Improving Salt Management on Multiple Fronts

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Abstract

Many provincial, municipal and private road authorities are being proactive in managing road salt use. Their efforts are on many fronts including:

- reviewing levels of service;
- refining plow and spreader routes;
- improving documentation and record-keeping;
- improving training;
- improving equipment;
- improving decision-making;
- improving material storage and handling practices; and
- factoring salt vulnerable areas into management practices.

This paper will present experiences with how a wide range of road authorities are improving their practices. The paper will include anecdotal information from operations managers on what improvements provided the best salt management results.

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1.0 Introduction

Since the mid 1990s, Environment Canada has had an ongoing program to assess the environmental effects of road salt and to improve the management of road salts in Canada. In 2004 Environment Canada published its "**Code of Practice for the Environmental Management of Road Salts"** (the Code). This Code of Practice encouraged public road authorities to develop and implement salt management plans with the goal of reducing the amount of salt entering the environment through improved winter maintenance practices.

The Code was supported by a number of Syntheses of Best Practices prepared by Ecoplans Limited (Ecoplans) for the Transportation Association of Canada (TAC). These documents are available at: http://www.tac-atc.ca/english/informationservices/readingroom.cfm#syntheses.

Many road authorities (both public and private) of all sizes across Canada have prepared and implemented salt management plans consistent with the Code. These efforts came with significant challenges as well as benefits. This paper discusses some of the benefits and challenges experienced.

2.0 Preparing the Salt Management Plan

Ecoplans has prepared over 50 plans for road authorities across Canada. These range from provinces with large road networks (e.g. Ontario) and smaller networks (e.g. Saskatchewan and Manitoba) to large municipalities (e.g. Toronto, Region of Niagara, Winnipeg, Calgary etc) to smaller municipalities (e.g. Kelowna, Whitby, Uxbridge). In addition private highway authorities (e.g. Hwy 407ETR), bridge authorities (e.g. Seaway International Bridge Corporation -SIBC) and airports (e.g. Pearson International Airport) prepared salt management plans with our assistance.

The process followed for all of these plans is essentially the same. Only the complexity varied to suit the road authority's needs. Whereas the Province of Ontario has over 16,500 km of highways, the SIBC has 6 km. While the Province of Alberta fully contracts out its winter maintenance services many municipalities use in-house unionized personnel. Some use a relatively small fleet with basic spreader controllers, whereas others use a variety of liquid and solid chemicals applied using sophisticated electronic spreader controllers and decision support systems. We therefore had to tailor the plan development process for each road authority.

Since the purpose of the salt management planning process is to reduce the amount of salt needed to achieve the specified level of service, the planning process must challenge the status quo and show road authorities how they can do the job better using best salt management practices. This can only be done if you and/or your winter maintenance planner are familiar with best winter maintenance practices and how they relate to your operation. Incomplete or inaccurate information and inexperience can lead you down the wrong path.

We have called them "Salt Management Plans" but they are really Winter Maintenance Management Plans. Since effective winter maintenance requires an integrated system we take a systematic and comprehensive approach to developing the plans that look at how you manage your roads throughout the winter.

"We are transforming our approach from tackling snow to managing roads."

Ian McPherson, Seaway International Bridge Corporation

3.0 Lessons Learned

Everyone launches into their salt management planning process with the best of intentions. Although they don't always save salt initially, road authorities usually end up with a better and more integrated winter maintenance program and salt savings in the longer-term. The following talks about a variety of our experiences.

3.1 *Education Is Key*

Road maintainers have been doing their job "successfully" for many decades. They have used what they consider to be tried and true methods to keep their roads safe. Their arsenal for the war on winter had included plows and spreaders; sand and salt; and a radio or TV to get weather reports. They learned that its easier to plow if the snow isn't stuck to the road, that salt helps break the bond and that sand gives good traction when it's too cold for salt. Many believed that more is better – so keep spreading that salt!

We have learned however that many operators and supervisors did not understand the basics of chemical use and how much is really enough. Everyone recognizes that education is critical to successfully introducing new principles, new technologies and new chemicals.

The City of Toronto made education its first priority while it decided what to do with higher cost initiatives. The City ran an information session for all of its in-house and contracted supervisors and operators. The sessions dealt with the science of salt, the basics of weather, salt storage and handling, environmental impacts of salt and record keeping.

The key focus was on encouraging operators to only apply the amount of salt that was needed to do the job. By calculating how much salt was needed for each route, the City started limiting the amount of salt put in the spreaders.

The simple action of training the staff and controlling the salt being put in the spreaders lead to astonishing savings. Without investing in any new equipment, the City realized a 15-20% saving in salt use. Building on the initial awareness programs provided by Ecoplans, the City established an ongoing in-house education program. It also worked with the Ontario Good Roads Association (www.ogra.org) and the Ontario Road Salt Management Group to develop a series of excellent train-the-trainer and CD-based training resources.

We cannot achieve change in our organizations without buy-in from staff and this only comes with education through training. Most of our salt management sessions start with an overview awareness session to prepare supervisors and operators for the changes that will come with a full salt management strategy.

3.2 *Level of Service (LOS)*

Most road authorities have some type of Level of Service document. Some are quite specific, others are very loose. Without clearly prescribed levels of service it's hard for staff and supervisors to know your objectives. Apart from being necessary for effective salt management, good LOS documentation is essential for managing your liability.

It is very difficult to reduce the level of service offered the public without raising a political firestorm. However in many cases road authorities are over-servicing their road network and significantly exceeding their intended LOS – leading to increased costs in equipment time, worker hours and materials (including salt) and exposing themselves to liability.

Reducing LOS can save salt. Some municipalities have cut back on the LOS on lower priority roads. Plowing and spot treatments are good enough for low volume flat local streets. This change can save both servicing and clean-up costs and reduce salt impacts.

Other municipalities have changed their practices through their SMP to achieve a better LOS – or maybe it's more correct to say to better achieve their LOS. One municipality had a bare pavement policy but tried to achieve it using a sand/salt mix. A better understanding of the science of salt led them to change to using pre-wetted salt on their higher priority arterial roads. Their ability to meet their LOS improved dramatically. The Politicians were so impressed that they now want a similar practice on their lower priority collectors. One caveat of course is that this could lead to more salt use.

Another municipality was trying to achieve its bare-pavement policy using a 70-30 sand/salt mix. We showed that with their application rate they were applying the equivalent of a full salt dose as well as their sand. By modifying their approach to use straight salt they better achieved their LOS; were able to save significantly on their sand costs; and their trucks could go much further since they reduced their application rate.

3.3 *Route Optimization*

Most road authorities have a sense of how long spreader and plow routes should be to be efficient and allow their operators to finish their routes without too much inefficiency. As practices and equipment change it is necessary to review routes from time-to-time to ensure that operations continue to be efficient. These reviews can be done manually or with the help of computer systems. However, they always must involve the operators to ensure that the routes are practical.

Our review of one municipality's routes showed that by changing their plowing and spreading practices they could reduce the cycle time to complete their routes thereby increasing the level of service and reducing their operating costs. The municipality also wanted to relocate one of its maintenance yards. The routing analysis identified where the County should set up its new yard and showed that they could eliminate two other yards and still effectively service their road network.

In the case of a City our route analysis showed that they could eliminate 2 trucks by re-organizing their routes and operating methods.

3.4 *Yard Rationalization and Design*

Most road authorities have located maintenance yards over the years based on their servicing needs predicated on their fleet size and configuration. The introduction of improved plow and spreader fleets, the use of liquids, improved storm response and variable application rates has in some cases increased the service area of each truck. As a result, the salt management planning process has lead some to review the number and location of their yards. This has given the road authority the opportunity to locate in less sensitive areas and to better design their facilities.

Many have improved the facility design to include indoor material delivery and spreader loading. This reduces the amount of salt being spilled and improves the efficiency of operations. These storage facilities are more expensive but they reduce the potential environmental liability. One yard we are designing had to be located near a salt vulnerable area. The yard is being designed to ensure that salt impacted water is managed in a way that protects the salt vulnerable area. The principles being followed are contained in an "Environmental Guide for Patrol Yard Design" prepared for the Ministry of Transportation, Ontario (http://www.ecoplans.com/ESP-Documents.htm).

There is still a challenge dealing with salt impacted water at maintenance yards. Some of the impacted water is being used for brine production. However there remains a significant disposal problem for the water that cannot be reused. This challenge has lead to innovations by two contractors in Alberta who are developing new technologies for dealing with the water. These technologies will also be useful for treating waste salt water from the oil and gas industry.

The key is to ensure that the yard design is in harmony with the yard operation so that as little salt as possible is spilled or released to the environment. The provinces of Alberta and Ontario have used the concept of a designated Winter Maintenance Area (WMA) in their yards. This is the portion of the yard where there is the highest likelihood of salt releases. Salt containment efforts are focused on the WMA rather than having to fully protect the entire site.

3.5 *Record Keeping*

There is a saying - ***"You can't manage what you don't measure!"*** Effective salt management requires you to know how much salt you are putting down, at what location and at what time. But how do you do that?

Many are using **AVL/GPS** to track their vehicles and obtain operating data. This technology is quite well developed and is good at giving you real-time information on the location of your trucks. But getting accurate information on what is being done or how much salt is being applied is more challenging.

We analyzed two years of data for one municipality to map the amount of salt being placed along roadways within salt sensitive areas (groundwater recharge areas). We downloaded the data from the AVL supplier and very quickly were able to create a map showing the amount of salt placed within the sensitive areas. However – the map was suspect. Our analysis showed that about 80% of the data that had been collected through the AVL/GPS system was unreliable because:

- In some cases the conversion software on the spreader was incompatible with the controller – often because the mechanics would switch controllers or upgrade controller software without advising the AVL service provider;
- Sometimes the GPS unit was disabled either through a malfunction or deliberate sabotage and it wasn't detected;
- Some data were lost due to limited data storage on the controller; and
- There were blind spots for the communication system meaning that the data could not be transmitted and therefore were lost.

The lessons that we learned were:

- Have a pre-season start-up program that ensures that the system is working properly before the start of the winter season;
- Have an ongoing quality assurance program to regularly check the validity of the data and that the collection system is working;
- Have sufficient and secure on-board data storage to ensure that data is not lost either due to communication or power problems or controller capacity issues;
- Work with your AVL/GPS supplier to ensure that they understand your information needs and can report the data in a way that meets and supports your management and decision-making needs.

The need for improved data reliability has lead to improvements in both spreader technology and support systems. Road authorities are increasingly moving to on-board data loggers that store the data until it is needed. These data can be off-loaded using wireless technology at the road authority's convenience. This can be daily or weekly, or whenever the truck enters the yard.

3.6 *Materials*

For a long time many road authorities only used rock salt or abrasive mixtures to maintain their roads in winter. Now we see a variety of different solid and liquid chemicals and abrasives being used. Most road authorities have realized that given the variability in winter conditions they need a variety of materials and application rates in their arsenal.

Pre-treating abrasive and salt piles and on-board pre-wetting is common-place. Direct liquid application (sometimes called anti-icing) is becoming more widely used although most road authorities are moving cautiously in this area. The usual approach is to try

direct liquid application (DLA) on bridges first and then move to a broader roadway application. Education is the key to rapid deployment of DLA. Many road authorities have inadvertently created slippery conditions as a result of improper use of DLA. In some cases too high an application rate and high humidity and temperature conditions have resulted in chemical slipperiness on the road. In other cases low concentrations or rapid dilution and refreezing have caused icy conditions. DLA is a very valuable tool in the hands of knowledgeable staff but can cause problems if used improperly.

Quality control and assurance is critical when using liquids. Failure to maintain the correct concentration can cause a number of problems. One of our clients had trouble with spreader nozzles clogging. A little detective work showed that the concentration was too high (above the eutectic concentration). At this concentration a precipitate was forming that clogged the nozzles. Another client in western Canada had a problem with their on-board tanks and pumps freezing at low temperatures. In this case the liquid that was purchased was off-spec and the concentration was lower than specified. The road authority did not have a procedure in place to test the concentration of the product being supplied. We encourage road authorities as part of all salt management plans, to have material standards and quality assurance and testing programs in place.

The range of available liquid chemicals is increasing. The quality of engineered products has significantly improved, providing snowfighters with chemical options at lower temperatures. There is also much more research – both in the lab and in the field – on the performance of various chemicals under different conditions. Traditionally this research looked at freeze point depression and corrosiveness. Recently there has been a greater focus on the implications on roadway friction. There has also been an increased interest in the effects of mixing chemicals to lower the effective working temperature. The Greater Toronto Airports Authority has a field study underway to test the effectiveness of one such additive. The study was designed this past winter and will be field tested next winter.

One of the challenges facing snowfighters is staying within the gross vehicle weight requirements for the spreaders. These multi-purpose spreader-plows with multiple plows and on-board pre-wetting are carrying a lot of weight (both solid and liquid materials). People are addressing this concern by moving to larger trucks or by reducing the amount of material carried. Some have modified their plow configuration – e.g. removed the wing.

Application rates for all materials vary significantly from one road authority to another. Some of this variability is appropriate. However, the temperature ranges for specific chemicals are fairly constant. Regardless of whether you are in Vancouver, Winnipeg, Windsor, or Charlottetown you will only use sodium chloride when pavement temperatures are above around -10 ^{o}C (some say -12 others say -8). We encourage road authorities to vary their rates depending on pavement temperatures and precipitation type/intensity. This is common practice in many areas of the U.S. and Europe. Many Canadian road authorities have introduced a “light” rate for frost and light snow. The Province of New Brunswick has taken this a step further and has specified the “light” rate

for the second round or spreading recognizing the fact that there is a residual from the first application.

3.7 *Equipment and Technology*

There are ongoing improvements to snowfighting equipment and technologies. However, one shouldn't lose sight of the improvements that can be made by simply maintaining your current equipment. One road authority that we worked with had a high rate of breakdown in their plow fleet. As a result they had to apply more salt to meet their LOS policy. Essentially they were "chemically plowing". By improving their plow fleet they were able to re-focus on mechanical plowing and reduce their material use.

The rate of change in equipment and technology to help snowfighters do their jobs better and more cost-effectively has been impressive. Spreaders are becoming more sophisticated with:

- electronic spreader controls that accurately meter out solids and liquids at variable rates;
- AVL/GPS systems that tell supervisors where the vehicles are and what they are doing; and
- pavement temperature sensors that help operators to make real-time material application decisions.

These are becoming standard equipment on modern spreaders. Future spreaders might include:

- automatic adjustments to material application rates and symmetry based on AVL/GPS information;
- collision avoidance systems;
- edge of pavement sensors;
- heads up display with virtual augmentation;
- weather and forecast information and radar delivered to the truck; and
- friction sensors.

Many of these innovations are already being used somewhere in the world now but have not become standard.

Other technologies that are being used or tested include:

- RWIS equipment is improving and we now see smart pucks with built-in modems that communicate directly with your computer;
- Low cost thermo-chromatic disks installed in the road that change colour when the road freezes providing early icy road warning;
- Fixed automated spray technology;
- Pavement overlay systems that "store and release" winter maintenance chemicals as needed;
- Monitoring for residual chemical on the road.

3.8 *Salt Vulnerable Areas*

Environment Canada's Code of Practice encourages road authorities to identify salt vulnerable areas (SVA) and take proactive actions to reduce salt impacts to these areas. We have conducted SVA studies for several large and small municipalities to assist in planning winter maintenance activities. In all cases the key environmental features were mapped using existing data sources and GIS. The road network was overlaid onto this environmental features map. We then ranked the sensitivity of the features to identify those that are at greatest risk. In the case of the Regional Municipality of Niagara we are holding meetings with the public and interest groups to review the findings. The next step is to fine-tune maintenance practices adjacent to these sensitive areas to minimize impacts. We have learned that the critical environmental features can vary from one location to another. For example in the Niagara Region, the impact to tender fruitlands is a key consideration whereas in Waterloo Region groundwater impacts are key.

3.9 *Decision-making Support*

Snowfighters are called upon to make decisions under challenging conditions with often imperfect information. These decisions have significant implications for the driving public. Considerable work is being done around the world to improve the information available to help snowfighters to make proper and timely decisions. There are two key elements to improving decision-making.

- The first is ensuring that decision-makers have the critical information in a timely fashion to predict and monitor road conditions.
- The second is ensuring that decision-makers and operators have the knowledge to use the information to make proper and timely decisions and to effectively execute those decisions.

Many decision-support tools are now broadly available. Others are still in the developmental stages. The following are some of these tools:

- Dedicated weather forecasts tailored to the needs of snowfighters and delivered via the internet directly to the decision-makers;
- Reliable pavement condition forecasts and current pavement condition trends;
- Thermal mapping to help identify problem areas and to better extrapolate RWIS information to other areas;
- Post-storm analysis to improve in-house knowledge of effective response strategies;
- Expert systems to provide typical storm response strategies (e.g. MDSS); and
- Increased automation using AVL/GPS.

4.0 Conclusions

The approach to winter maintenance in Canada has changed significantly since Environment Canada raised concerns about the environmental effects of excessive salt use. A large percentage of the road authorities representing the majority of Canada's road network and population have salt management plans in place. Many are now grappling with implementing these plans. Road authorities know that they can obtain greater results by taking a systematic approach to their winter maintenance and salt management. We have seen considerable modernization of winter maintenance programs across Canada and as long as this momentum is maintained, improvements will continue.

About the Author

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Bob has over 30 years of experience working in the transportation and environment fields and has been consulting on Road Salt Management across Canada since 1997. He was the project manager for most of the existing Salt Management products issued by the Transportation Association of Canada. His team prepared TAC's Salt Management Guide and Syntheses of Best Practices for Salt Management. Bob has led the preparation of close to 50 Salt Management Plans for National, Provincial and Municipal road authorities in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan, Alberta and B.C.. In addition to salt management plans, Bob and his team have completed studies in:

- Brine production;
- Maintenance yard audits, rationalization and design;
- Snow disposal site assessments and design;
- Microclimate studies and RWIS site location and design;
- Salt Vulnerable Area Mapping and response strategies;
- Route optimization;
- FAST warrant study;
- Winter maintenance equipment rationalization;
- Winter training;
- Level of Service Standards;
- Operational assessment studies;
- And Risk Management Training

Bob is also the technical advisor to Environment Canada's team that prepared the *Code of Practice for the Environmental Management of Road Salt*. Bob has spoken on salt management at conferences across Canada and in the U.S..

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