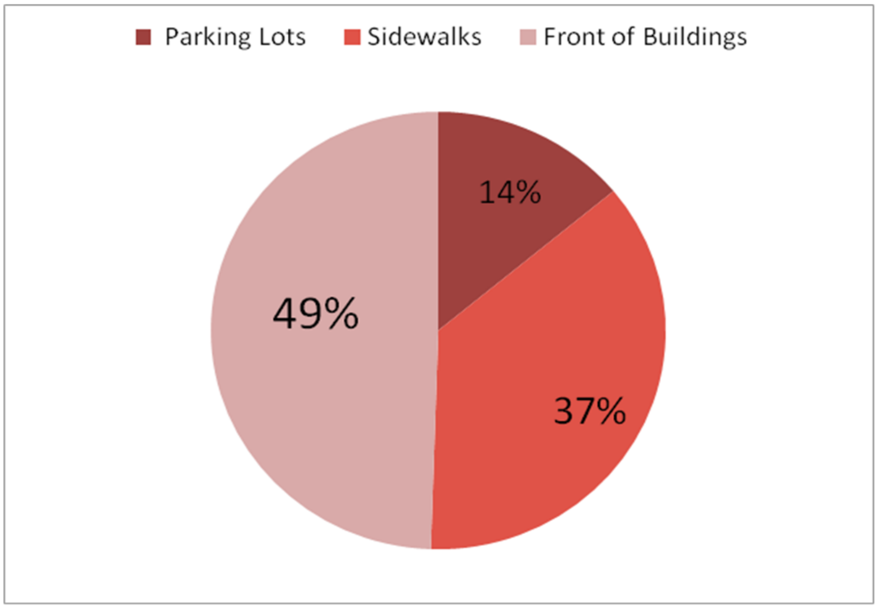

Figure 3. Proportion of total salt coverage allocated to each of the parking lots, sidewalks and fronts of buildings on Dalhousie's Studley campus.

Figure 4. Average volume of salt per square metre for each of parking lots, sidewalks, and fronts of buildings on Dalhousie's Studley campus.

The average percent cover of salt per square metre in parking lots was found to be 8.05%. The average volume of salt collected per square metre in parking lots was found to be 16.2 cubic centimetres. The average percent cover of salt per square metre on sidewalks was found to be 21.05%. The average volume of salt collected per square metre on sidewalks was found to be 40.9 cubic centimetres. The average percent cover of salt per square metre for the entrances of buildings was found to be 28.15%. The average volume of salt collected per square metre for the entrances of buildings was found to be 48.25 cubic centimetres. The values above were calculated using the data found in Appendix B.

Face to face or email interviews were conducted to obtain qualitative and quantitative data in relation to salt management practices on Dalhousie's Studley campus. The questions and answers for each interview subject can be found in Appendix D.

DISCUSSION SECTION

The Purpose of this project was to examine Dalhousie University's current winter de-icing practices in order to determine if they were operating in a way that would minimize the possible negative effect to the environment. Our research objectives were threefold: to research the environmental effects of excessive salt use, to explore the feasibility of the current ice-removal practices undertaken at Dalhousie and suggest areas for improvement, and to analyze the feasibility of alternative ice-removal practices that could be undertaken at Dalhousie.

Through literature research and personal interviews it was determined that there are negative environmental effects related to excess salt use. Salt is considered to be a toxic substance, though it has not yet been banned from use as a road de-icer. The use of road salt is directly responsible for the contamination of groundwater systems, poisoning terrestrial wildlife and the inhibition of the osmotic balance and nutrient absorption processes in plants.

Despite the negative environmental effects which were discovered, there remain a number of valid reasons to continue its use as a road de-icer. From interviewing Dalhousie's health and safety management staff it was clear that the university must do what is necessary to keep their sidewalks, paths and entrances clear of any slipping hazard. Our research found that salt has been used because of its relative affordability, and high level of effectiveness. It is for these reasons that salting is considered to be a feasible way to de-ice the campus.

This project looked at alternative products and methods which can be used for de-icing. We found that there are four main alternatives to salt: abrasives, calcium magnesium acetate, calcium chloride, and magnesium chloride. It was determined that these alternatives would not be considered feasible alternatives because they were either too expensive, not effective, or did not represent a significant reduction in negative environmental effects. These findings are consistent with previous research which had been performed by student groups in the past.

Research found that there are highly feasible alternatives to the methods used for spreading salt at Dalhousie. Both interviews and literature search found that cities and municipalities in Canada are increasingly recognizing the benefits of utilizing a salt management plan (SMP). These plans are designed to "help municipalities and other road authorities better manage their use of road salts in a way that reduces the harm they cause to the environment while maintaining road safety" (Road Salts 2007). It was determined from gathering experimental data that Dalhousie could utilize a SMP to minimize its salt use, and thereby, minimize the negative environmental effects related to current de-icing practices.

Results from the gathering of experimental data showed that there is excessive salt use in some areas of the campus. It was determined that excess salt would be defined by amount of salt left over after the roadway or walkway has no slipping hazard from ice or snow.

The data showed that salt use on parking lots was not considered to be excessive. The average percent cover of salt was 8.05% and the average volume was 16.2 cm^3. These values show that there could have been a slight reduction in the amount of salt spread, however it is not considered significantly excessive. The area's which were determined to have excessive salt use were the building entrances and sidewalks. These areas had more salt applied than was required to accomplish the de-icing, with an average percent cover of 28.15% and 21.05% respectively.

The data also indicates that there was a significant amount of variation in the amount of salt found at individual locations sampled. This shows that the salt was not spread consistently. Given that any snowfall event on campus would distribute an even depth of snow per unit area on all areas of the campus, it would follow that an even distribution of salt volume per unit area would be needed to do the work of de-icing. Data from the sampling showed that the volume per square meter ranged from 0 cm^3 to 200 cm^3 for sidewalks, and from 0 cm^3 to 180 cm^3 for building entrances.

The implication of this variation in salt volume is that salt is not being spread in an even distribution. This also shows that what was determined to be excess salt use on the sidewalks and building entrances is not evenly excessive. Fifteen of the forty samples plots for these two areas had less than 15 cm^3, which is considered to be an acceptable excess. Eight of the forty sample plots had over 100 cm^3, which is considered to be highly excessive.

These findings show that salt is being used properly in some areas and dumped in large volumes in other areas. Reasons for this variation in distribution may be related to equipment malfunction, improper equipment or methods, improper training, or human error.

By implementing a salt management plan on the Dalhousie University Studley campus the issues mentioned, with relation to variation in salt volumes being spread, could be addressed.

CONCLUSION

The average volume of salt collected per square metre for each of parking lots, sidewalks, and fronts of buildings represents the amount of salt applied excessively. Based on the journal research of alternative materials to common road salt (NaCl), it was concluded that calcium magnesium acetate (CMA) is the most environmentally friendly material but it is also the most costly. The most economic material is NaCl, however there are a number of adverse environmental effects on terrestrial wildlife, vegetation and aquatic ecosystems. Based on the results of the study we conclude that there are no economically viable de-icing alternatives to salt. However, it is evident from the levels of excessive salt measured on Studley campus that Dalhousie University can stand to reduce its use of salt, which would reduce the potential liability for damages to private or commercial properties. Moreover, Dalhousie could benefit economically by reducing costs related to winter maintenance and remediation of contaminated sites and groundwater; and environmentally by minimizing negative impacts associated with salt use.

To ensure the inter-rater reliability of our findings, we recommend an in-depth follow-up study which replicates our methodology. Moreover, to ensure the validity of the project a study employing alternative experimental methods could help to prove or disprove our results. Areas for further research could include a study of the environmental effects caused by excessive salt use, specifically on Dalhousie's campus. This includes a study on the local flora and fauna to determine their sensitivity to road salt toxicity. Furthermore, the characteristic of the soil could be examined to determine the potential for groundwater contamination.

WORKS CITED

[HRM] Halifax Regional Municipality (2008). By-Law Number S-300: By-Law Respecting Streets.

[HRM] Halifax Regional Municipality (2009). Reminds City Residents Re: Sidewalk Snow Removal By-Laws. Halifaxlive.com. <http://www.halifaxlive.com/content/view/310/2/>

Beckerson, D.W., N.P. Cain, G. Hofstra, D.P. Ormrod and P.A. Campbell. 1980. A guide to: plant sensitivity to environmental stress. Landscape Archit. May: 299-303.

Dalhousie University (2009) Campus Map. Retrieved February 8, 2009, <http://www.dal.ca/visit/map/>

Delahaut, K.A. (1999). *Salt Injury to Landscape Plants.* Wisconsin: Cooperative Extension Publishing.

Environment Canada (1999). Priority Substance List Assessment Report for Road Salts. <http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl2-lsp2/road_salt_sels_voirie/index-eng.php>

Environment Canada (2004) Road Salts, Code of Practice for the Environmental Management of Road Salts. Retrieved March 24, 2009 from: http://www.ogra.org/lib/db2file.asp?fileid=8893

Environment Canada (2004a). Best Management Practices for Salt Use on Private Roads, Parking Lots and Sidewalks. <http://www.ec.gc.ca/nopp/roadsalt/reports/ParkingLot/EN/p4.cfm>

Environment Canada (2004b). Code of Practice for the Environmental Management of Road Salts.<http://www.ec.gc.ca/nopp/roadsalt/cop/en/code.htm>

Environment Canada (2007) Road Salts, Retrived March 24, 2009 from: http://www.ec.gc.ca/nopp/roadsalt/en/index.cfm

Howard, K.W.F. and J. Haynes. 1993. Groundwater contamination due to road de-icing chemicals - salt balance implications. Geosci. Can. 20(1): 1-8

Johnson, G.R. & Sucoff, E. (2000). Minimizing De-Icing Salt Injury to Trees. (Retrieved on 25th Feb.2009) from http://www.extension.umn.edu/distribution/naturalresources/DD1413.html

Keizer, P.D., D.C. Gordon, J.W. Rowell, R. McCurdy, D. Borgal, T.A. Clair, D. Taylor, J.D. Ogden and G.E.M. Hall. 1993. Synoptic water quality survey of Halifax/Dartmouth Metro Area lakes on April 16, 1991. Biological Services Branch, Scotia-Fundy Region, Department of Fisheries and Oceans.

Morin, D., W. Snodgrass, J. Brown and P.A. Arp. 2000. Impacts evaluation of road salt loadings on soils and surface waters. Supporting document for the road salts PSL assessment. Report submitted to the Environment Canada CEPA Priority Substances List Environmental Resource Group on Road Salts, June 2000. Commercial Chemicals Evaluation Branch, Environment Canada, Hull, Quebec. 76 pp.

Palys (2008). *Research Decisions: Quantitative and Qualitativ Perspectives 4th Edition*. Toronto: Thompson.

Red Deer (2009) Salt Management Plan. Retrieved March 25, 2009 from, http://www.city.red-deer.ab.ca/Connecting+with+Your+City/City+Services+and+Departments/Public+Works/Snow+and+Ice+Control/Salt+Management+Plan.htm

Red Deer[B] (2008)Population Size and Growth. Retrieved March 25, 2009 from: http://www.city.red-deer.ab.ca/NR/rdonlyres/3C16E95E-7F2A-4B01-9DF2-03679C3C46C6/0/Chapter1_PopulationSizeandGrowth_DSET2008_COM.pdf

Red Deer[C] (2009) Ice control. Retrived March 25, 2009 from: http://www.reddeer.ca/Connecting+with+Your+City/City+Services+and+Departments/Public+Works/Snow+and+Ice+Control/Ice+Control.htm

Salt Institute (2009) Winter Road Safety. Retrieved March 24, 2009 from: http://www.saltinstitute.org/Uses-benefits/Winter-road-safety

Toronto (2002) City of Toronto Works & Emergency Services, Transportatoin Services Division, Salt Management Plan. Retrieved March 24, 2009 from: http://www.toronto.ca/transportation/snow/pdf/02smp.pdf

Vancouver City Council (1998). Administrative Report: Use of road salt for de-icing. CC File No. 5801. http://vancouver.ca/ctyclerk/cclerk/980407/a5.htm

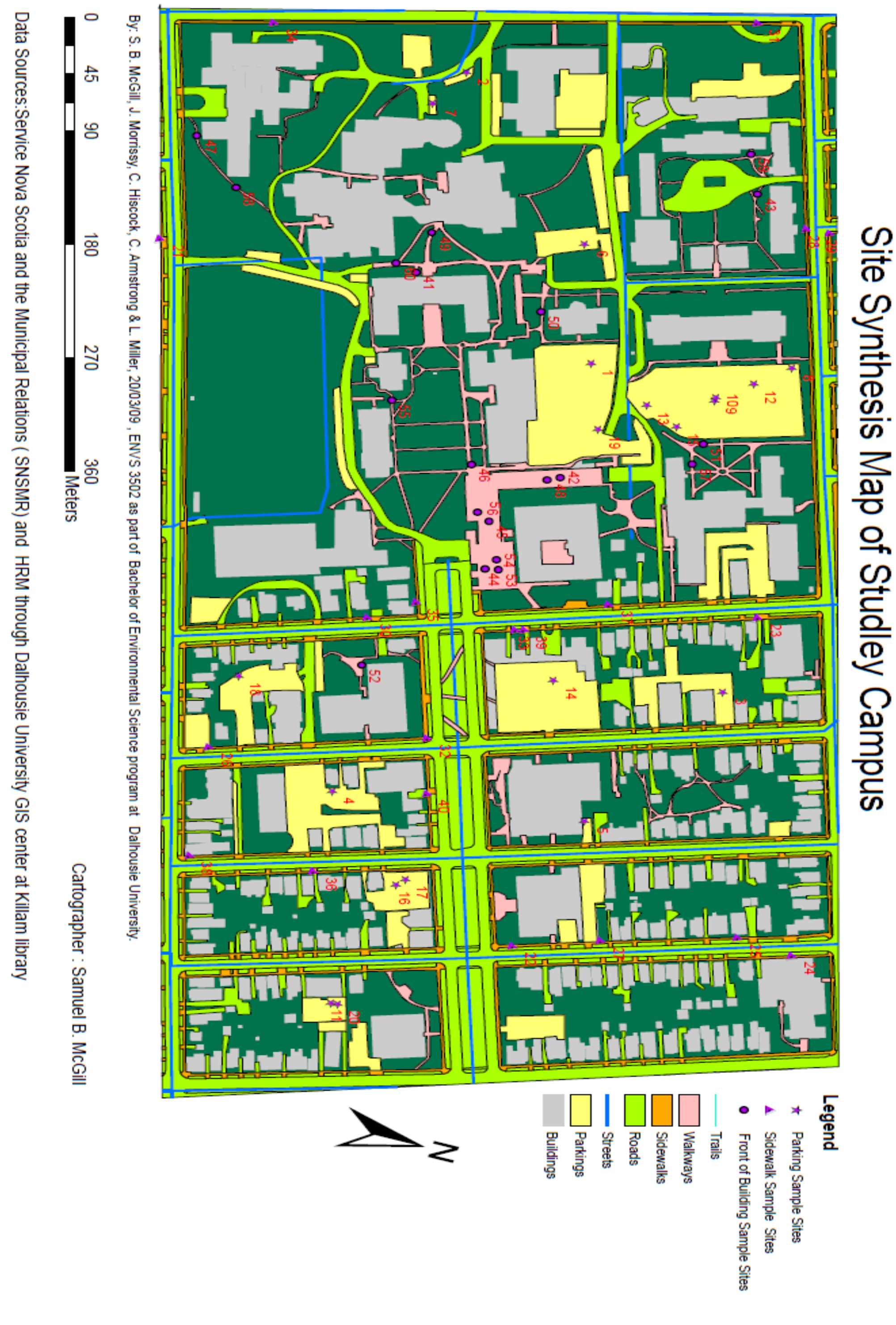

Figure 4. Map of Studley campus indicating the sample sites.

Table 1. Data collected from each of the 60 sample sites; including GIS coordinates, date of sampling, percent cover and volume of salt collected.

Random Parking Sample Sites

Id	POINT_X	POINT_Y	Date Sampled	% Cover	Volume (cm^3)
1	452979	4942819	March 12th	30	90
2	452781	4942676	March 12th	0	0
3	453204	4942975	March 12th	15	50
4	453352	4942762	March 12th	5	10
5	453328	4942922	March 12th	30	70
6	452889	4942788	March 13th	15	50
7	452811	4942663	March 13th	1	1
8	452945	4942942	March 13th	1	1
9	452985	4942902	March 13th	1	1
10	452982	4942902	March 13th	25	10
11	453512	4942810	March 18th	1	1
12	452964	4942922	March 18th	1	1
13	453001	4942862	March 18th	1	1
14	453226	4942870	March 18th	1	1
15	453011	4942885	March 18th	4	2
16	453411	4942822	March 19th	0	0
17	453405	4942826	March 19th	20	30
18	453281	4942678	March 19th	10	5
19	453028	4942838	March 19th	0	0
20	453512	4942814	March 19th	0	0

Random Sidewalk Sample Sites

Id	POINT_X	POINT_Y	Date Sampled	% Cover	Volume (cm^3)
21	452964	4942530	March 12th	0	0
22	453436	4942907	March 12th	40	100
23	453141	4942980	March 12th	10	10
24	453391	4943079	March 12th	60	110
25	453388	4943041	March 12th	0	0
26	453341	4942677	March 13th	5	1
27	453416	4942960	March 13th	3	45
28	452837	4942918	March 13th	85	150
29	452836	4942934	March 13th	40	2
30	453213	4942744	March 13th	1	1
31	452690	4942841	March 18th	5	1
32	453294	4942807	March 18th	25	40
33	453195	4942836	March 18th	60	200
34	452779	4942549	March 18th	7	3
35	453193	4942769	March 18th	5	50
36	453416	4942769	March 19th	30	80
37	453159	4942886	March 19th	0	0
38	453427	4942691	March 19th	0	0
39	453194	4942841	March 19th	10	15
40	453336	4942820	March 19th	40	10

Random Building Sample Sites

Id	POINT_X	POINT_Y	Date Sampled	% Cover	Volume (cm^3)
41	452942	4942691	March 12th	75	130
42	453080	4942823	March 12th	0	0
43	452820	4942880	March 12th	40	80
44	453155	4942802	March 12th	50	110
45	453118	4942793	March 12th	0	0
46	453078	4942770	March 13th	10	30
47	452879	4942527	March 13th	5	25
48	453076	4942819	March 13th	60	75
49	452909	4942692	March 13th	20	20
50	452949	4942776	March 13th	9	20
51	453019	4942905	March 18th	40	10
52	453251	4942750	March 18th	70	65
53	453153	4942805	March 18th	20	20
54	453152	4942854	March 18th	5	30
55	453044	4942706	March 18th	4	20
56	453116	4942790	March 19th	0	0
57	453037	4942903	March 19th	5	10
58	452911	4942563	March 19th	10	10
59	452791	4942867	March 19th	80	180
60	452939	4942677	March 19th	60	130

LEVEL OF SERVICE

- The Level of Service Policy will be reviewed and updated as needed.

ELECTRONIC SPREADER CONTROLS

- By 2005 all equipment used to spread salt shall have ground speed regulated electronic spreader controls.

PRE-WETTING AND ANTI-ICING EQUIPMENT

- 9 anti-icing trucks equipped for winter 2003/2004.
- 2/3 of all arterial road salt trucks equipped with pre-wetting for winter 2004/2005.

SPREADER CALIBRATION

- Standardized Salter Calibration Procedures have been developed.
- All beats have been benchmarked against the spreader settings.
- All spreaders will be properly calibrated each fall.
- Calibration will be checked regularly and recalibrate as needed.

EQUIPMENT WASHING

- By Fall 2002, all City vehicle washing shall be carried out indoors and washwater shall pass through oil/water separators before being discharged.

DE-ICER ORDERING AND DELIVERY

- Measures are being taken to reduce the loss of salt during delivery operations.

DE-ICER RECORD KEEPING

- The City will record salt use by each vehicle, beat and storm and periodically compare the usage to benchmarked rates to confirm the spreader calibration.

SAND/SALT BLENDS

- The City will investigate how it can reduce the amount of salt in sand/salt blends while maintaining the effectiveness.

SALT AND BLENDED SAND STORAGE

- By 2004, all salt and sand/salt blends shall be stored inside buildings on impermeable floors.
- All new maintenance facilities will be designed in accordance with the principles set out in TAC's Code of Practice for Design of Maintenance Yards.

GOOD HOUSEKEEPING PRACTICES

- The City has developed a Good Housekeeping Code of Practice that improves salt management practices at storage facilities.

WEATHER FORECASTING

- The City will improve its access to weather information and provide training to all staff on interpreting weather information when making snow and ice control decisions.

ADVANCED ROAD WEATHER INFORMATION SYSTEMS

- The City has installed 4 RWIS stations. It will now contract with a forecaster to provide pavement temperature forecasts.
- Staff will be trained in using RWIS information.

STORM RESPONSE

- Storm response data keeping will be improved to help in fighting future storms and analyzing how storms were attacked.

WINTER PATROL

- Patrol guideline will be amended to ensure that the City's level of service policy is met and demonstrated.

Dear: __________

We are third year Environmental Science students at Dalhousie University and are currently investigating the effects of salt usage around campus for our ENVS 3502 group project.

As a group we would really appreciate the opportunity to meet with you and ask you a few questions pertaining to the use of salt as a method for ice removal around Dalhousie?s campus. If a face to face interview is not convenient we would greatly appreciate either a phone interview or for you to respond to our interview questions via e-mail.

This would be extremely helpful for our group project and again, greatly appreciated. If you wish to grant us an interview, it would be ideal to set up a meeting on or prior to March 20th 2009.

Thank you for your time,

Sincerely,

Crystal Armstrong, Luke Miller, John Morrissy, Samuel McGill and Chad Hiscock

INTERVIEW WITH MILTON

John: What are the environmental effects of salt use on campus?

Milton: One would think that because salt is soluble and can dissolve into two separate elements, sodium and chlorine, that it would be harmful to plants. However, during the winter most vegetation retreat away and in fact are not subjected to the possible direct effects that salt may have on such vegetation. It's important to note that even in a soluble solution, salt does little damage to vegetation.

John: Does the salt travel past the sidewalk?

Milton: Not usually unless the facilities management spread the salt in a "widely" manner. Most salt is contained to the paved areas; however, if salt does manage to reach grassy areas, this still will not be a significant problem. We did a study a few years ago in the DISP program that investigated the effects salt had on the growth of beans. Students observed the effects that the application of salt on sidewalks at Dal had on bean plants that grew nearby. The final result was that the bean plants that were situated close to where the salt was laid in fat grew at a faster rate than the bean plants who did not receive the salt.

John: How far into the surrounding environment can salt go?

Milton: The salt can reach as far as the water table. This does not pose a problem though since Dal does not use the water table; the water table essentially drains into the harbour.

John: Can the salt being spread for ice management get into the water system?

Milton: Public water systems, no. But it can get into the water table.

John: How significant of a problem do you consider this to be?

Milton: I consider the problem of salt use mostly a maintenance one more so than anything else. The issue of salt getting into the water system is not an issue at all because of how well drained paved areas are around Dal and thus any salt runoff will more than likely find it's final destination in the harbour, which contains plenty of salt water (among other things). Thus I see it as more of a maintenance problem for custodians who have to clean it up inside the buildings. At this rate, an alternative such as sand or sand mixed with salt would not be desirable from a custodian perspective. This is because sand is made up of minerals that, in fact, scratch the surface of the floor tiles and is harder to clean up. Salt, being a soluble and angular substance, is easily washed away and cleaned up compared to something like sand.

John: Do you have any additional comments that may be helpful to our study?

Milton: I would just like to say that I personally do not view the use of salt on campus as an environmental concern or issue. It's affordable compared to most other alternatives which can become very costly and it also makes for good traction as a result of its angular nature. There is one thing I think is interesting that occurred a few years ago. A while back here at Dal the salt was stored down by the waterfront because the building they were going to store it in on campus was used for something else instead. In order to obtain the salt, management would have to drive down to the waterfront to get it and drive back to campus. What this ensured were better application processes of salt because management did not want to have to continuously drive back down to the waterfront for more salt. Thus, they were more conscientious about the amount of salt they were using and how they were applying it because as I said, they did not want to make that trip back down to the water to get more.

INTERVIEW WITH CUSTODIAN

John: How long have you worked in this position?

Custodian: I have worked at Dal since 2005, I've been working in the Killiam for about a year.

John: What months do you observe the most salt being tracked into the buildings?

Custodian: Usually the winter months, January, February, and even March.

John: Does the salt get tracked farther than the entryway?

Custodian: Yes. It gets tracked all the way upstairs and into the computer labs.

John: Do you think that excess salt is used on the entryway to your buildings?

Custodian: Yes, I believe that there is too much salt being used around the doors and on the staircases.

John: Have you heard any complaints from students or staff about salt in the buildings?

Custodian: Lately I have been receiving complaints from staff that there is too much salt being used in front of the doors and entryways. Students never complain, well not us anyways.

John: Do you have any complaints yourself?

Custodian: There is too much salt being used, I agree with the staff here. It's hard to clean and causes for a dirty indoor environment.

John: Do you have any additional comments that may be helpful to our study?

Custodian: Maybe something else can be used as an alternative, like sand.

INTERVIEW WITH MIKE MURPHY AND MIKE WILLKINSON

*Mike Murphy answered question 5, Mike Wilkinson answered 1-4 (done by email)

1. What is your role related to the issues of ice removal on campus?

- Supervisor of the in house staff who shovel steps and entrances and wheel chair access, as well as overseeing the snow removal contractor who is contracted to look after sidewalks and parking lots within the campus.

2. Is salt use on campus an environmental concern?

From a landscaping perspective it does pose a problem but one that is manageable to some degree. Being right on the coast does eliminate the potential of contamination of groundwater because any run off is almost instantly in the ocean.

3. Have you had any complaints about salt use on campus?

Yes: from custodial staff who are responsible for cleaning building interiors.

4. Has Dalhousie made any attempts in the last few years to reduce salt use?

Yes: with the purchase of spreaders which are calibrated to supply an optimal amount of salt to a given area to ensure safe conditions without over applying. Where efficiently possible we use more environmentally sensitive salt alternatives like the heated ramp at CRC and ice removal alternatives like *Environmelt.*

5. Do you have any additional comments that may be helpful to our study?

Relating to Question #3, from time to time various people on campus express concern that we are using too much salt. However, it seems no matter how little ice or snow we have someone always manages to fall on campus and the university can be held liable for such incidents. In many cases, I expect individuals are not paying proper attention or are wearing inappropriate footwear. Nonetheless, the University tends to still be held accountable for such mishaps. I think that individuals need to be more aware of the potential conditions and respond accordingly. In this way, we may be able to service the campus with less salt and have a reduced environmental impact.

INTERVIEW WITH RAYMOND ILSON

Luke: What is your role related to the issues of ice removal on campus?

Ray: I am responsible for dealing with matters pertaining to ice related injuries and the prevention of such matters.

Luke: Is salt a health and safety issue on campus?

Ray: We do not view salt as a health and safety issue on campus. Instead we view salt as a means of preventing injuries and ensuring the health and safety of the students, faculty members, and the general public.

Luke: Have you had complaints from students or faculty in relation to de-icing practices?

Ray: No complaints from students; some from faculty members who complain about too much salt on the stairways.

Luke: How many ice related injuries occur each year?

Ray: I don't have that stat right now but I can look into it.

Luke: At current levels, is salt use on Dalhousie campus considered toxic?

Ray: No. Current levels of salt use at Dal abide by the standards set in place in regards to what the appropriate pH level of salt solution is allowed. That is between 6 to 9 pH; salt in water solution has approximately a pH level of 7.

Luke: Have any formal studies been done to your knowledge?

Ray: There have been studies pertaining to samples that come from sewers that directly come from Dal buildings around campus. This take's into consideration many other chemicals and waste, so I am not aware of any specific studies done with salt and concentration levels relating to salt.

Luke: Why is salt not used at the Dalplex?

Ray: That question would be for Mike Murphy of facilities management.

Luke: What is used in its place?

Ray: That question would also be for Mike Murphy

Luke: Do you have any additional comments that may be helpful to our study?

Ray: You should try and get in touch with Rochelle Owen and see what she has to say about the issue. She may be able to help you guys out with your project and provide more insight into your topic.

INTERVIEW WITH JOHN CHOPTIANY

Group: Does Dal have a salt management plan?

John: I'm not completely sure if they have one or not.

Group: If there is no salt management plan at Dal, do you think it should have a plan put into place?

John: Anything over 500 tonnes of salt usage is required by environmental Canada that a salt management plan be put in place. It would be a case of legal matters if they did not abide by this regulation. In my opinion, if they don't already have a plan, they definitely should.

Group: Can you offer any good examples of salt management plans from other universities?

John: Not sure of specific universities but I do know that the city of Toronto has an excellent salt management plan.

Group: Do you have any additional comments that may be helpful to our study?

John: It would be good for you guys to review a salt management plan that's already in place in another city or university if you could find one. I recommend the website saltinstitute.net as a means of great information regarding salting practices. I do know that alternative means of de-icing practices can get rather expensive like the system RWIS.

GENERAL INFORMATION

1. Title of Project: Salt Management: an alternative salt management program at Dalhousie University

2. Faculty Supervisor(s)	**Department**	**Ext:**	**e-mail:**
Tarah Wright			

3. Student Investigator(s) Department e-mail:

John Morrissy	B00470411	ENVS & IDS	john.morrissy@dal.ca
Chad Hiscock	B00440925	ENVS & IDS	CH579954@dal.ca
Samuel McGill	B00470411	ENVS	sm820097@dal.ca
Chrystal Armstrong	B00463274	ENVS	cr504618@dal.ca
Luke Miller	B00466936	ENVS & IDS	lk636654@dal.ca

4. Level of Project:

Non-thesis Course Project [Yes] Undergraduate [ ] Graduate

Specify course and number: __ENVS3502_

5. a. Indicate the anticipated commencement date for this project: __January 5th____

b. Indicate the anticipated completion date for this project: ______March 31st_______

SUMMARY OF PROPOSED RESEARCH

1. Purpose and Rationale for Proposed Research
Briefly describe the purpose (objectives) and rationale of the proposed project and include any hypothesis(es)/research questions to be investigated.

- the purpose of this research project is to evaluate the effects of current salt use practices at Dalhousie and to recommend alternatives. Our research objectives are to:
- Explore the feasibility of the current ice-removal practices undertaken at Dalhousie and suggest areas for improvement
- Analyze the feasibility of alternative ice-removal practices that could be undertaken at Dalhousie and suggest areas for improvement
- Research the environmental effects of excessive salt use on Dalhousie University

2. Methodology/Procedures

a. ***Which of the following procedures will be used? Provide a copy of all materials to be used in this study**..*

[ ] Survey(s) or questionnaire(s) (mail-back)
[ ] Survey(s) or questionnaire(s) (in person)
[ ] Computer-administered task(s) or survey(s)]
[y] Interview(s) (in person)
[y] Interview(s) (by telephone)
[ ] Focus group(s)
[ ] Audio taping
[ ] Videotaping
[ ] Analysis of secondary data (no involvement with human participants)
[ ] Unobtrusive observations
[ ] Other, specify ____

b*.* ***Provide a brief, sequential description of the procedures to be used in this study**. **For studies involving multiple procedures or sessions, the use of a flow chart is recommended.***

The procedure will be to initate contact and ask the prospective interviewies if they are willing to answer some questions related to salt use at Dalhousie. Then a time for an interview will be set up. The interview will take place. The results will be used as data in this report.

3. Participants Involved in the Study

a. ***Indicate who will be recruited as potential participants in this study****.*

Dalhousie Participants: [ ] Undergraduate students
[y] Graduate students
[y] Faculty and/or staff
Non-Dal Participants: [ ] Children
[ ] Adolescents
[ ] Adults
[ ] Seniors
[ ] Persons in Institutional Settings (e.g. Nursing Homes, Correctional Facilities)
[ ] Other (specify) ________________________________

b*.* ***Describe the potential participants in this study including group affiliation, gender, age range and any other special characteristics. If only one gender is to be recruited, provide a justification for this****.*

Raymond Ilson of Environmental Health and Safety
Mike Murphy, the manger of Environmental Sciences
Jeffrey Lamb, the Director of Facilities Management
Contractors
Milton Graves Professor.

John Choptiany the TA
Custodian

c. ***How many participants are expected to be involved in this study?*** _______*7*_______

4. Recruitment Process and Study Location

a. ***From what source(s) will the potential participants be recruited?***

[ ] Dalhousie University undergraduate and/or graduate classes
[ ] Other Dalhousie sources (specify) ______________________________
[ ] Local School Boards
[ ] Halifax Community
[ ] Agencies
[ ] Businesses, Industries, Professions
[ ] Health care settings, nursing homes, correctional facilities, etc.
[ ] Other, specify (e.g. mailing lists) ____

b. ***Identify who will recruit potential participants and describe the recruitment process.*** *Provide a copy of any materials to be used for recruitment (e.g. posters(s), flyers, advertisement(s), letter(s), telephone and other verbal scripts).*

5. Compensation of Participants

Will participants receive compensation (financial or otherwise) for participation? Yes [ ] No [n]
If **Yes**, provide details:

6. Feedback to Participants

Briefly describe the plans for provision of feedback and attach a copy of the feedback letter to be used. Wherever possible, written feedback should be provided to study participants including a statement of appreciation, details about the purpose and predictions of the study, contact information for the researchers, and the ethics review and clearance statement.

Note: When available, a copy of an executive summary of the study outcomes also should be provided to participants.

Feed back will be in the form of an invitation to each of the participants to attend the project presentation to be held on march 31st

<u>POTENTIAL BENEFITS OF STUDY</u>

1. **Identify and describe any known or anticipated direct benefits to the participants from their involvement in the project**. *N/A*

2. **Identify and describe any known or anticipated benefits to society from this study.**

If successful this project will help to provide Dalhousie University with a safer, greener de-icing plan.

POTENTIAL RISKS TO PARTICIPANTS FROM THE STUDY

1. **For each procedure used in this study, provide a description of any known or anticipated risks/stressors to the participants. Consider physiological, psychological, emotional, social, economic, legal, etc. risks/stressors**

   [n] No known or anticipated risks
   Explain why no risks are anticipated:

No risks are anticipated because there is no hazard.

   [ ] Minimal risk
   Description of risks:

   [ ] Greater than minimal risk
   Description of risks:

2. Describe the procedures or safeguards in place to protect the physical and psychological health of the participants in light of the risks/stresses identified in Question 1.

None

INFORMED CONSENT PROCESS

1. **What process will be used to inform the potential participants about the study details and to obtain their consent for participation?**

   [ ] Information letter with written consent form; provide a copy
   [ ] Information letter with verbal consent; provide a copy
   [ ] Information/cover letter; provide a copy
   [y] Other (specify) _____participants will be contacted via telephone or email and asked to participate in an interview. By agreeing to participate the interviewee will be consenting.

2. **If written consent cannot be obtained from the potential participants, provide a justification.**

Most of the interviews will take place over the phone and not in a face to face matter. Because the participants are busy they may not have time to meet in person.

ANAONIMITY OF PARTICIPANTS AND CONFIDENTIALITY OF DATA

1. **Explain the procedures to be used to ensure anonymity of participants and confidentiality of data both during the research and in the release of the findings.**
   Participants will not remain anonymous.

2. **Describe the procedures for securing written records, questionnaires, video/audio tapes and electronic data, etc.**

3. Indicate how long the data will be securely stored, the storage location, and the method to be used for final disposition of the data.

[ ] Paper Records
[ ] Confidential shredding after ______ years
[ ] Data will be retained indefinitely in a secure location
[y] Data will be retained until completion of specific course.

[ ] Audio/Video Recordings
[ ] Erasing of audio/video tapes after ______ years
[ ] Data will be retained indefinitely in a secure location
[ ] Data will be retained until completion of specific course.

[ ] Electronic Data
[ ] Erasing of electronic data after ______ years
[ ] Data will be retained indefinitely in a secure location
[ ] Data will be retained until completion of specific course.
[ ] Other ____
(Provide details on type, retention period and final disposition, if applicable)

Specify storage location: ____________________researchers will keep the data at their residences.