Simon Fraser University

Salt Management Plan

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1.0 Overview

1.1 Purpose of the Salt Management Plan
The purpose of the Simon Fraser University’s (SFU) Salt Management Plan is to fulfill the University’s obligation as per Environment Canada’s “Code of Practice for the Environmental Management of Road Salts”. The plan establishes a framework with specific goals and actions to ensure the University’s roads are maintained in a safe manner while minimizing the negative impacts of road salts on the local environment.

The Salt Management Plan is required to ensure the University establishes salt management procedures that follow the Transportation Association of Canada’s best management practices as set out in “Syntheses of Best Practices Road Salt Management”.

1.2 Salt Management Plan Policy Statement
Simon Fraser University will work to provide an acceptable level of winter maintenance to the SFU Road network and other public facilities while managing the salt usage effectively. To achieve this objective, each year SFU will:

- Meet the guidelines within this document
- Work to improve the Salt Management Plan by reviewing it and identifying any shortfalls
- Constantly strive to improve on practices and utilize the newest technologies to provide better salt usage and management
- Stay current and update the plan to meet or exceed the Federal regulatory guidelines
- Continue to train staff on the importance of salt management and the impacts that excessive use has on the environment.

1.3 Policy Application
This Policy is adopted by the Simon Fraser University’s Facilities Services Snow and Ice Operations and applies to all employees involved with snow removal.

1.4 Policy Principles
The SFU salt management plan is a dynamic model and it will be reviewed annually. The review process and improvement implementation will be based on environmental management principles.

- Review of industry standards and equivalent benchmarking
- Implementation and documentation of the implemented plan
- Ongoing training and education of staff
- Monitoring of environmental impacts by sampling and lab analysis at identified locations
- Policy review and revisions

2.0 Winter Maintenance Practices

2.1 Introduction
Simon Fraser University’s Facilities Services Snow and Ice Operations under the direction of Buildings and Grounds provide winter snow and ice control services for:
Simon Fraser University Salt Management Plan

- the University’s 28.0 lane kilometres of roadways
- UniverCity’s 3.3 lane kilometres of residential roads
- the 110,000 square meters of uncovered parking area (see appendix A).
- Sidewalk salting and walkway snow clearing

Winter Maintenance Practices are maintained throughout snow and ice season by the University’s staff and sub-contractors. During extreme snow and ice conditions laneway snow clearing services may be assisted by private grader and bobcat contractors. Private contractors do not assist SFU in the application of road salt or brine on sidewalks, laneways, or parking areas.

Table 2.1 Roadway and Parking Salt Application Area Data

<table>
<thead>
<tr>
<th>ID</th>
<th>Designation</th>
<th>Lane (Km)</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane*</td>
<td>University Primary Bus Route</td>
<td>12.04</td>
<td></td>
</tr>
<tr>
<td>Lane*</td>
<td>University Primary Road</td>
<td>9.56</td>
<td></td>
</tr>
<tr>
<td>Lane*</td>
<td>University Secondary Road</td>
<td>5.08</td>
<td></td>
</tr>
<tr>
<td>Lane*</td>
<td>UniverCity Secondary Road</td>
<td>4.74</td>
<td></td>
</tr>
<tr>
<td>Parking Areas</td>
<td>Parking Uncovered</td>
<td></td>
<td>110,000</td>
</tr>
</tbody>
</table>

*lane is defined as one standard road-width.

2.2 Snow and Ice Control Best Practice Guidelines

Improvements in salt management and snow and ice control are the primary goal of the Salt Management Plan. Areas identified as requiring improvement(s) have been identified using the guiding principles of the Transportation Association of Canada “Syntheses of Best Practices Road Salt Management”.

The following sections of the “Syntheses of Best Practices Road Salt Management” have been used in the development of goals in managing and improving Salt, and Snow and Ice management at Simon Fraser University:

1.0 Salt Management Plans
4.0 Drainage and Storm water Management
5.0 Pavements and Salt Management
7.0 Design and Operation of Road Maintenance Yards
9.0 Winter Maintenance Equipment and Technologies

Table 2.2 identifies SFU’s goals for improvement in the management of Snow and Ice at Simon Fraser University is as follows:

Table 2.2 Salt Management Plan Objectives and Goals

<table>
<thead>
<tr>
<th>Section</th>
<th>Area of Objective</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC 1.0</td>
<td>Snow and Policy</td>
<td>To develop a Salt Management Policy in conjunction with senior University administration and Facilities Services.</td>
</tr>
<tr>
<td>TAC 4.0</td>
<td>Impact Identification</td>
<td>Implementation of a comprehensive surface water monitoring program.</td>
</tr>
<tr>
<td>TAC 4.0</td>
<td>Impact Identification</td>
<td>Implementation of a ground water monitoring program.</td>
</tr>
<tr>
<td>TAC 4.0</td>
<td>Impact Identification</td>
<td>Identify areas within the University</td>
</tr>
</tbody>
</table>
that indicate high levels of residual salt contamination.

<table>
<thead>
<tr>
<th>TAC 5.0</th>
<th>Improved Information Systems</th>
<th>To add road temperature sensors to monitor current road temperatures.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC 5.0</td>
<td>Applying Road Salts</td>
<td>To reduce salt use by operating at 100% pre-wet application.</td>
</tr>
<tr>
<td>TAC 7.0</td>
<td>Improved Yard Operations</td>
<td>Operate the road salt loading under cover or utilize contained loading methods.</td>
</tr>
<tr>
<td>TAC 7.0</td>
<td>Improved Salt Storage</td>
<td>Install bay doors on the existing salt storage shed.</td>
</tr>
<tr>
<td>TAC 7.0</td>
<td>New Winter operations Facility</td>
<td>Design of a new relocated state of the art winter operations facility to contain all wash down water, improve salt storage and recycle wash down water for brine used to reduce overall salt requirements.</td>
</tr>
<tr>
<td>TAC 9.0</td>
<td>Alternative Products &amp; Methodology</td>
<td>Reduce salt application on walkways through the introduction of alternative products.</td>
</tr>
</tbody>
</table>

2.3 Operating Practices

Roads are maintained by University operators trained in the safe operation of University snow and ice equipment; this includes a complete understanding of the operation of salt application equipment. Standardized operator training with yearly updates is mandatory for all University operators (see appendix D). Training involves a training session to review “Syntheses of Best Practices Road Salt Management” best practice and salt application rates specific to University snow and ice conditions.

Operators of snow and ice vehicles are required to maintain the following:

- The appropriate class of driver’s license and brake endorsements; licenses and endorsements must be maintained in good standing.
- Adequate training, both in snow and ice theory and practical application, on all equipment operated by the individual; assessments are kept on file for review.
- Annual re-certification procedures.
- Education on the environmental impacts that salt can have.
2.4 Existing Winter Operations Facility

The existing SFU winter operations facility is located across from the Facilities Service works yard. The facility operates under the guiding principles identified in the *Transportation Association of Canada's best practice guideline “Design and Operation of Road Maintenance Yards”* including the following:

- Salt storage is covered year round.
- Ground area is covered with a asphalt surface (low permeable);
- Surface water from the salt storage site is captured and redirected away from the storm drainage into alternate drainage, in this case the existing sanitary system.

Brine storage is located within the surface water capture zone at the salt storage facility and is further contained within a membrane lined capture tank.

The vehicle wash down site is also at this location. Water from wash down is directed away from storm drains and directed into alternate drainage.

The salt storage facility has been used at the current location for decades and may have salt residue present in-situ. A program of surface soil sampling and core sampling has been undertaken to assist in determining if a salt contamination problem exists at the site. If the current site is maintained efforts will be undertaken to ensure any road salt entering the environment is minimized. If testing determines the current site is contaminated a rehabilitation plan will be explored.

To assist in walkway salt applications De-Icer storage sites are maintained at locations throughout the University (see appendix D). Due to the corrosive and harmful impact salt has on the surrounding environment salt will no longer be stored at these sites. Instead an environmentally safe alternative De-Icer will be used on all walkways and stairs around campus.

2.5 Snow Clearing and Removal

During heavy snowfalls, SFU employs the use of plows, bobcats, graders and loaders to clear snow from roadways and parking areas. Snow is piled at the edges of parking areas and roadways and left to melt during the warmer temperatures.

Snow removal at the University is not utilized. In future, severe conditions may result in snow being removed from the campus, but snow removed in this manner would be removed prior to the application of road salt and only to authorized preapproved dumping sites.

2.6 Road Salt and Brine Usage

2.6.1 Salt Usage

Salt application is paramount to SFU’s snow and ice operations. Minimizing application rates reduces costs and mitigates the negative effects of road salt on the local environment. In order for salt to be used most effectively and efficiently road salt and brine solutions are applied as follows:

- At the application rate specified in the operators training session.
- In correct places; road crowns, elevated corners, and roadway travel paths.
- At the correct vehicle speed.
Salt on SFU laneways, parking lots, and walkways is applied when temperatures are above -6° Celsius and at an application rate that utilizes the “working effect” of traffic. Utilizing the “working effect” of traffic reduces application rates and the number of applications required to ensure roadway safety. Traffic breaks the road salt down into a solution more quickly than environmental conditions alone which improve road salt de-icing properties.

2.6.2 Brine Usage

Salt brine is applied to University roads at 23% salt to water solution. Brine is utilized in both pre-wetting and in brine only applications. When conditions indicate salting is required but the salt will not adhere to the road surface due to dry road conditions brine only applications are utilized to minimize salt loss along the road verge. Table 2.3 identifies the equipment used to place salt and brine on the SFU road network. As technologies improve upgrades to the fleet are made to improve controls on spreading rates and to monitor the road conditions to help determine the best method for ice and snow mitigation.

Table 2.3 Salt Management Road Application Data & Equipment

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Spreader Control Type</th>
<th>NaCl/Sand Application Rate (kg/lane-km)</th>
<th>Liquid Application</th>
<th>Liquid Application Rate (kg/lane-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Ton</td>
<td>-</td>
<td>-</td>
<td>Brine</td>
<td>60</td>
</tr>
<tr>
<td>Three Ton</td>
<td>Broadcast</td>
<td>Est. 124</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Three Ton</td>
<td>Broadcast</td>
<td>Est. 124</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Five Ton</td>
<td>Computer Control</td>
<td>Preset 124</td>
<td>Brine</td>
<td>60</td>
</tr>
<tr>
<td>Five Ton</td>
<td>Computer Control</td>
<td>Preset 124</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kubota Tractor</td>
<td>Broadcast</td>
<td>As req’d</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bobcat Truck</td>
<td>Broadcast</td>
<td>As req’d</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2.4 indicated the historic usage of road salt and brine at SFU. As identified, the severity of the winter months can greatly affect the required usage and will vary from year to year.

Table 2.4 Material Data

<table>
<thead>
<tr>
<th>Material</th>
<th>2005/06 winter</th>
<th>2006/07 winter</th>
<th>2007/08 winter</th>
<th>2008/09 winter</th>
<th>2009/10 winter</th>
<th>Average annual usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl Solid Bulk Road Salt (Tonnes)</td>
<td>907</td>
<td>1196</td>
<td>1262</td>
<td>1042</td>
<td>20</td>
<td>885</td>
</tr>
<tr>
<td>NaCl Solid Bag Salt</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NaCl (23%) Brine Water Solution</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sand Mixed (salt volumes excluded)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
2.7 Salt Venerable Areas

Areas identified as salt vulnerable in the SFU Strategic Infrastructure Plan (2005 Update) are Stoney Creek, Silver Creek, and Eagle Creek. Areas identified as salt vulnerable by Facilities Services’ Snow and Ice Operations are any stream and watercourse subjected to salt contaminated storm drain water, or salt storage run-off water.

Salt vulnerable streams can be adversely influenced the runoff that is captured and concentrated in the elaborate University storm drainage system (see appendix C), as such, monitoring stations are being established at locations along the storm drain system and at the convergence streams to identify and monitor salt concentrations. Efforts to trace high salt concentrations back to the source location will be taken in order to minimize high salt concentration sources. Salt application procedures will be established to reduce or redirect salt entering the storm drainage system at these locations.

2.8 Training

See appendixes “D Winter Operations Driver Operator Procedures” and “E Winter Operations Equipment and Material Procedures”

3.0 Salt Management Strategies

3.1 Storm Water Management

The objective of SFU’s storm water quality monitoring program is to provide baseline water quality data on conductivity levels and chloride concentrations as they relate to SFU’s salt management program. Total metal and coliform water quality parameters will be included in sample analyses to provide additional insights into the quality of storm water discharging from SFU campus.

Five storm water runoff sites will be monitored from parking lot “B” (MH85) and “C” (MH27), as well as discharges from below the salt storage area, and discharges from the east (MH212) and west (MH8F) campus area. The first three sites allow monitoring of areas where salt usage is most prominent. The last two sites will provide information on overall cumulative effects of salt management activities prior to discharge of storm water into the Stoney Creek system.

Monitoring will be undertaken on or near to a monthly basis. However, the determining factor for sampling will be rainwater events since the parking lots have no surface runoff during dry periods.

In-situ measurements will include pH, conductivity, and temperature. Samples will be collected for laboratory testing of hardness, dissolved chloride, total metals, and total and fecal coliforms. Summary data reports will be submitted twice per year.

3.2 Weather

The University utilizes the services of professional weather forecasts for timely and accurate weather information to assist in decision-making. These sites include:

- Weather data collected from the University’s weather station
- Environment Canada
- The SFU web site – www.sfu.ca/
- The Weather Network – www.theweathernetwork.com

In addition, University staff (including Campus Security) continuously monitor and report on weather and road conditions, both on and off-campus.
3.3 Record-Keeping

The University keeps logs of snow and ice callouts and collects the following data related to daily snow operations:

- Annual use of salt and salt brine solution.
- Training of Snow and ice operations personnel.
- Geographical areas of salt/brine application by vehicle operators.
- Weather conditions from snow and ice events.
- Vehicle and equipment deficiencies or maintenance requirements.
- Snow and Ice worker shift data.

Examples of data collected are in the following tables:

Figure 3.1 Salt Applications—# Shifts per Month

![Salt Application All Shifts per Month](image)

Figure 3.2 Salt Applications—# Callout Shifts per Month

![Salt Application Callout Shifts by Year per Month](image)
3.4 Management Review

After each snow and ice season SFU management and University groups affected by the previous year’s snow and ice program review the previous year’s snow and ice program to confirm the University achieved the desired objectives. The Salt Management Plan is included in this review. Salt management and snow and ice removal objectives are developed and best practice procedures are used to identify any shortcomings or opportunity for improvement in the operations.

3.5 Benchmarking the Salt Management Plan

SFU recognizes that the salt management plan is a dynamic model and it must constantly be reviewed and improved upon. In order to improve the practices SFU has in place, benchmarking existing usages, etc and then setting goals to improve on these procedures will help effectively develop a strategy to maintain road safety and also mitigate the local environmental impacts. Table 3.1 identifies SFU’s benchmarking and improvement strategies for their Salt management on a 5 year basis.

Table 3.1 Benchmarking and improvement strategies

<table>
<thead>
<tr>
<th>Item</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Salt</td>
<td>100%</td>
<td></td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkway Salt</td>
<td>100%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brine</td>
<td>33,000 L</td>
<td>40,000 L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abrasive</td>
<td>0%</td>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate Walkway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMA</td>
<td>10%</td>
<td>90%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eco-traction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendices

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WINTER OPERATIONS:
DRIVER/OPERATOR PROCEDURES:

General Safety
Call-Out Procedures

Operations:
   Plowing
   Pre-Wetting
   Anti-Icing
   Bulk Plant
INTRODUCTION:

In snow and ice control, drivers have additional responsibilities. In addition to driving the vehicles, they must simultaneously operate the equipment that is related to their tasks. There are controls for the equipment inside the cabs of the vehicles; the equipment itself is mounted on the vehicles and/or attached in a number of ways. The functions of driving are, therefore, only a part of what the operator must do at this job, since the operation of the equipment is of principal importance during winter conditions.

Operators are the key to a successful winter road maintenance program. They can contribute to an efficient snow and ice plan and can assist in optimizing dollars by:

- Putting material on the road correctly
- Putting down the right amount of material
- Using safe and efficient plowing techniques
- Operating at appropriate speeds
- Driving in a fuel-efficient manner
- Taking care with the snow and ice control equipment, including the truck.

Following is a set of procedures that operators of equipment and drivers of vehicles must follow during winter conditions:
GENERAL OPERATOR SAFETY:

Before any winter maintenance operations can begin, drivers must remember the importance of safety when they are operating the vehicles. This means:

✓ The driver must make sure that the vehicle is in a safe operating condition.

✓ The driver must be aware of the potential for hazards when driving in less-than-ideal conditions.

✓ The driver must be clear on the specifics of his tasks.

The snow and ice control tasks are always challenging at first until the operators get used to the equipment and to negative road conditions. Snow and ice control is not a function that can actually be practised!

By taking the necessary amount of time to make sure that all conditions of professional operating have been met, the operators can be safe and confident, and can operate in the proficient manner that has to be used during these conditions.

All operators should be encouraged to:

- Ask questions
- Communicate with others
- Assist and support other operators
- Learn new skills each season
CALL-OUT PROCEDURES:

As outlined in other sections, the SFU call-out system is composed of:

- a ‘board’ of available operators
- Campus Security
- Drivers and Equipment Operators

Security Officers are responsible for calling out drivers when necessary. If drivers are required outside of regular working hours, they are called by Campus Security.

At the onset of adverse weather conditions,

1. Each driver/labourer is called on his cell phone.
2. If contact is not made, then the next driver/labourer is called.

The driver/labourer who is on call is responsible for re-posting the board – he updates it at the end of his shift.

During normal working hours, it is the responsibility of The Superintendent of Buildings and Grounds to organize and dispatch drivers and operators, including the contract grader operator who focuses primarily upon the clearing of parking lot areas.

Once a driver/operator has been advised of the tasks to be done, he has a set of task functions to complete. The operator has the responsibility for:

- ensuring that the equipment is safe, operating, and ready to go
- being aware of the snow and ice control plan for that shift
- carrying out the task in as safe and efficient a manner as possible.

In order to ensure that the specific equipment being used is safe and functioning, the operator must complete a pre-trip inspection before utilizing the vehicle or machine. Pre-Trip Inspection Log Books are kept in the vehicles and must be filled out at each shift.

(Specific information on the required pre-trip inspection is found in DRIVER/OPERATOR PRE-TRIP INSPECTION PROCEDURES.)
PREPARING FOR THE TASK:

There are a number of procedures to be followed before the winter road maintenance task is done. Over and above the pre-trip inspection, the vehicle must have fuel to run, salt to spread, and brine to distribute on the salt and on the road itself.

Driver Fueling and Re-Fueling Procedures:

Fueling of the vehicles should be done at the end of the shift.

The Diesel Fuel Pump is located on the North side of the South Science Building adjacent the loading dock on Science Road.

Gasoline is dispensed from the Gasboy Pump located at Facilities Management

All fueling must be done with the following safety precautions observed:

- The pump is not to be left unattended while in use.
- There is no smoking around the pumps
- There is to be no use of cellular phones in the area where vehicles are re-fueling.
- The nozzle should be grounded before the fuel is dispensed. This will prevent static electricity from developing and starting a fire.

*Note: It is best to always re-fuel a diesel engine at the end of the shift. This will prevent condensation from building up in an (empty) tank.

Use of the Salt Shed:

The salt storage facility is located close to Facilities Management. It is there that the product is stored for use on the roadways.

When preparing for snow and ice control tasks, drivers do not load their vehicles with salt – this is done by loader operators only:

- Loader operators must be careful not to strike the tops of the trucks grizzly screens when they are loading salt onto the trucks.
- Loader Operators must ensure that they do not strike the trucks at any time while loading them.
- Loader Operators must ensure that they do not overload the trucks – salt must not be piled above the trucks’ grizzly screens.

At the end of shift, if salt remains in the box of the truck, drivers spin off the rest of the salt into the salt shed, after which the loader operators will re-pile it.
Use of the Bulk Brine Plant:

Salt brine is used on campus as a pre-wetting agent (it pre-wets the salt as it comes out onto the road), and as an anti-icing product when it is dispensed directly onto the road’s surface.

The brine is brought on campus and is stored at the Brine Bulk Plant, located across from Facilities Management.

There is a set of procedures in place for loading and unloading the product onto the trucks. A system is used for filling the trucks or putting materials back to the bulk tank for further use. Drivers who use this computerized system receive proper training before loading, using, or unloading salt brine.

Loading:

Drivers must position their vehicles downhill from the tank in order to use gravity’s assistance in loading.

Unloading:

Extra liquid is put back into the bulk tank when it is not needed. In this case, the vehicles must be positioned uphill from the bulk tank when drivers are unloading excess liquid (back to the bulk plant tank).

Nozzles and valves must be used correctly and truck tanks must not be overfilled.

The Anti-Icing equipment allows for a hand sprayer to be used to dispense salt brine to areas other than the roadway (eg: sidewalks). Again, training is provided to operators who will do this function.
TREATING THE ROADS:

Pre-Salting:

If operators are salting a roadway, there are several factors which affect how they apply the material. First, there is the practice of “getting under the storm”. Simply, this is pre-salting.

Using this strategy prevents or reduces the build-up of ice on the road’s surface. The driver makes a light application of salt to the bare pavement before the storm arrives.

Another way to pre-salt the roadway is through the use of salt brine. This is in practice at the University and is an effective way to prevent or lessen the build-up of ice on the surface of roads, before and during snow and ice conditions.

Applying Salt to the Roadway:

With an application of pure salt, a brine (salt water solution) is formed, and this can assist in preventing or lessening slippery conditions.

Normally, salt is applied by a spinner which places the salt all across the road. If the road has a crown, then the spinner is not normally used, since then most of the salt would be lost.

Straight salt is applied at a much lower rate than other materials. On the road salt is used not as an abrasive but as a reactant and so a little can go a long way. Salt is much more expensive than sand, so efficient use of it must be made - as well, environmental concerns are now a significant issue. If the salt is used properly, it can last longer and be very effective on its own and along with mechanical movement (cars driving over it).

The rates for salt application are determined by the weather in which it is being applied. If the storm is bad, more salt may be used; if drivers are out pre-salting in anticipation of a storm, less may be used, as it is only a stopgap measure before a fullblown storm arrives.

There are a number of situations which will dictate exactly how salt should be applied:

- If the road is level and has no crown, the salt should be applied to the travel part of the road.

- If the road has a crown, the salt should be applied to the crown. This way, the salt can melt and turn into a brine, which will run down to the level and do its job.

- If the road has a “super-elevation” or is banked in the corners, the salt should be applied in those upper corners. Then the salt will run downhill, doing its job.
Lane Position:

If possible, drivers are to position their trucks to salt both of the lanes where it is safe to do so.

Usually, it is not desirable to have a vehicle do this; however, with some units the discharge is in the centre of the back of the unit. It is best then to have the vehicle straddle the centre line in order to have the material end up on the crown of the road. If a driver does place the vehicle in this position on the road, he must exercise extreme caution.

Applying Salt to Hills:

Other concerns when distributing material relate to road grade. Some roads, of course, are more of a challenge than others. Road grade is defined as the rise or fall of the roadway profile per 100 units of length—we use the term to indicate how steep a road is, and it is expressed in a percentage.

In snow and ice control operations a hill that is over 5% in grade is considered critical. On hills as steep as this and steeper, coming to and from the University, drivers must focus on applying additional material to the crest of the hill—the highest point—and at the bottom.

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<th>Areas for Application of Salt</th>
<th>How Salt Should be Applied</th>
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<td>To the travel part of the roadway</td>
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<td>Road with a crown</td>
<td>To the crown only</td>
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<td>Road with a super-elevation in corners</td>
<td>To the upper corners</td>
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<tr>
<td>Road that has a significant grade</td>
<td>To the crest and the bottom</td>
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</table>
ANTI-ICING PROCEDURES:

The purpose of anti-icing is to pre-apply chemical to the roads to prevent the build-up of ice.

This process can also be used during a storm to help keep the roads bare and wet.

The Anti-Icing agent at SFU is salt brine. A bulk plant for its use has been set up on campus. Operators who use this facility and this method must participate in theory and practical training in the use of the material and the equipment which distributes it.

The salt brine is taken from a large tank. The system involves the use of tanks on the anti-icing vehicle – the 5-ton truck— and there is a pump that sprays a pre-measured amount of liquid onto the roads.

This system is activated by the operator turning on the computer’s switch in the cab of the truck. There are settings on the system, and the adjustment allows for the appropriate distribution rates. The operator’s main task is to drive the truck while the liquid is sprayed onto the road’s surface according to the setting and the truck’s speed. If the driver speeds up, the computer speeds up the application rate to maintain the pre-set amount. If the driver drives too fast, usually an alarm will sound, indicating that the computer cannot keep up the proper application rates.

The sprayed brine can go to the sides and behind the vehicle to allow for better coverage.

The spray bars are located close to the ground so that the material is not blown away—it makes good contact with the road surface.

The benefits of this anti-icing process are twofold:

1. The load goes further than a load of solids

2. The vehicle speed can be considerably higher than when spreading materials from a hopper system.
PRE-WETTING:

Pre-wetting is another process used in snow and ice control at SFU. It is done through equipment that has been installed on the hopper of the truck’s spreading system. Pre-wetting is the application of a liquid, in this case, salt brine, to a load of dry material.

Tanks of the liquid are mounted to the side of the hopper. The load is sprayed through nozzles located in the hopper chute. The material that goes onto the road is then wet, which helps keep the material on the road; The pre-wet material works more quickly and effectively than a dry product. And if done properly, pre-wetting can save materials.

The pre-wetting equipment can be activated when the spreader is being turned on by a simple switch. Pre-wetting in this way

- makes salt and sand stick to the road surface
- makes a material that reacts quickly
- is easy to do
- makes re-application less necessary
- uses less material
- does not blow off of the road as easily

When a load of salt is pre-wet with brine it is applied the same way as a straight salt application—1 to 2 meters width on the road.

**Straight Salt or Pre-Wet Salt Spreadwidth**

1-2 meters
PLOWING:

As the operator of a snowplow, the driver has a major responsibility:

*The objective is to move snow out of the way in a safe and timely manner.*

- The driver must be a competent, skilled driver of the vehicle.
- The driver must be very knowledgeable about the equipment that is on the vehicle.

The driver must also be aware of the hazards associated with the *equipment* on the vehicle. With a front mount plow, there is a hazard in simply having this attachment on, whose length goes beyond the front bumper.

As well, difficulties can be encountered in tight areas and around corners.

Front Mount Plows…

- Can handle any amount of snow;
- Articulate for better results;
- Ride on shoes or castors.
- Can push snow further than can underbody plows.

However, Front Mount Plows:

- Require extra attention by the operator
- Require a longer turning radius
- Must be checked frequently for damage.
Attaching and Setting Up the Plow—

Hooking up a front mount snow plow is usually a job for 2 persons. Drivers must be very careful when doing this—the plow can slip.

The plow should be hooked up so that its push frame is mounted as close as possible to 19 inches from the ground. This will maximize the pushing power of the truck. If the plow is mounted too high, the truck has to push down, and this is dangerous, because the truck can ride easily over the top of the plow if the plow were to dig in or hit something solid. If the plow is mounted too high, the truck has a tendency to push the plow up over the top of the snow.

The plow frame must be connected at the right height and all of the lights connections must be made.

The front mount plow has an attack angle—the angle at which the plow cuts into the snow—of about 45°. If this angle is changed to one that is less than that, the snow plow has to push hard and the snow will quickly pile up in front of the plow. If the angle is higher than 45°, the plow will not be as wide, and more passes will be required to do the same amount of work. In areas where there is heavy snow, drivers may have to deviate from the normal angle to push through the deep snow. However, this should be done only under supervision.

- The front mount plows stick out to the right side when carried: drivers must keep about 2 feet away from any hazards that are to their right.

- The left side of the plow, when turned all the way to the right, should be in line with the left side of the truck.

The front mount plows on many vehicles are articulating—they can turn in both directions, and they allow the operator to plow either to the left, or more commonly, to the right side of the road. The advantage of the front mount articulating plow is that it can be effective in ‘tight’ areas such as alleyways, where space is limited.

Plow Kick-Out Springs:

The front mount plow has a safety device, a kick-out spring, that will prevent the plow from stopping the truck if the truck hits something solid. On the SFU trucks there are two types of these springs—one is a flipover; the other is a bottom kick-out. If the truck strikes an object, these springs allow the cutting edge to ride upwards behind the moldboard of the plow.
Operations – Plowing, cont.

Vehicle attachments, such as plows, coupled with a spreading program, can make for effective snow and ice control. At SFU, the front mount plows are used in conjunction with the spreading of an anti-icing agent; therefore, the snow is pushed out of the way by the plow, and remaining snow and the road surface is treated with the anti-icing agent (usually salt) in order to obtain the optimum result.

Plowing Preliminaries:

1. The front mount plow should never be used on a gravel road that is not completely frozen. Because that surface will be soft, the plow will dig into the road surface and this can cause the truck to ride up over top of the plow.

2. The cutting edge of the front mount plow sometimes will skate across the ice surface, and can veer into oncoming traffic—this is dangerous!

   Drivers must take corners slowly!

3. Drivers must try to avoid making left hand turns with the front mount plow. There will be a snow trailer coming off the plow—called a windrow, and these formations should not be left on the roadway.

4. Drivers must remember to dump the snow off the front mount plow before making right-hand turns—this is because snow in the plow will cause the front end of the truck to shift as the driver is rounding the corner.

5. Front mount plows are used for widening streets. They can be straightened to direct snow when in intersections, but they definitely need to swing wide at intersections.

Plowing Procedures...

The First Pass:

---

This pass should expose the centerline (or where the centerline would be). If it does not do this, the product coming down after cannot do its job properly.
Operations – Flowing, cont.

The Second Pass:

The second pass should be done on every road that has had the first pass. If not, traffic will move over to drive on the plowed side. The second pass keeps the roadway more clear, and it prevents water from building up in wrong areas of the road.* If there are severe storm conditions, and only one pass along a roadway can occur, then the second pass will need to be done later, as priorities change.

The Third Pass:

The third pass clears off the parking area of the road—unless there are 2 travel lanes. It can be a dangerous pass because of curbs and traffic islands. *This is not a priority during snow and ice conditions.

The Fourth Pass:

The fourth pass is somewhat like the third. However, its purpose is to expose parking lanes and curbs, so it can be somewhat dangerous due to hidden hazards. This pass is usually the final one, so it must be done well, with all of the snow pushed out of the way.
Simultaneous Plowing and Salting:

- When operators are plowing, the spreader must be spreading only to the width of the plow.

- Operators must try to not plow off the material that they have just spread.

- Operators must shut off the spreader when stopped at an intersection.

- Operators must increase the amount of material that they put down when plowing an intersection.

- The speed that operators use when plowing and spreading together must be consistent with the correct speed for spreading—no faster than 25 km per hour.

- If operators are applying brine and are plowing at the same time, they should spray only to the lane width.

- The operator should always work from the inside or centre lane out when both plowing and applying materials. This prevents the operator from having to ‘double-handle’ the snow with extra passes later when the roads are being widened.

- If the traffic is light, two lanes can be done at a time. Operators should not attempt to do more lanes that this because the material then becomes too sparse on the road and may not be effective.
Stopping Operations:

*Drivers must always have on the truck rotary light whenever they are operating.*

Stopping for any reason also requires the rotary light to be on. When stopping for any reason, all drivers must:

1. Have on a safety vest and hard hat.
2. Be sure that the truck’s rotary light is on.
3. Be pulled as far off the roadway as possible.
4. Check what needs to be checked.
5. Quickly check the vehicle running lights—clean them if necessary.
6. Exercise extreme caution
7. Call the foreman and report the location, providing an estimate of the length of the stop. Re-contact should be made when the driver is again mobile.

Passing Other Vehicles:

Drivers should always try to turn off the spinner when passing other vehicles. This is to prevent those drivers’ vehicle from getting damaged. The material will still be spread onto the roadway.

In some situations, such as when salting the steep hill, in intersections, or in other hazardous areas, the driver cannot turn off the sander. If this is the case, the driver must reduce his speed—this will eliminate the bouncing of the material, the effect of which can break headlights and windshields.

All spreaders are designed to be shut off quickly. Some machines have a hydraulically-driven spreader with a lever that can shut off everything quickly. Sometimes referred to as an *Interrupter Lever,* this feature can be used when drivers are passing vehicles.

Many of the spreaders are computerized and have many good features such as ‘Pause’ that allows for the material spreader to be shut off quickly, similar to the interrupt lever on the hydraulic system.

Intersections:

Intersections are extremely dangerous during storm conditions. Extra material, no matter what an operator is applying, should always be put down in intersections. Because of the potential for accidents, it is best to do intersections, particularly traffic-controlled ones, one lane at a time. This way, the operator is likely making more passes, but is operating more safely—staying in his lane and allowing for other vehicles to get through. This definitely applies at the intersection of Gagliardi Way and Burnaby Mountain Parkway.
Conclusion:

There are many tasks involved in the maintenance of the roads at the University.

Drivers and operators must always keep their objectives in mind and must work carefully and with diligence. As well, any problems with the equipment or tasks must be reported to the Snow Foreman or to the Superintendent of Buildings and Grounds in order that they can be addressed.

The Snow and Ice Control operator has a very important job to fulfill, and all systems are in place in order for him to do this.
WINTER OPERATIONS:
EQUIPMENT and MATERIAL:

Description of Vehicles
Description of Machines
Description of Equipment
Equipment Functions/Applications

Overview - Materials Used at SFU:
Straight Salt
Brine

Overview - Methods of Application
Clean-up Procedures
INTRODUCTION:

There are a number of vehicles and machines that are used in Snow and Ice Control at the University. In addition to their snow and ice control functions, these vehicles and machines are used in a variety of applications at times other than in winter, so their use, care, and maintenance are ongoing.

The Snow and Ice Control plan makes use of these vehicles and machines in conjunction with a set of winter attachments and with materials used to reduce the effects of snow and ice.

Each of the vehicles has a specific function within snow and ice control.

Driver/Operator Qualifications:

It is very important that drivers of vehicles and operators of equipment are fully qualified to utilize that equipment:

- Operators must hold the appropriate class of driver's licence
- Operator licences must be in good standing
- Operators must hold the required licence endorsement(s)
- Operators must have received adequate training – theory and practical - on the equipment to be operated. Assessments should be on file.
- Operators must participate in annual re-certification procedures

Following is a brief description of the vehicles and machines in use, information regarding how they are used, and requirements of operators who operate them.
1. University-Owned Equipment:

**One-Ton Truck (Brine):**

This truck is equipped with
- A tanker for anti-icing activities
- Computerized control for anti-icing

It is used for
- Applying liquid de-icers to the roadway
- Spraying sidewalks if necessary (has a hand nozzle)

In order to operate this vehicle, the driver must have:
- Class Five driver’s licence
- Snow and Ice Control certification – Level 1
- Annual practical training – driving and computer functions
- Bulk Plant Operations training

**One-Ton Truck:**

This truck is equipped with
- A slide-in spreader
- An articulating front mount plow

It is used for
- Applying straight salt to the roadways
- Plowing snow

In order to operate this vehicle, the driver must have:
- Class Five driver’s licence
- Snow and Ice Control certification – Level 1
- Annual practical training – driving and computer functions

**Single-Axle 5-Ton Truck:**

This truck is equipped with
- Air Brakes system
- Front Mount plow
- Slide-in spreader, with Dickie-John computer system
- Pre-Wetting system

It is used for
- Applying straight salt or pre-treated salt to the roadway
- Plowing snow

In order to operate this vehicle, the driver must have:
- Class 5 driver’s licence w/air brakes endorsement (Restriction 15)
- Snow and Ice Control certification – Level 1
- Annual practical training – driving, plowing
Single-Axle 5-Ton Truck:

This truck is equipped with
- Air Brakes system
- Front Mount plow
- Slide-in spreader, with Dickie-John computerized system

It is used for
- Applying straight salt to the roadway
- Plowing snow

In order to operate this vehicle, the driver must have:
- Class 5 driver’s licence w/air brakes endorsement (Restriction 15)
- Snow and Ice Control certification – Level 1
- Annual practical training – driving, plowing and computer functions

Kubota Tractor:

This tractor is equipped with
- Small front plow
- Small salt spreader

It is used for
- Clearing walkways
- Spreading salt on walkways

In order to operate this machine, the operator must have:
- Class Five driver’s licence
- Snow and Ice Control Certification - Level 1
- Familiarization training

John Deere Front End Loader:

This loader is equipped with
- 4-in-1 front bucket

This loader is used for
- Loading trucks with salt
- Clearing parking lots and parkades

In order to operate this machine, the operator must have
- Class Five driver’s licence
- Practical loader training
- Snow and Ice Control certification – Level 1
2. Contracted/Rental Equipment:

**Grader and Loader:**

These are currently supplied by Columbia Bitulithic Ltd. Equipment and its operators are provided under an annual retainer to the University (at specified hourly rates).

The machine is useful for clearing parking lots and other areas outside of normal University hours.

During severe snow storms it may also be used to assist with clearing snow from main arterial roadways.

**Bobcat and Loader:**

These are currently supplied by Jerry Williams Excavating Ltd. The bobcats are utilized for cleaning and the upper level Visitor Parkade (they have no salting capabilities).

**Toolcat C/W, with Plow, Spreader, and Bucket**

This equipment is supplied by Surfwood Supply Ltd. It is operated by University staff during the rental period from November to the end of March.

**Emergency Parts Suppliers:**

The following organizations provide equipment parts to the University:

- Coquitlam Automotive
- Del Equipment
- Freightliner
- Avenue Farm Machinery
- Barnes Wheaton
- Metro Motors
- Danco
- Spray Air (Brine equipment)
### Snow and Ice Equipment Overview:

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<th>JOHN DEERE LOADER RENTAL LOADERS</th>
<th>KUBOTA TRACTOR</th>
<th>SINGLE AXLE 5-TON TRUCK</th>
<th>SINGLE AXLE 5-TON TRUCK</th>
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<td>Air Brakes system Front Mount Plow</td>
<td>Air Brakes system Front Mount Plow</td>
<td>A slide-in spreader</td>
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<td>Loading trucks with salt; clearing parking lots and walkways</td>
<td>Small salt spreader</td>
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<td>Clearing walkways; spreading salt on walkways</td>
<td>Applying straight salt to the roadway; plowing snow</td>
<td>Applying straight salt to the roadway; plowing snow</td>
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<td>Snow and Ice control and computer functions.</td>
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<tr>
<td>Class 5 driver's licence; Practical loader training; Snow and Ice control certification – Level 1</td>
<td>Class 5 driver's licence; Practical tractor training; Snow and Ice control certification – Level 1</td>
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<td>Annual Practical Training – Level 1, Brakes endorsement – Level 1, Snow and Ice Control</td>
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<td>Snow and Ice control and computer functions.</td>
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Vehicle Attachments:

The University utilizes a number of attachments to vehicles and equipment in order to complete the Snow and Ice Control task. Following is a brief description of each:

Front Mount Plows:

These are the most common plows in use. They are a reasonable size and can be easily attached to the trucks. The front mount plow can be used in almost all situations. Since it is a plow that pushes rather than scrapes, it can be easier to operate than some plows.

For smaller trucks like the 1-ton, the front mount plow is the only plow that can be used, due to the restricted space underneath these vehicles.

Operators of this type of plow must be aware of the hazards associated with its use. There is a hazard in simply having this attachment on, an accessory whose length goes beyond the front bumper. Working in tight areas and turning corners presents challenges.

Spreaders:

Spreaders are the attachments that dispense material by a chain onto the roadway. The ones in use here are slide-in style—they go right into the box of the truck. The spreaders can be controlled from the cab. They have chains which are driven by the hydraulic pump on the truck. The spinner at the back of the spreader is also powered by that hydraulic pump. The spreaders allow for the operator to control both the chain and the spinner from inside the cab. The operator can set the rate and the spreader will speed up and slow down with the speed of the vehicle.

At SFU, these attachments are used to dispense salt. They are also used in conjunction with the pre-wetting system, which is attached and which wets the material (salt) coming out of the spreader before it contacts the road surface.

Anti-Icing Equipment:

At the University an anti-icing process is used:
Salt brine is pre-applied to the roadways to prevent the build-up of ice. This process is also used during a storm to help keep the roads bare and wet. The salt brine is applied from a large tank and a pump that sprays a pre-measured amount of liquid onto the roads. With the use of this system,

- the load goes farther than a load of solids
- the speed can be considerably higher than when spreading materials within a hopper system.
Anti-Icing, cont.

The Anti-icing system is activated by the driver using a computer switch in the cab and then adjusting the settings to allow for the proper distribution rates. As the driver is driving, the liquid is sprayed according to the computer setting and the truck speed. If the driver speeds up, the computer speeds up the application rate to maintain the preset amount. If the driver over-speeds, usually an alarm will sound, indicating that the computer cannot keep up the proper application rates at that rate of speed.

The sprayed brine can go to the sides and behind the vehicle to allow for better coverage. The spray bars are located close to the ground so that the material makes good contact with the road surface and is not blown away easily.

Pre-Wetting Equipment:

Pre-wetting is another process used in snow and ice control. It is done through equipment that has been installed on the hopper of the spreader. Pre-wetting is the application of a liquid, in this case, salt brine, to a load of dry material. At SFU, this system is used extensively.

Tanks of the salt brine are mounted to the side of the hopper. The load is sprayed through nozzles located in the hopper chute. The material that goes onto the road is then wet, which helps keep the materials on the road and makes them work more quickly and effectively. If done properly, pre-wetting can save materials.

The pre-wetting equipment is activated easily; it comes on when the hopper is turned on. Pre-wetting in this way

- makes salt and sand stick to the road surface
- makes a material that reacts quickly
- is easy to do
- makes re-application less necessary
- uses less material
- does not blow off of the road as easily

There is a set of procedures to be followed when using the anti-icing and pre-wetting equipment. These are outlined in the training programs in which operators participate.
Materials Used in Winter Road Maintenance at SFU:

There are a number of materials that are used in snow and ice control. Their common characteristic (with the exception of straight sand*) is that they are salt-based. The use of salt, in one form or another, is still the most effective way of breaking down ice. There is a variety of liquids in use and there are various mixtures of materials in use.

At the University, two materials are used on the roadways: straight salt and salt brine. These are both known as reactants, materials which cause a chemical reaction to occur when they are placed upon the road’s surface.

Straight Salt:

Salt is applied to the roadways through the spreader on the back of the vehicle. At temperatures of -6° and above, salt is very effective in breaking down snow and ice.* As well, the mechanical movement of traffic over a salt-treated roadway can create an additional benefit – the vehicles “working” the material can make the salt work even more effectively.

Unfortunately, straight salt can have a negative effect on the environment – it can bounce off the roadway and remain at the roadside, where it can cause damage.

In order for it to be used effectively, salt must be applied:

- At the correct application rate
- In the correct places – crown, super-elevated corners, and travel part of the roadway
- At the correct vehicle speed - this is very important.

*Salt is not as effective when temperatures drop to -6 or colder. However, if anti-icing and pre-wetting procedures have been used, this can be mitigated.
Materials in Use at SFU, cont.

Salt Brine:

Salt brine is mixed (approximately 23% salt to water) at the Bulk Plant on campus. It is
carried in tanks on the vehicles and is distributed prior to a storm and/or during a storm.
It is effective in that

- Brine works in a similar way to straight salt, breaking down ice and exposing
  the road surface.

- Unlike some products, salt brine is not slippery once it is down

- It does not have to be agitated – the salt will stay suspended in the liquid

- Brine is quite cost-effective

- It can be made on-site

- The Brine system requires very little maintenance

The following materials are not in use at SFU:

Sand
Salt/Sand mixes
Calcium chloride
**Equipment Clean-up Procedures:**

The importance of cleaning the equipment used in snow and ice control cannot be over-emphasized. Since the main ingredient in snow and ice control materials is *salt*, there is always a strong possibility of damage to equipment and components.

Clean equipment lasts longer in general:

- Equipment that spreads salt or sand or a combination requires a good wash-down with lots of water to ensure that there is no salt and sand residue in the equipment. Salt causes rust very quickly. If salt remains long enough it will cause the equipment to seize up – then the auger chains and the spinner may be a problem during the next use.

- Spreading units that use chains for augers must be cleaned very well to ensure that they will operate the next time.

Cleaning the vehicles takes some time at the end of the shift, and must be done right. The cleaning time should be no less than about 30 minutes, depending on the size of the equipment that is being operated (larger will obviously take longer).

A pressure washer is available for the operators to use for this task.

*If the weather is very cold and the water is freezing, it may be safe to not rinse the equipment, since that cold temperature will also not encourage rust to form. This situation is not a common one at SFU.*

**Procedures:**

*The spreader must be operating while the equipment is being cleaned.* This is so that the chain will cycle through several times during the wash down procedure.

The *chain guide* (this is where the chain fits under the spreader) is another area that requires careful washing, as the salt can easily build up. This may be a challenge as the water has to be sprayed in this area for an extended period of time to make sure that all of the salt is cleaned out.

The *truck frame* must be hosed down to get rid of any leftover salt; as well, the operator must wash down the *bulkhead* so that there is not a build-up of material at the front of the box - that extra weight will put stress on the sprockets. The operator may have to do this more that once per shift if there is a notable amount of salt at the front of the box. Shoveling the material into the hopper is usually the best course of action for this.

The *inside of the hopper* must be rinsed well. If it is not, and salt builds up inside, the material will not slide down to the auger chain when it is needed.
Clean-up Procedures, cont.

Plows and vehicle chassis must be washed down thoroughly so that the salt does not cause problems with the brakes of the vehicle or any other of the vehicle components. A lubricant containing a rust inhibitor is used to spray the equipment after it has been washed down at the end of the shift.

Some operators may have the misguided idea that as long as the salt is not wet it will not be a problem. However, salt itself will build up moisture from the air and this will cause rusting very quickly.

Conclusion:

At SFU there are a number of vehicles, machines, equipment, and materials in use during the winter season. All of the vehicles, machines, attachments, and products require trained and skilled operators to utilize them.

Because snow and ice control operators are trained in the effective use of salt and other products on the roads, they are aware of the procedures to be used in distributing them correctly. Objectives are set, and equipment and materials are used to reach those.
Materials Suppliers:

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<td>Brine (Liquid)</td>
<td>Mainroad Contracting Ltd.</td>
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</tbody>
</table>
On average, 5 million tonnes of road salts are used each year as de-icers on roadways in Canada. Due to concerns about the large quantities of chlorides being released to the environment, road salts underwent a comprehensive five-year scientific assessment under the Canadian Environmental Protection Act, 1999 beginning in 1995. The road salts assessment covered the chloride salts — sodium chloride (NaCl), calcium chloride (CaCl₂), magnesium chloride (MgCl₂) and potassium chloride (KCl) — as well as brines used in road de-icing/anti-icing and dust suppression, the salt portion of abrasive mixtures and ferrocyanide additives.

Road salts enter the environment through losses at salt storage and snow disposal sites and through runoff and splash from roadways. The assessment report, published on December 1, 2001 concluded that high releases of road salts were having an adverse effect on freshwater ecosystems, soil, vegetation and wildlife. The publication of this report initiated the risk management process to address the risks posed to the environment by road salts.

To assist Environment Canada with this complex task, a multistakeholder working group was formed, which included members from provincial and municipal road authorities, federal and provincial governments, industry, environmental non-governmental organizations and related associations (see the list of working group members at the end of this Code). This working group worked together over a two-year period towards the development of the Code of Practice.

The Transportation Association of Canada worked in parallel to the working group to produce the Syntheses of Best Practices. The syntheses are a detailed resource on winter maintenance practices and supplement the recommendations made within the Code.

The main objective of the Code of Practice is to ensure environmental
protection while maintaining roadway safety. There are two main recommendations in this Code:

1. The development of salt management plans, based on a review of existing road maintenance operations, identification of means and goal-setting to achieve reductions of the negative impacts of salt releases; and
2. The implementation of best management practices in the areas of salt application, salt storage and snow disposal, as outlined in the Transportation Association of Canada’s *Syntheses of Best Practices*.

Monitoring and reporting aspects are also included in the Code. The information collected will play an essential role in evaluating the progress achieved.

This Code of Practice does not address the use of road salts on parking lots and private properties, use as dust suppressants or use of ferrocyanide additives. These applications are being addressed separately by Environment Canada.

When applied, the recommendations made within this Code will result not only in benefits to the environment, but will also have the potential to result in benefits to road authorities, including more efficient operations, improved roadway safety and savings in material usage. Since the beginning of the assessment process, many road authorities across Canada have taken early actions to improve their salt management practices. Case studies documenting the resultant benefits of these practices, as well as other related information on road salts management, can be found on Environment Canada’s road salts website at [http://www.ec.gc.ca/nopp/roadsalt/](http://www.ec.gc.ca/nopp/roadsalt/).
INTRODUCTION

The purpose of Annex A is to provide guidance by identifying concentrations of chloride in the environment at which certain negative environmental impacts are likely to occur. A series of thresholds have been identified for different environmental compartments: surface water, groundwater and soil. Concentrations above these levels have the potential to result in negative impacts. In all cases, natural background concentrations should be considered in evaluating regional and local impacts. Data in this annex are based on findings presented in the Road Salts Priority Substances List Assessment Report.

SURFACE WATER

The following paragraphs present certain thresholds associated with concentrations of chloride in surface water.

Figure 1 presents background concentrations of chloride in Canadian surface waters and concentrations of chloride that cause adverse biological effects. The column on the left provides a range of average background concentrations for five regions in Canada. The variation in background concentrations of chloride is greatest in western Canada and markedly decreases moving eastward to the Great Lakes area and Atlantic Canada. The lowest variation in chloride concentration is reported on the Canadian Shield.

The right column of Figure 1 is useful for identifying the levels of chloride in surface waters above and below concentrations reported to cause certain negative impacts. Concentrations of chloride of
approximately 140 mg/L should be protective of freshwater organisms for short-term exposure; concentrations less than 35 mg/L are likely protective during long-term exposures. Overall, approximately 5 percent of species are predicted to experience effects from chronic exposure to concentrations of chloride of about 210 mg/L, while 10 percent of species would be affected at concentrations of about 240 mg/L.

Other jurisdictions have derived guidelines for the exposure of aquatic organisms to chlorides (Fig. 1). The United States Environmental Protection Agency (EPA) developed a similar guideline. Overall, the EPA guideline indicates that biota, on average, should not be affected unacceptably if the four-day average concentration of chloride does not exceed 230 mg/L more than once every three years. Similarly, the biotic impacts would be minimal if the one-hour average chloride concentration does not exceed 860 mg/L more than once every three years.

Lakes located in Canada typically undergo vertical mixing every spring and fall as a result of a change in water temperature. Dissolved salts can hinder the vertical mixing of water bodies as dense, salt-laden water sinks to deeper layers (meromixis). The absence of vertical mixing can ultimately lead to a depletion of oxygen in the lower layers of lakes and a reduction in the cycling of nutrients. Meromictic conditions have developed in lakes with salt concentrations of approximately 60 mg/L Na and 105 mg/L Cl. Small, deep lakes are the most vulnerable, although concentrations associated with meromixis will vary greatly, depending on local conditions.

Figure 1  Comparison of natural background concentrations of chloride in Canadian surface water and thresholds for adverse biological effects. The column on the left provides an overview of average background concentrations for five regions in Canada. The column on the right identifies levels at which certain impacts may occur. Data in this figure helps characterize average background concentrations for different areas and impacts that can occur at different concentrations.
Species should not be negatively affected if one-hour average concentration of Cl does not exceed value more than once every 3 years (U.S. EPA 1988).

Species should not be negatively affected if 4-day average concentration of Cl does not exceed value more than once every 3 years (U.S. EPA 1988).

Based on predicted data, 5% of species would be negatively affected (median lethal concentration) [Evans and Frick, 2001].

Estimated no affects value derived from Ceriodaphnia dubia 4-day LC50 (Cowgill and Milazzo, 1990).

Estimated no affects value derived from 33-day LOEC survival for fathead minnow (Birge et al., 1985).

Chloride concentrations in lower layers of water body associated with meromixis (Smol et al., 1985).

To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of total chloride at any time should not exceed this value. (BC Ambient Water Quality Guidelines for Chloride, 2002)

To protect freshwater aquatic life from chronic effects, the 30-day average concentration of total chloride should not exceed this value. (BC Ambient Water Quality Guidelines for Chloride, 2002)

**GROUNDWATER**

Chloride concentrations identified for freshwater biota will likely be protective of groundwater biota and groundwater that emerges into surface water.

A significant proportion of road salts may be contained within the groundwater system. The time taken to reach an equilibrium where salt inputs are balanced by salt outputs depends on local hydrogeological conditions and may take from a few years to hundreds of years.
SOILS

Soil integrity, soil organisms and vegetation will generally be protected at concentrations of about 60 mg Na/L and 90 mg Cl/L. Damage to plants has also been observed at soil concentrations of 16 mg Na/kg and 30 mg Cl/kg (dry weight). Changes in natural plant communities have been recorded in areas affected by road salts runoff and liquid salt spray from moving vehicles.
purposes | considerations |

**PURPOSE**

The purpose of Annex B is to provide guidance for organizations to consider when identifying areas of a receiving environment that may be particularly sensitive to road salts. Once a vulnerable area has been identified, organizations may then determine the level of vulnerability and the need to implement additional salt management measures.

Additional salt management measures in vulnerable areas may include:

- using technologies that further optimize the use of road salts;
- using environmentally, technically and economically feasible alternatives to road salts;
- increasing monitoring and measuring of chlorides and/or their impacts;
- locating patrol yards and snow disposal sites outside of vulnerable areas; or
- considering location and protection of vulnerable areas in the design of new roads and/or upgrading of existing roads.

It is important to note, when identifying vulnerable areas, that an area may be vulnerable either to infrequent but heavy addition of road salts or to light but frequent addition of road salts.

Organizations may consider consulting with entities that conduct, under their programs, work that could be relevant to the identification of areas vulnerable to road salts. In addition, organizations may wish to exchange information with other organizations adjacent to or having common authority over these vulnerable areas, and consult...
with their constituents.

Notes:

- Subsection 36(3) of the *Fisheries Act* prohibits the deposit of a deleterious substance into water frequented by fish. Nothing in this Annex should be interpreted as an authorization or recommendation to ignore this prohibition.

- The recommendations described above are intended to complement road salt management procedures already established in areas identified, designated or protected by a local, provincial, territorial, aboriginal, national or international system or body as ecologically significant or ecologically important.

CONSIDERATIONS

When identifying vulnerable areas, organizations should consider:

1. areas draining into bodies of water, such as:
   a. lakes and ponds with low-dilution and long residence times;
   b. watercourses that experience the cumulative effects of a dense network of highways; and
   c. provincially significant wetlands adjacent to roadways where the addition of road salts has the potential to significantly raise the chloride concentration of the water to the point where it could present a threat of serious or irreversible environmental damage;

2. areas draining into small, moderately deep lakes, where the addition of road salts has the potential to create layers of water of different salinity within the lake that prevent normal vertical mixing of the water (meromictic conditions);

3. areas where the addition of road salts has the potential to raise the chloride concentration, after mixing, to levels that could harm local fish or fish habitat;

4. areas adjacent to salt-sensitive native or agricultural vegetation, where the addition of road salts has the potential to cause severe reductions in flowering and fruiting, severe
foliar, shoot and root injury, growth reductions, or reductions in germination and seedling establishment caused by elevated soil levels of sodium and chloride or aerial spray of sodium and chloride;

5. areas where the addition of road salts has the potential to harm the integrity of a life cycle (e.g. spawning grounds, nursery, rearing, food supply and migration areas for birds);

6. areas where the addition of road salts has the potential to harm a habitat necessary for the survival or recovery of a wildlife species listed on the List of Wildlife Species at Risk (Schedule 1 of the Species at Risk Act) where the area is identified as the species’ critical habitat in the recovery strategy or in the action plan for the species established under that Act;

7. areas draining into sources of drinking water (surface water or groundwater, including wells), where the addition of road salts has the potential to raise the chloride concentration of the water to the point where it could not be used as a source of drinking water. Due regard should be given to background concentrations of chloride and other possible sources of chloride in making such a determination;

8. areas draining into groundwater recharge zones or that have an exposed or shallow water table, with medium to high permeability soils, such as medium to coarse sand and gravel, where the addition of road salts has the potential to significantly raise the chloride concentration of the groundwater to the point where it could present a threat of serious or irreversible environmental damage.

Inquiries and comments on this Code of Practice, as well as requests for additional copies of the Code, should be directed to:

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Chemicals Control Branch
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Environment Canada gratefully acknowledges the contributions of all working group participants who assisted in developing this Code of Practice.

Extended thanks go out to the Transportation Association of Canada for the development of the Syntheses of Best Practices.

Report Date: 04/04
Important Notices
annex C: monitoring and measuring progress

The purpose of Annex C is to provide a common approach to monitoring and measuring progress in road salt use, the implementation of best management practices with respect to road salts, and the concentration of road salts in the environment. Information collected will be used in conjunction with additional winter severity weather data provided by the Meteorological Service of Canada, environmental monitoring data collected from case studies and water quality monitoring programs, and road safety data provided by Transport Canada to determine the extent and effectiveness of implementation of the Code of Practice.

Information to be provided to Environment Canada by organizations is described below.

1. Background Information

   Organization
   • Name and address;
   • Technical contact, telephone and fax numbers, and electronic mail address;
   • Population (municipalities only).

   Salt Management Plan
   • Existence of a salt management plan;
   • Date of approval of the salt management plan;
   • Date of latest revision of the salt management plan, where applicable.

   Road Length Serviced
   • Total length of road on which salt is applied in the organization’s jurisdiction.

   Winter Severity
   • Organization’s rating of the severity of the winter;
• Municipal Organizations Only – Total number of events requiring salt application during the winter averaged over all districts within the organization’s jurisdiction.

2. Materials Used

• Total quantity of road salts used for winter road maintenance;
• Description of non-chloride materials used for winter road maintenance.

3. Material Storage

• Organization’s objectives for implementing best management practices related to material storage, as indicated in its salt management plan;
• State of implementation of each management practice.

4. Winter Road Maintenance Equipment and Road Salt Application Practices

• Organization’s objectives for implementing best management practices related to road maintenance equipment and salt application practices, as indicated in its salt management plan;
• State of implementation of each management practice;
• State of calibration program for equipment.

5. Snow Disposal

• Organization’s objectives for implementing best management practices related to snow disposal, as indicated in its salt management plan;
• State of implementation of each management practice.

6. Winter Road Maintenance Training
7. **Areas Vulnerable to Road Salts**

- Existence of areas vulnerable to road salts;
- Description of additional salt management practices undertaken by the organization in identified vulnerable areas, where applicable.

8. **Environmental Monitoring**

- Chloride concentration and frequency of sampling at each sampling location, if available.

Inquiries and comments on this Code of Practice, as well as requests for additional copies of the Code, should be directed to:

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Place Vincent Massey
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Environment Canada gratefully acknowledges the contributions of all working group participants who assisted in developing this Code of Practice.

Extended thanks go out to the Transportation Association of Canada for the development of the *Syntheses of Best Practices*.

Report Date: 04/04
1.0 SALT MANAGEMENT PLANS

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. This Synthesis is provided as advice to road maintainers for consideration when developing their own Salt Management Plan. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of individual road agencies. Syntheses of Best Practices have been produced on Salt Management Plans, Training, Road and Bridge Design, Drainage and Stormwater Management, Pavements and Salt Management, Vegetation Management, Design and Operation of Road Maintenance Yards, Snow Storage and Disposal Sites and, Winter Maintenance Equipment and Technologies. For more detailed information, please refer to TAC’s Salt Management Guide – 1999.

INTRODUCTION

In Canada, over $1 billion is spent annually on winter maintenance to keep roads safe and passable. Snow and ice control is a key part of winter maintenance operations. Road salts (particularly sodium chloride) are the preferred deicing/anti-icing chemicals for maintaining winter roadway safety because of their cost, effectiveness, and ease of handling. Road salt (particularly calcium chloride) is also used to control dust on gravel roads and construction sites during dry weather. Excessive use of salt can have environmental impacts. Recognizing their responsibility to the environment, many road authorities across Canada are taking positive actions towards implementing salt best management practices. The Transportation Association of Canada has published a Salt Management Guide and a series of Syntheses of Best Practices to assist road authorities as they find ways to more effectively manage their salt used in winter maintenance and provide the public with the safe and efficient road systems they expect, while minimizing effects on the environment.

The amount of salt used is a function of local policies, practices, roadway system, funding constraints and weather conditions. Because of the variability of conditions across Canada, salt management initiatives need to be developed and implemented locally by each road authority. Road authorities should be responsible for developing their own salt management plans. This framework has been developed to support road authorities in their pursuit of best management practices and the preparation of salt management plans. The framework follows an environment management system (EMS) approach.

A successful Salt Management Plan is based on the following principles:

- It is grounded in policy with guiding principles – set and endorsed at the highest level in the organization.
- It is activity based, with each activity being assessed at the outset against clearly established standards and/or objectives to determine how they can be carried out with minimal environmental impact.
- Deficiencies in current operations are identified and corrective action established and implemented.

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Objectives of a Salt Management Plan 2
Commitment and Policy 2
Guiding Principles 2
Framework for a Salt Management Plan 3
Conclusion 5
- Required actions are documented in policies and procedures and communicated throughout the organization.

- Activities are recorded, monitored, audited and reported periodically to assess progress and identify areas for further improvement.

- Gaps between actions and desired outcomes are identified and corrective actions are developed and implemented, with necessary modifications being made to policies and procedures and appropriate training.

- The cycle begins again and continues on an ongoing basis in the spirit of continual improvement.

Figure 1 illustrates the process.

**OBJECTIVE OF A SALT MANAGEMENT PLAN**

An agency’s salt management plan will provide the vehicle through which each agency commits to implementing salt best management practices as it fulfills its obligation to provide safe, efficient and cost-effective roadway systems. The Plan should contain best management practices to protect the environment from the negative impacts of road salts. The Plan should apply to all winter maintenance personnel – both staff and hired resources/contractors.

**COMMITMENT & POLICY**

To be effective, the senior management of an agency must commit to developing, implementing and updating its salt management plan. A senior manager who is responsible and accountable for the implementation of the agency’s salt management plan should be appointed. Road agencies should establish a clear road salt management policy endorsed at the highest level of the organization.

**GUIDING PRINCIPLES**

The salt management plan should be grounded in the following principles:

i) Safety – In recognition of the importance of effective winter maintenance to the safety of roadway users and maintenance crews, the development and implementation of the salt management plan will make safety the overriding priority.

ii) Environmental protection – In recognition of the adverse effects that excessive use of road salt can have on the environment, the salt management plan will strive to minimize the amount of road salt entering the environment.

iii) Continual improvement – Different roadway authorities within Canada are at different stages of implementation of salt best management practices (salt BMPs). The cost of moving towards salt BMPs can be high, and changes must be phased in over time. Therefore the salt management plan must recognize that change will be incremental and ongoing.

iv) Fiscal responsibility – The salt management plan will need to be within the financial capabilities of each road authority.
1.0 SALT MANAGEMENT PLANS

v) Efficient transportation systems – In recognition of the importance of efficient roadway transportation to Canada’s economy and quality of life, development and implementation of the salt management plan will take into account the effects on transportation system performance.

vi) Accountability – Each road authority must be responsible and accountable for developing and implementing its salt management plan.

vii) Measurable Progress – Indicators must be developed to ensure that progress on implementing the salt management plans can be tracked and reviewed.

viii) Agency-based – The plans must be developed and implemented by each road agency rather than be centrally driven.

ix) Communication – A communication plan must be developed for communicating internally and externally with key stakeholders.

x) Knowledgeable and Skilled Workforce – The plans must include regular, comprehensive and effective training for managers, supervisors and operators.

FRAMEWORK FOR A SALT MANAGEMENT PLAN

Each road authority should develop and implement its own salt management plan incorporating the guiding principles set out in this framework. The plan should be results-oriented and contain the following elements.

1. Salt Management Policy and Objectives

The road authority should adopt a salt management policy that commits the organization to measurable improvements in its salt management practices.

The cornerstone of an effective plan is a clear salt management policy endorsed by senior management and communicated to the organization.

2. Situational Analysis

An inventory of current practices must be established to form a benchmark against which progress can be measured. It should contain consistent elements to allow the transportation community to measure and track progress in managing the amount of road salt being placed into the environment on a national basis. The following elements may be considered in an overall situational analysis:

- Type and amount of chloride freeze point depressant used (all sources including solids, liquids, and abrasive mixes)
- Type and amount of non-chloride freeze point depressant used (all sources including solids, liquids, and abrasive mixes)
- Current application rate for each type of material
- Percentage of fleet with pre-wetting
- Percentage of fleet with liquid only applications
- Percentage of fleet with electronic spreader controls
- Number of road weather information systems (RWIS) installations
- Number of other surface temperature measuring devices (hand-held or vehicle mounted)
- Use of dedicated pavement and/or atmospheric forecasting

Salt Vulnerable Areas:

- Locations of salt vulnerable areas
- Description of winter maintenance practices in the vicinity of salt vulnerable areas (e.g. alternate treatment)

Examples of Possible Salt Vulnerable Areas

- Groundwater recharge areas
- Areas with exposed or shallow water tables with medium to high permeability soils
- Sources of drinking water
- Salt-sensitive vegetative communities
- Salt-sensitive wetlands
- Small ponds & lakes
- Rivers with low flows
- Salt-sensitive agricultural areas
- Salt-sensitive habitats for species at risk

Sand and Salt Storage Sites:

- Number and capacity of storage sites
- Percentage of sand/salt piles covered and type of cover

On Road Use:

Road Salt Management
The documentation should be aimed at introducing best salt management practices with both in-house and outsourced operations.

TAC’s Salt Management Guide and Syntheses of Best Practices can be used to supplement in-house procedures and other available documentation on best management practices.

Policies, procedures and guidelines should be clearly documented and communicated throughout the organization.

4. Proposed Approaches

Salt management plans should have clear tasks, schedules with milestones, budget considerations and assigned responsibilities for implementing best salt management practices. The plans should deal with four areas of concern – general road use, salt use in salt vulnerable areas, salt storage, and snow storage and disposal.

The plan can be developed by comparing current practices to best management practices and documenting the gaps. The salt management plan should then focus on closing these gaps. The plan should include pre-season, in-season and post-season actions to be taken to reduce the adverse impacts of road salts. It should also include consideration of equipment, labour, materials and the local climate.

Although not all salt management techniques are applicable to all regions of Canada, the salt management plan should consider strategies for introducing best practices in the four areas of concern.

Where specific technologies are inappropriate, the fact that they were considered and determined to be inappropriate should be explained in the plan. The plans should be results-oriented and measurable with proper commitment of funding and personnel to ensure successful implementation.

The other TAC Syntheses of Best Practices will assist road authorities in assessing these practices.

5. Training

Human behaviour is predicated upon attitudes based on knowledge and experience. Changes in approach require changes in behaviour. A successfully managed salt strategy requires changes in procedures, practices
and equipment. Success also requires acceptance of the new approaches by managers, supervisors and operators. Each salt management plan should therefore include a comprehensive education program that demonstrates the value of new procedures and ensures that personnel are competent in delivering the new program. The Training Synthesis of Best Practice provides guidance on developing a salt management training program.

The public must also be educated on proposed initiatives and on their role in adjusting driver behaviour to roadway conditions. Each road authority should have a program for informing the public of winter maintenance practices.

Each plan should include monitoring of progress, analysis and reporting of the results to senior management.

7. Management Review

Each year, senior management within each administration should review the results of the previous year’s salt management actions to confirm that the plan is achieving the desired results and to adjust the next year’s salt management plan to respond to shortcomings and new opportunities. Policies and procedures should be updated prior to the next snow and ice control season and communicated to management and operational personnel.

This review should be integrated into the budgetary process to permit timely acquisitions of new equipment and to identify other funding needs.

Progress on implementation of the salt management plan should be communicated to senior management, local politicians, staff and the public.

CONCLUSION

Effective road salt management requires dedication to adopting, implementing and refining best management practices. This is not an easy task. It will require a long-term vision, senior management support, dedicated resources, adequate and regular training, perseverance, continual innovation and improvement, and an ability to deal with changing organizational culture and attitudes. It cannot be rushed. Public safety must be maintained as best management practices are implemented. Personnel at all levels of the organization will need to be trained and educated so that maximum benefits are realized.
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4.0 DRAINAGE AND STORMWATER MANAGEMENT

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. This Synthesis is provided as advice to road maintainers for consideration when developing their own Salt Management Plan. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of individual road agencies.

Syntheses of Best Practices have been produced on Salt Management Plans, Training, Road and Bridge Design, Drainage and Stormwater Management, Pavements and Salt Management, Vegetation Management, Design and Operation of Road Maintenance Yards, Snow Storage and Disposal Sites and, Winter Maintenance Equipment and Technologies. For more detailed information, please refer to TAC’s Salt Management Guide – 1999.

INTRODUCTION

Salt-laden runoff can have impacts on the natural environment. The nature and extent of these impacts are site specific, and may be temporary or can persist for long periods of time. In some areas, the concentration of chloride in the groundwater and stream baseflow may reach levels sufficient to impair the potability of groundwater or alter aquatic habitat. This Synthesis of Best Practices establishes Guiding Principles to aid in the design of drainage works for existing or new roadways, and provides a framework to identify the specific practices that can be implemented to minimize potential impacts of salt on the surrounding environment.

This Chapter of the Synthesis of Best Practices does not specifically address the impacts of salt-laden runoff and salt spray on vegetation. The Synthesis of Best Practices for Vegetation Management provides information on this aspect of snow and ice control chemicals. It also does not deal with other contaminants in roadway runoff.

RELATIONSHIP TO SALT MANAGEMENT

Much of the salt that is placed on a road during snow and ice control operations eventually runs off with the roadway drainage. This drainage enters the environment through three primary pathways. The first is through overland drainage or stormsewer systems ultimately discharging to nearby surface water. The second is infiltration into the ground potentially entering groundwater. The third is through spray caused by traffic and wind, potentially affecting adjacent vegetation and agricultural crops.

If any of these pathways introduce high salt concentrations to salt vulnerable areas, then adverse impacts may occur.

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Proper drainage planning and design can reduce the potential impacts on salt vulnerable areas by isolating the drainage from vulnerable areas.

This Synthesis of Best Practices, when used in combination with other policies and guidelines for drainage design, will assist in the responsible selection of drainage management measures. Regardless of the policy framework, the following guiding principles exist for creating an overall management plan that also minimizes salt related impacts:

1. Roadway safety is the priority. Drainage design must ensure that roadway runoff is efficiently and safely removed from the travel surface.
2. Drainage design must comprehensively consider all drainage related impacts in the formulation of a responsible, effective management strategy.
3. The most significant, potential, long-term impact of salt-laden runoff is impairment of domestic groundwater supply.
4. Drainage design must endeavor to protect the natural environment.
5. Drainage design must be practical and must not impose undue maintenance requirements.

**SALT MANAGEMENT PRACTICES**

The main purpose of any road drainage system is to safely convey runoff downstream to either a natural or man-made drainage system. Management measures should be implemented to ensure that this is done with minimal impact to the infiltration characteristics, water quality, erosion potential, and flood risk of the receiving drainage system. At the onset of any drainage design, sufficient information should be collected to characterize the existing drainage system surrounding and downstream of the roadway.

**IMPACT IDENTIFICATION**

A detailed surface water assessment should be completed to identify all potential impacts to natural features as a result of the roadway. The requirements of the assessment will be defined by the policy framework in the area where the drainage design is being completed. As a minimum, the assessment should include a review of the impacts of salt-laden surface water on potable water taken from groundwater sources, sensitive aquatic habitat, agricultural lands, wetlands, and wildlife.

Each of these features is described below. Guidelines have been provided to establish the relative importance of each feature as defined by low, medium or high potential for impact. Specific site characteristics may require that other features be considered as well. The impact potential identified for all significant features will assist in the selection of suitable mitigative measures.

**Ground Water**

The suitability of groundwater for potable use and irrigation can be significantly impaired by the infiltration of salt captured by roadway runoff. To determine the potential for impact from salt-laden runoff on groundwater, the following questions must be addressed:

- Are there domestic wells near the roadway?
- If there are wells, do they draw from a surficial aquifer?
- Are the surficial soils permeable (sand and loams)?

The degree of potential impact on groundwater can be determined based on the responses to these questions:

- **High:** The answer is ‘yes’ to all three questions.
- **Medium:** The answer is ‘yes’ to the first question and ‘yes’ to either the second or third question.
- **Low:** All other cases.

**Aquatic Habitat**

Salt-laden runoff can potentially impact aquatic habitat in two ways: sudden pulses of chlorides during spring runoff, and continuous levels of chloride present in the groundwater discharging to the receiving stream. Although both types of impacts are a concern, the literature generally points to sudden pulses as the greater concern. With either type of impact, the existing literature is not clear on “how much is too much”. The following provides a guideline for assessing the potential impact:

- **High:** The receiving watercourse has a permanent baseflow, and the catchment area of the road represents more than 10 percent of the catchment area of the stream.
- **Medium:** The receiving watercourse has a permanent baseflow, and the catchment area of the road represents less than 10 percent of the catchment area of the stream.
- **Low:** All other cases (i.e. receiving watercourses with no permanent baseflow).
**Agricultural Land**

Salt-laden runoff can impact crops in cases where there is the potential for water to pond on agricultural lands. This situation can arise where there is poor positive drainage or an outlet has been blocked by ice or debris. Guidelines for assessing potential impacts are as follows:

- **High:** Agricultural land is adjacent to the road, and off road drainage has a high likelihood of ponding or blockage.
- **Medium:** Agricultural land is adjacent to the road, and off road drainage has a low to moderate potential for ponding or blockage.
- **Low:** Agricultural land is either outside the road runoff influence zone, or there is no agricultural land adjacent to the road.

**Wetlands**

Swamps, peat bogs, marshes, and other types of wetlands can be impacted where runoff is directed to natural roadside vegetation features. In these cases the runoff may enter the wetland as sheet flow or via a roadside ditch. With very high and prolonged chloride loading, there is the possibility that changes in local plant composition may occur, with the possibility of a reduction in the overall value and diversity of the wetland. Small, perched wetlands that intercept the shallow water table or that are primarily surface water dependant may be most susceptible to chloride loading effects due to their small size and a reduced dilution potential. Large wetlands with extensive catchment areas and high dilution potential are likely more tolerant of chloride loading. Potential impacts may be classified as follows for wetlands located adjacent to the roadway:

- **High:** No clear flow path evident through the wetland and/or small perched roadside wetlands present (<5 ha in size).
- **Medium:** Poorly defined channel evident through the wetland and/or moderate sized wetland with better dilution potential (5 - 20 ha in size).
- **Low:** Clearly defined channel evident through the wetland and/or large wetland with good dilution potential (>20 ha in size).

**Wildlife**

Ponded runoff can serve as a salt source for wildlife. The attraction of the wildlife to the saltwater can be a safety hazard. Potential impacts may be classified as follows:

- **High:** Roadway located in an area where large mammals (such as elk, big horned sheep, white-tailed deer and moose) are present and where roadside ponding is a current problem or has a high potential based on design limitations and topography.
- **Medium:** Roadway located as above but roadside ponding is not a current problem or has only a moderate potential based on design limitations and topography.
- **Low:** Roadway located as above but there is no existing or future roadside ponding problem, or large mammals are limited or absent in the area.

**Impact Identification Summary**

The potential impacts of salt on each of the categories can be summarized in a table similar to the following example. This table represents a starting point for identifying appropriate drainage management practices that can be used to minimize the impacts of salt on the adjacent environment:

<table>
<thead>
<tr>
<th>Impact Potential</th>
<th>Groundwater</th>
<th>Aquatic Habitat</th>
<th>Agriculture</th>
<th>Wetlands</th>
<th>Wildlife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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95% of all questions were answered correctly. Thank you for using our service.
IDENTIFICATION OF ALTERNATIVE MANAGEMENT PRACTICES

The minimization of salt related impacts should be one objective of any management strategy formulated for roadway drainage systems. Unfortunately, the range of potential impacts from salt-laden runoff offers considerable challenges to the designer. There are a number of practices that can aid in the management of runoff, however each practice may mitigate some types of impacts while accentuating others. For example, promoting rapid conveyance of runoff to a receiving watercourse will reduce the potential for impairment of potable groundwater while increasing potential impacts on aquatic environment.

Eight alternative management practices can be considered. In most cases, these practices will be required to achieve other drainage objectives. For some sites, combinations of these measures may be required to effectively minimize impacts related to salt rich surface drainage. This is not a comprehensive list of measures available to the designer. Local drainage policies in different parts of the country may identify additional measures that could be implemented effectively to mitigate drainage impacts.

<table>
<thead>
<tr>
<th>Management Practice</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sheet Flow</td>
<td>Runoff conveyed across grass buffer strips or embankments.</td>
</tr>
<tr>
<td>2 V-ditch</td>
<td>Runoff conveyed by roadside ditch to receiving watercourse.</td>
</tr>
<tr>
<td>3 Storm Sewer</td>
<td>Runoff conveyed away from sensitive areas using storm sewer system (negligible infiltration potential).</td>
</tr>
<tr>
<td>4 Flat Bottom (Trapezoidal) Ditch</td>
<td>Runoff conveyed by roadside ditch with flat bottom ditch.</td>
</tr>
<tr>
<td>5 Flat Bottom (Trapezoidal) Ditch with Storage</td>
<td>Runoff conveyed by flat bottom ditch which includes on-line storage to trap sediment and reduce velocities and runoff rates.</td>
</tr>
<tr>
<td>6 Dry Basin (Pond)</td>
<td>Runoff directed to stormwater management basin designed to reduce runoff rates and promote sedimentation.</td>
</tr>
<tr>
<td>7 Wet Basin (Pond)</td>
<td>Runoff directed to stormwater management basin designed to reduce runoff rates, promote sedimentation and enlarge biological uptake.</td>
</tr>
<tr>
<td>8 Buffer Strip and Containment Berm</td>
<td>Berm designed to contain runoff within buffer strip, with positive outlet provided to prevent flooding and sustained water levels.</td>
</tr>
</tbody>
</table>

The following table illustrates the merits of each management practice in addressing the potential impacts that can result from salt-laden runoff. As the table illustrates the practices which benefit groundwater impacts are typically consistent with those that benefit agriculture, wetlands, and wildlife. However, most of these practices have the potential to negatively impact aquatic resources. This table, in conjunction with the ranking summary table prepared at the end of the impact identification process, will help to determine which impacts can be successfully mitigated through the use of specific drainage measures.

In most cases conflicts will not arise, and the selection of suitable management practices for minimization of salt impacts will be relatively simple. The measures will typically be selected as part of the overall management strategy formulated to achieve other drainage and stormwater management objectives. In cases where objectives are conflicting, the practitioner must review each site on its own merits and set priorities such that the overall impacts are minimized.
<table>
<thead>
<tr>
<th>Management Practice</th>
<th>Characteristics</th>
<th>Feature that May Be Impacted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Groundwater</td>
</tr>
<tr>
<td>Sheet Flow</td>
<td>Disperses runoff</td>
<td>-</td>
</tr>
<tr>
<td>V-Ditch</td>
<td>Channels runoff</td>
<td>+</td>
</tr>
<tr>
<td>Storm Sewer</td>
<td>Channels runoff with little opportunity for infiltration</td>
<td>+</td>
</tr>
<tr>
<td>Flat Bottom Ditch</td>
<td>Channels runoff Some attenuation of flow rate Some sediment trapping Some potential for infiltration</td>
<td>0</td>
</tr>
<tr>
<td>Flat Bottom Ditch with Storage</td>
<td>Channels runoff Attenuates flow rate Some sediment trapping Some potential for infiltration</td>
<td>-</td>
</tr>
<tr>
<td>Dry Basin (Pond)</td>
<td>Attenuates flow rate Sediment trapping Potential for infiltration</td>
<td>-</td>
</tr>
<tr>
<td>Wet Basin (Pond)</td>
<td>Attenuates flow rate Sediment trapping Potential for infiltration</td>
<td>-</td>
</tr>
<tr>
<td>Buffer Strip and Containment Berm</td>
<td>Contains and disperses runoff</td>
<td>-</td>
</tr>
</tbody>
</table>

**Legend:**

+ The identified management measure may reduce the level of impact from salt-laden runoff (i.e. The level of impact potential for a feature may be decreased from high to medium, medium to low, etc.).

- The identified management measure may increase the level of impact from salt-laden runoff (i.e. The level of impact potential for a feature may be increased from low to medium, medium to high, etc.).

0 The identified management measure will have minimal effect on the level of impact potential.

**DESIGN REQUIREMENTS OF PREFERRED MANAGEMENT PRACTICES**

The policy framework in the area where the design is being completed will define specific design characteristics of the recommended stormwater management measures. In most cases, stormwater management objectives other than salt management will dictate the design requirements.

In addition to local policy frameworks, design information for these measures can be found in numerous technical documents relating to stormwater management.

**SALT VULNERABLE AREAS**

Drainage designers need to consider the environmental setting into which their drainage system will be placed. Salt vulnerable areas need to be identified and the potential for salt impacted drainage to affect these vulnerable areas must be assessed. Special design modifications to traditional stormwater management measures may be warranted to protect these salt vulnerable areas. Measures may include clay or geosynthetic liners in conveyance ditches and ponds, infiltration ponds where appropriate, or use of storm sewers to transport drainage past vulnerable areas.
TRAINING

Since roadway drainage depends primarily on design and not on operations, typical salt management training programs would pay little attention to drainage issues except to teach the concept and importance of proper design.

Training for drainage designers should include design options for managing the adverse effects of snow and ice control chemicals.

MONITORING AND RECORD KEEPING

It is not practical to monitor all runoff from roadways for chloride levels. However, road authorities should consider monitoring salt vulnerable areas. One municipality worked with their local conservation authority to add chloride monitors to their stream monitoring network. They measured the chloride concentration in the watercourses as they entered the municipality and again as they left the municipality to track fluctuations. There are many complications with such a monitoring program. These include:

- At what frequency will samples be collected?
- Will the sampling be continuous?

- Will the data be communicated back to a central location automatically?
- The sampling stations will likely need power and telephone capability for communicating the data.
- Sampling locations must be protected from vandalism, flooding and ice impacts.
- If conductivity is being used as the measure, then it will need to be correlated to chloride levels.
- Data analysis will have to take into account any confounding data such as chlorides entering the environment from other sources (e.g. private uses, water softeners, landfills etc.)

Records should be kept on the chloride or conductivity levels and snow and ice control events to determine how the levels fluctuate around an event. The analyst will want to be able to draw conclusions on whether or not the applications of best salt management practices are having an effect on the chloride levels in the aquatic environment. It will be important to determine whether or not drops in chloride levels can be attributed to improved practices and not just different weather conditions.

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New Brunswick Department of Transportation
Nova Scotia Transportation and Public Works
Salt Institute
Saskatchewan Highways and Transportation
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5.0 PAVEMENTS AND SALT MANAGEMENT

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. This Synthesis is provided as advice to road maintainers for consideration when developing their own Salt Management Plan. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of individual road agencies. Syntheses of Best Practices have been produced on Salt Management Plans, Training, Road and Bridge Design, Drainage and Stormwater Management, Pavements and Salt Management, Vegetation Management, Design and Operation of Road Maintenance Yards, Snow Storage and Disposal Sites and, Winter Maintenance Equipment and Technologies. For more detailed information, please refer to TAC’s Salt Management Guide – 1999.

INTRODUCTION

This Synthesis of Best Practices has two key purposes. The first is to provide pavement designers with information on methods to mitigate the environmental and pavement impact of road salt through proper pavement design. The second is to provide road maintainers with information on pavement-related salt management considerations. For further information on the factors identified in this Synthesis of Best Practices the designer should refer to the Road Salt Management Guide-1999.

RELATIONSHIP TO SALT MANAGEMENT

There are pavement design factors to be taken into account that relate to the ability of pavements to withstand snow and ice control chemicals. These can have a bearing on the way in which winter maintenance is carried out, the melt performance of salt, and therefore the amount of chemical necessary to be used. The pavement designer should make every effort to provide pavement designs that serve to support the minimizing of the use of salt for deicing purposes. Consideration should be given to the following factors affecting salt usage:

- Type of pavement surface.
- Pavement thermal and material properties.
- Environment and climate.

Pavement surfaces generally consist of either concrete or asphalt, while pavement structures can be either concrete or asphalt, or a composite of both. Road maintainers do not report significant differences with the pavement variations, although there are subtleties that affect the way snow and ice behave on different surfaces in the winter and how they need to be maintained. The key is to understand how the various pavement types function under different winter conditions.

Because of their light colour and higher thermal mass, concrete pavements tend to heat up and cool down more slowly than do asphalt pavements. This heating and cooling occurs differently at different times of the year, depending on the temperature of the underlying materia-
Asphalt pavements can have different porosity depending on the construction, and this porosity can change over time as the asphalt wears and oxidizes. Open Friction Course (OFC) pavements are often used because of the improved drainage and reduced noise—they are a quieter pavement. The OFC in facilitating drainage also reduces spray. This reduced spray can be beneficial in proximity to areas that are vulnerable to salt spray.

A good crossfall on any pavement will permit the placement of chemicals on the crown or the high side of the road and allow for the slope of the pavement and traffic to distribute the chemical down the driving surface. This tends to keep the chemicals on the road longer to work. Higher slope percentages tend to shed the chemical “brine” more quickly; in this regard, a 2% crossfall on tangent is preferred over a 3% crossfall. Poor crossfall due to deterioration of the pavement necessitates broadcast spreading, leading to greater loss of chemicals to the ditch.

**SALT MANAGEMENT PRACTICES**

Road salt does not generally damage properly designed, constructed and well maintained pavements, however there is some potential for magnesium chloride to react chemically with cement paste and affect the structural integrity of concrete over time. The corrosivity of snow and ice control chemicals can be reduced by the use of additives. The following discusses the potential effects of salt on pavements and best practices for pavement design. It also discusses some winter maintenance considerations related to the type of pavement surface.

**Effects of Salt on Pavements**

The typical salt-related damage to flexible and rigid pavements listed below is described in further detail in the section that follows:

- Salt can accelerate damage to some poorly-designed or constructed hot-mix asphalt pavements.
- Salt can cause scaling of poor-quality concrete pavements and concrete pavers.
- Salt can cause spalling of steel reinforced concrete by accelerating steel corrosion if cracks allow chloride ions access to the reinforcing steel.
- The brine resulting from road salt use can damage some thin, cracked or poorly drained flexible pavements by causing differential frost heaving at the pavement edge or at unsealed cracks.
5.0 PAVEMENTS AND
SALT MANAGEMENT

- The magnesium in magnesium chloride may react with the cement paste in concrete, weakening the pavement structure.

Pavement Design

The design and evaluation of new pavement alternatives requires the pavement designer to identify subgrade conditions, drainage mechanisms, climatic data, material properties, traffic data, pavement geometry, constructability and life-cycle costs. The designer should review the advantages, disadvantages and costs to develop an appropriate solution for each situation. If pavement materials do not have proven performance, they should be tested before construction to ensure they are durable.

The principal design considerations to reduce salt impacts on pavements include:

- Improving resistance of asphalt pavements to moisture susceptibility by:
  - Ensuring that the specifications include asphalt mix designs using a standard method such as the Asphalt Institute’s MS-2 or the SHRP Superpave Mix Design Method.
  - Conducting anti-stripping testing of the materials and mix designs to be used in construction.

- Specifying suitable compaction requirements and testing procedures.

- Ensuring that both QA and QC procedures are specified to ensure that the material produced complies with the mix design proportions and includes the necessary anti-stripping agents.

- Improving resistance of rigid/concrete pavement and concrete pavers to scaling by:

  - Ensuring that durable concrete, which will resist the action of freezing and thawing and de-icing salts, is specified. The concrete should comply with CSA-A23.1 requirements outlined in Table 1.

  - Ensuring that durable concrete pavers, which will resist the action of freezing and thawing and deicing salts are specified. The concrete should comply with CSA-A23.1.

  - Ensuring that mix designs include certification that the aggregates, cement and other materials used comply with CSA-A23.1 requirements.

  - Ensuring that the air voids system in the hardened concrete complies with CSA-A23.1 requirements.

**TABLE 1 Durability Requirements of Concrete used for Pavements**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirements for Exposure Class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class</strong></td>
<td><strong>C-1</strong></td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td>Structurally-reinforced concrete exposed to chlorides and with or without freezing and thawing conditions</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>Bridge decks, parking decks and ramps</td>
</tr>
<tr>
<td>Minimum, specified 28 day compressive strength, MPa</td>
<td>35</td>
</tr>
<tr>
<td>Maximum water/cementing material ratio</td>
<td>0.40</td>
</tr>
<tr>
<td>Air content* based on nominal maximum aggregate size</td>
<td>6 to 9 %</td>
</tr>
<tr>
<td>10 mm</td>
<td>6 to 9 %</td>
</tr>
<tr>
<td>14 - 20 mm</td>
<td>5 to 8 %</td>
</tr>
<tr>
<td>28 - 40 mm</td>
<td>4 to 7 %</td>
</tr>
</tbody>
</table>

* For concrete exposed to freezing and thawing.
Improving the resistance of embedded reinforcing steel, tie bars and dowel bars to corrosion by:
- Ensuring that the minimum concrete cover over reinforcing steel meets the requirements of CSA-A23.1. Provision of additional cover to provide some tolerance during construction is also desirable.
- Ensuring that bridge deck joint design, particularly the shape of the longitudinal and transverse seal reservoirs, is selected to maintain a positive seal for the longest possible time. The designer should refer to American Concrete Pavement Association’s (ACPA) joint and crack sealing guide.
- Ensuring that the seals for longitudinal and transverse joints are made of durable materials.
- Ensuring that dowels and tie bars are resistant to corrosion by using epoxy coated steel or corrosion resistant steel.

Mitigate the damage caused by brine infiltration into flexible/asphalt pavements by:
- Designing pavements that are resistant to cracking by providing adequate pavement structure for the climate, sub-grade and traffic conditions.
- Designing asphalt pavements with an appropriate thickness consistent with best management practices.
- Designing partially or fully paved shoulders for roadways constructed with a rural cross-section that shed the brine away from the traffic lanes where it can cause less damage are desirable.
- Specifying that asphalt mixes with asphalt cements are resistant to thermal and fatigue cracking. Designers should select suitable grades of asphalt cement using guidelines such as the current Asphalt Institute’s “Superpave - Performance Graded Asphalt Binder Specification and Testing,” manual which provides guidance on the selection of appropriate grades, and specification requirements which can be used to develop QA and QC testing procedures.
- Providing a suitable internal drainage system as part of the pavement structure to drain away any infiltration that does take place. This includes the provision of base and sub-base layers that are permeable enough to drain rapidly and designing suitable outlets to allow the water to drain away.
- Limiting the fines content of the base granular material (passing the 75 mm sieve) to around 8 percent maximum for gravel sources and 10 percent maximum for quarried sources is desirable.
- Where drainage is a major concern, a limit of 5 percent fines content is desirable.

Construction

Designers should provide suitable project specifications to ensure good construction practices and quality materials. Contracts should include provisions for Contractors to carry out Quality Control (QC) testing to ensure materials meet the specification requirements and provisions for owner’s Quality Assurance (QA) testing to verify results.

Applying Road Salts

- Snow and ice control decision-making should be based on pavement temperatures rather than air temperatures.
- Pavement surface temperatures can fluctuate significantly depending upon the time of day, degree of cloud cover, sub-surface conditions (i.e. frost penetration, moisture presence, thermal retention properties, etc.) and type of pavement. Therefore ongoing monitoring of pavement temperatures is important to good decision-making.
- Solid road salt is usually placed on the crown or high side of the driving surface where a good crossfall and traffic will distribute the resulting brine over the road.
- Wider spread patterns are called for when spreading on deteriorated pavements where an undulating surface or poor crossfall will not ensure adequate chemical migration across the entire road, or when rapid distribution is required to address frost or black ice conditions.
- Applying liquid melting agents or pre-wetted salt can prevent or clear frost more quickly than solid salt. A straight liquid will avoid the endothermic cooling effect that solid salt can have on pavements.

SALT VULNERABLE AREAS

Though open friction course asphalt or grooved concrete pavements will shed surface brine more quickly, they can reduce salt spray and therefore may be beneficial in proximity to areas that are vulnerable to the effects of salt spray.
**MONITORING AND RECORD KEEPING**

- Pavement temperatures should be monitored to assist in making decisions. This can be done when mobile using hand held or truck mounted infrared thermometers. Road Weather Information Systems can provide a surface and subsurface pavement temperature at a fixed location, and can support the generation of a pavement condition forecast as well as real-time pavement condition information.
- Pavement temperature trends should be recorded in daily logs, along with pavement conditions, weather conditions and winter treatment strategy.
- Pavement temperature monitoring equipment should be tested at least annually to ensure that they are operating correctly. Inaccurate equipment should be recalibrated, repaired or replaced.

**TRAINING**

Training is described in detail in the Training Synthesis of Best Practices. The following pavement related topics should be included in a Salt Management training program.

- Understand the role of pavement crossfall in snow and ice control and when to windrow and when to broadcast chemicals;
- Understand the importance of pavement surface temperature on snow and ice control decision-making;
- Understand how to track pavement temperature trends;
- Understand what factors can affect pavement temperatures and how knowledge of these factors can be used to predict temperature changes;
- Understand how to treat different pavement conditions during different types of weather events.

**CONCLUSION**

Generally, good pavement design and construction will help resist the negative effects that snow and ice control chemicals can have on pavement structure integrity.

Also, good pavement design can help improve road salt performance, minimize usage for the same or better level of service and safety, and thus reduce environmental impact.

Road maintainers need to understand pavement temperatures and how these temperatures can vary, throughout both the day and the winter season, in order to make proper treatment decisions.
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7.0 DESIGN AND OPERATION OF ROAD MAINTENANCE YARDS

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. This Synthesis is provided as advice to road maintainers for consideration when developing their own Salt Management Plan. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of individual road agencies. Syntheses of Best Practices have been produced on Salt Management Plans, Training, Road and Bridge Design, Drainage and Stormwater Management, Pavements and Salt Management, Vegetation Management, Design and Operation of Road Maintenance Yards, Snow Storage and Disposal Sites and, Winter Maintenance Equipment and Technologies. For more detailed information, please refer to TAC’s Salt Management Guide – 1999.

INTRODUCTION

A Road Maintenance Yard is the location from which a road authority stages its road maintenance operations. It is referred to by a variety of other names including: patrol yards, camps and depots. It is likely that a road maintainer will work out of several different road maintenance yards throughout his or her career. Often in the past, these yards have been located and designed on the basis of some historic rationale. The yard layout is not often questioned and is not always understood.

This Chapter of the Syntheses of Best Practices is intended to present the salt management and environmental considerations that should be taken into account when designing, operating and maintaining road maintenance yards. There are many other considerations, particularly related to safety, that are unrelated to salt management that are not addressed in this document, but that should be taken into account when designing and operating maintenance yards.

The role of a maintenance yard can vary from being the central location for road operations (including administration functions) to simply serving winter operations only. The practices described in this chapter apply to both.

This Synthesis of Best Practices includes:

- salt storage;
- site drainage;
- site operation and maintenance;
- monitoring;
- record keeping; and
- training

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**RELATIONSHIP TO SALT MANAGEMENT**

In general, maintenance yards are constructed for multiple purposes including the delivery of winter road maintenance services.

For winter operations, there is a strong need to focus on salt loss, whether in the form of salt dust, brine runoff or simple wastage of road salts through improper handling practices. Lost salt will dissolve and can infiltrate into the soils below and adjacent to the site. Components of road salt entering the groundwater can travel great distances and affect wells, vegetation and surface water where the groundwater emerges as springs or discharges into streams.

There are cases where road authorities have had to replace salt impacted wells and the resultant corroded appliances of affected homeowners.

In addition, salt impacted runoff can affect vegetation and agricultural operations on, and adjacent to the yard.

Good yard design and salt handling practices are essential to preventing unnecessary salt loss and the resultant environmental impacts.

**The Yard In Action**

The yard layout should be designed to be efficient in all activities. Considering the cycle of handling road salts in the yard may reveal potential enhancements that can be made to improve yard efficiency and reduce salt loss.

The typical salt handling cycle (Figure 1) flows from delivery, to stockpiling, to loading on the spreader and then to exiting the yard. Upon return, the spreader off-loads unspent salt (preferably indoors), and the equipment is then washed to remove remaining salt residue.

Each area affected by these activities can provide an opportunity for improvement.

Typically, a delivery transport trailer end dumps or off loads the salt via a longitudinal conveyor. Preferably, the storage facility has been designed and constructed to allow the salt to be unloaded directly inside. If unloaded outside, the salt must be reloaded into a pile under cover.

Ideally, the salt should not be “double handled.” In some cases salt is blown into storage facilities using a closed pipe system to eliminate double handling. Whether mechanically piled or blown, each handling can cause particle breakdown, segregation and loss. While handling can serve to break up any chunks that may be present, the gradation will usually vary and this effort is inefficient. It also allows for a greater wind-blown loss of salt and the loss of salt fines that are remaining on the outdoor surface.

Spreaders are usually loaded using a front-end loader. Ramps at the yards were once common to facilitate loading by short loaders with small buckets. Ramps are prone to tipping and spillage accidents. Larger loaders and bucket sizes have increased the speed of the operation, however spillage at the time of loading is made worse by overloading. This spillage can occur either at the yard exit or before the spreader reaches the designated location, and to the operator yielding to the temptation of spreading the entire load rather than spinning off a potential surplus.

Where liquid melting agents are used, spillage of liquids can occur during production, delivery and transfer to spreaders.

It is not always necessary to spread the full load of material. Operators should be instructed to spread only what is needed to achieve the prescribed level of service. Unused materials must be returned and offloaded to the storage facility.

To minimize corrosion, spreaders are often washed following a storm. The wash water is likely contaminated with dirt, oil, grease, and salt (chlorides). If not properly handled, this wash water can harm groundwater quality, receiving streams, ponds and lakes and adjacent vegetation or agricultural operations.

To summarize, salt is lost to the environment in a variety of ways during the salt handling process. These include:

- spillage of solid salt during delivery, mixing of sand/salt blends, stockpiling and loading/overloading of spreaders;
salt being dissolved from uncovered stockpiles of salt and sand/salt blends;
- spillage of liquid deicing chemicals during production, delivery, transfer to spreaders or tank/line failures;
- vehicle washing; and
- blowing salt dust from exposed piles.

**Guiding Principles**

When planning, designing and operating a winter maintenance yard, the following guiding principles should apply.

- Locate and operate storage sites to minimize impacts to the natural environment and control nuisance effects, including noise, dust, litter and visual intrusion on adjacent landowners;
- Place stockpiles inside storage structures;
- Use low permeable surfaces to minimize infiltration;
- Collect and reuse or properly manage salt impacted site drainage and vehicle washwater to comply with local water quality regulations and protect surface and groundwater resources;
- Promote indoor operations where possible;
- Handle materials and clean up spilled salt to minimize salt loss to the environment;
- Collect and dispose of onsite contaminants and wastes in accordance with local waste management legislation; and
- Control emissions (drainage, noise, dust, litter, fumes) to prevent off-site environmental impacts.

**SALT MANAGEMENT PRACTICES**

**Planning**

While summer activities may dictate the core staff complement needs, winter route times and service levels are the determining factor in establishing the numbers of staff and equipment that must be allocated and housed. Recently, the number of maintenance yards in use has been scrutinized through benchmark comparisons for in-house services as well as through the evaluation of alternative service delivery models, with a view to consolidation. Whether consolidating or constructing at new locations, there is more to consider than simply efficiency improvements. The re-evaluation of yard needs provides an opportunity to achieve the most functional design with positive environmental returns.

A general yard location is dependent upon:

- Control of emissions (drainage, noise, dust, litter, fumes) to prevent off-site environmental impacts.
- the needs of the road authority;
- optimization of route times calculated to meet a required level of service;
- equipment abilities and capacities;
- the time and distance assumptions which are somewhat dependent upon loader and spreader capacities; and
- environmental considerations.

The supervisor of winter operations may not be able to make immediate changes to the winter equipment fleet. However, over time, as the winter fleet is improved, there will be more efficient use of resources. This will help to maximize the effectiveness of salt used, and to optimize the number of maintenance yards needed.

**Site Selection**

Next to the proximity to the road network to be serviced, it is important to assess site physiography and topography when choosing a new site. Ground conditions (soils or rock) and the lay-of-the-land complement the drainage management objectives.

For example, unlike granular bases, clay bases will prevent rapid infiltration of salt laden water. Conversely, highly permeable soils almost always allow the surface water to reach the ground water table. This may not be a serious concern if there is relatively quick outlet to a tolerant watercourse, but this can generate considerable liability if the groundwater impacted by salt becomes a well water source.

A site that has natural surface drainage will limit the impact on groundwater. Underlying soil and rock characteristics, groundwater characteristics and use, and proximity to, and sensitivity of surface water should be understood to evaluate potential impacts from the presence of salt. It is also important when selecting a site for a maintenance yard to understand the long-term land use plans around the potential site. If a development based on groundwater sources for its water supply is to be located down gradient from the maintenance yard then the road authority could face a future liability due to salt impacts to the groundwater.

A properly conducted environmental impact assessment, emphasizing the risks associated with salt loss pathways, will help to ensure that an appropriate site is selected.
7.0 DESIGN AND OPERATION OF ROAD MAINTENANCE YARDS

selected and that the proper considerations go into facility design.

When planning and designing road maintenance yards salt vulnerable areas must be taken into account. These vulnerable areas should be avoided to the extent possible. Where they cannot be avoided, specific measures should be included in the design to protect vulnerable areas.

Salt vulnerable areas could include:

- areas draining into bodies of water with low dilution, low volume or salt sensitive species;
- areas adjacent to salt sensitive vegetation and agricultural operations;
- areas draining into a source of drinking water (surface water and groundwater); and
- areas associated with groundwater recharge zones or shallow water table, with medium to high permeability soils.

The assessment of alternative sites should consider the potential chloride loadings to salt vulnerable areas and whether or not these loadings could have any adverse effects. Sites that have the potential to adversely affect vulnerable areas even after applying best management practices should be eliminated from further consideration.

**Design**

Maintenance yards are multi-functional facilities. A maintenance yard can be an evolving design. All functions conducted at the yard must be considered in designing the most suitable layout and features for the yard. The designers should consult with the people who will work at the facility when laying out the flow of the yard. The yard should be laid out to permit vehicles involved in the salt-cycle to move efficiently and safely about the site. The design should be flexible enough to allow the yard to be expanded as service delivery areas increase, or to be retrofitted to satisfy the latest method or policy change.

A yard which has ample size and access, and which has managed drainage is a facility which:

- is safe to operate from;
- is cost effective to use;
- facilitates the management of site drainage and vehicle wash water;
- protects salt vulnerable areas; and
- generates limited liability.

Practical considerations must include:

- providing indoor storage for all salt and sand/salt blends, preferably large enough to allow indoor delivery and spreader loading;
- noting the prevailing winter wind direction and positioning building and doors with regard to sheltering loading operations, minimizing snow drifting around doorways, and keeping precipitation out of the storage areas;
- providing proper lighting to help ensure safe and accurate salt loading operations when visibility is reduced during a storm event, especially at night;
- property spacing buildings and material storage facilities (e.g. liquid storage tanks) in order to maneuver vehicles promptly and safely;
- properly locating the office building with a viewing window suitable for observing the loading area (to confirm numbers of trucks, sizes of loads, and general yard activity);
- constructing storage facilities on low permeability pads to limit infiltration of salt laden drainage;
- constructing the loading pad of asphaltic concrete or other low permeability material at the entrance of the facility;
- directing drainage away from storage facilities and providing for the interception and management of salt impacted drainage;
- locating parking, fuelling and loading/unloading areas as well as paved pathways to permit efficient vehicle movements and limit backing operations;
- locating catch basins properly, with hook-ups to avoid directing salt-laden runoff through storm sewers into salt vulnerable watercourses, or directly into the ground through poorly sealed sumps;
- identifying snow storage around the yard perimeter to lessen the impacts of salt-laden melt water (see the Snow Storage and Disposal Synthesis of Best Practices); and
- locating the water well for the maintenance yard up-gradient to prevent it from being impacted by site operations.

**Storage**

Solid salt stockpiles must not be exposed to rain or snow. Dissolved salt does not “disappear”, but rather enters the groundwater and creates problems offsite.
Therefore, proper storage of salt and sand/salt blends requires that they be covered to protect them from the elements.

There are a variety of types of covers available. They range from temporary seasonal tarps to sheds, to large domes, barns or silos. Salt should never be stored outside.

In some cases, sand/salt stockpiles have been stored outside on low permeable asphalt or concrete pads and covered with tarps. Tarps are not recommended. It is very difficult to maintain tarps and keep the pile covered. Where they are used, tarping that has deteriorated must be repaired or replaced. Where covering the pile is not feasible, a system should be in place to prevent salt loss and environmental impact.

Sand/salt blend should be stored in structures, or on pads using containment. In British Columbia some yards are designed with a 12 mil plastic liner under sand piles to contain and collect drainage.

Structure designs range from the domes, to rectangular sheds or barns, to high arch structures, to elevated silos. Storage structures can be made of different materials including wood, steel, aluminum, fiberglass or fabric. The trend is to enclose the base of the pile and support the structure on a concrete wall, with or without a footing. These walls need to be designed to withstand the strain of materials and loaders pushing against them. They must also be free of gaps that would allow salt or salt impacted drainage to escape. Some combination of covers may also be possible, such as a canopy attached to a dome, or adjacent to a tarped pile in order to protect both the working face of the pile and to work under cover from the elements.

The roof and exterior of the storage structures should be constructed of waterproof material such that precipitation and moisture are prevented from entering the building.

The quantity of material to be housed depends on expected needs, the reliability of the material source, and the delivery frequency possible during the winter season. The volume housed must include a contingency quantity to ensure that the supply will not run out in times of need.

Consideration should be given to the multiple function of storing sand with salt or other winter operations materials. Some structures provide a more efficient capacity than others depending on the intended methods of putting up the piles as well as in using the materials.

Spillage during stockpiling and spreader loading is the main sources of salt loss. The extent, to which these activities can be carried out under cover, minimizes salt loss. However, there are special considerations that have to be taken into account when selecting the storage facility design to permit indoor activities. The two most significant ones are ventilation and door/roof clearances.

Even the door location and size is important. The door should be high enough to allow a transport trailer to end dump inside the structure. On rectangular structures, end doors are advantageous.

The entrance to the storage structure should have a door, curtain or a sufficient overhang to minimize precipitation entering the structure.

Where possible, the storage facility should be generally oriented such that the door is facing away from the prevailing winter wind direction. This will reduce the amount of precipitation entering the structures. Operational access and egress to the structures must also be considered in entranceway layout.

As well, many road authorities like to have their salt at one end of the structure and their blended sand at the other end with space to allow a pug mill and conveyor for creating the blend. This configuration warrants side doors to allow spreaders to drive through the structure and be loaded with different materials from either end.

Good ventilation is required when vehicles will be operating inside.

The floor of the structure provides both the operating surface and the barrier to infiltration of salt impacted water into the ground. Since indoor operations will place significant stresses on the floor, the floor must be designed properly. The floors of all structures should have low permeability and be constructed of quality strength asphalt or concrete that is sloped away from the centre of the storage area for drainage purposes. Both asphalt and concrete are somewhat permeable and should be sealed to minimize infiltration.

In evaluating the costs of the various storage alternatives, of special note is the comparison of the actual, realistic in-use capacity that is expected in service, rather than simply the theoretical capacity. For example, a conical structure with a given design capacity will be greatly underutilized if the material stored is in two piles, one on either side. Further, life cycle costs for repairs and intermittent refurbishing may demonstrate a less expensive net present value than that often presumed from an initial low bid. This caveat is mentioned
to generate interest in what may be a more functional facility at an appropriate cost over the longer term. In other words, the added cost to build a more functional facility can be recovered through the savings resulting from having a more efficient operation.

Other considerations include:

- adequate lighting;
- ample ventilation, either powered or natural; and
- accommodations for the method of “putting up the pile” e.g. baffles for minimizing loss when blowing in salt, adequate height for trailer dump or conveyors (either permanent or portable), protection for the use of loaders or excavators, subsurface hoppers, etc.

**Liquid Storage Facilities:**

- Designers should consult with local environmental regulatory authorities regarding siting and containment requirements for storage facilities.
- The required storage capacity will depend on the security of supply, production/delivery times and rate of use.
- Storage capacity can be reduced by using an “on demand” system.
- Where supplier-owned storage containers are used, arrangements need to be made for the delivery of full containers and removal of empty during yard operations.
- Supplier-owned storage containers should be treated the same as other brine storage containers (i.e. protected from vehicle impacts and provided with spill containment were appropriate).
- Where practical, secondary containment should be provided through double walled tanks or containment dykes. Typically, containment capacity is 110-125% of the capacity of the largest tank.
- Crash protection should be provided to prevent vehicles from impacting the production and storage facilities.
- Sufficient water supply is often a constraint when designing a brine production facility. The designer must ensure that sufficient water capacity is available to produce brine at the required rate for the maintenance operation.
- Water supply lines may need to be heat traced to prevent them from freezing.
- The freeze point of the liquid being stored and the lowest possible winter temperatures must be taken into account when determining the need to heat the production and storage tanks and piping.
- Emergency power supplies may be needed to ensure that liquid supplies are available in the event of a power failure.
- Designers must take into account the desired fill time for spreaders when selecting pump and line sizes. Pumps and lines that are too small will prolong the time it takes to refill onboard tanks.
- Production and storage tanks must be designed with a clean-out or flushing capability to remove settled impurities.
- Some liquids may require periodic circulation to prevent settlement of impurities, additives or product separation.

**Site Drainage:**

- The site should be graded to direct drainage away from the storage areas and to the extent possible, away from any down grade ground water well locations or salt vulnerable areas.
- Snow plowed from the site should be directed to areas where the melt water will be directed away from groundwater wells, storage area and salt vulnerable areas.
- Salt-laden water should be collected and properly managed. The water can either be used in brine production or sent for disposal at sewage treatment facilities where permitted.

**Operation/Maintenance**

In addition to proper design, good operating practices are important to minimizing material wastage and environmental impacts. Road authorities must review all aspects of their operations (delivery, storage, handling, site drainage, brine operations, vehicle washing etc.) to determine where salt loss is occurring and to develop procedures to minimize or eliminate these losses. The following practices should be followed.

**Salt Handling:**

- Where practical to do so, spreaders should be loaded inside the storage structure. Where inside loading is not possible, other systems are needed to recover salt spills that occur during loading.
- When loading spreaders outside of the storage structure, care should be taken to minimize spillage of salt onto the loading pad.
Overloaded spreaders are prone to spilling salt during operations. Therefore, spreaders should not be loaded beyond their capacity and, where feasible, should be covered with tarps when loaded with salt or sand.

When loading spreaders a maximum height above the grate should be approximately 30 cm to avoid lumps falling off into traffic and spillage. A rake down rack is often used.

A primary source of salt entering the groundwater is salt spillage that is either plowed or washed from the maintenance yard. Care to minimize spillage and practices to clean up spilled salt can reduce costly losses.

Stockpiles frequently have portions that have become frozen. These frozen blocks need to be properly managed and should not be placed into spreaders. These blocks should be pushed into the corner of the storage facility and allowed to thaw and dry. Once they have thawed and dried, the material should be broken up and reintroduced to the pile. Where brine production is ongoing, blocks of pure salt can be put into the brine production tank.

Deliveries of salt should be arranged such that material is placed within the covered storage facility as soon as possible upon delivery. Deliveries should be scheduled for periods of good weather.

All deliveries should be covered when being transported to the maintenance yard.

Spreaders should be properly calibrated and periodically checked to ensure continued calibration. They should be recalibrated following any servicing of the salt delivery system.

Some road authorities benchmark their beats to establish the amount of material that would be placed under specified application rates. At the end of a run, the total material placed can be compared to the benchmark to see if the projected amount was put down. If there is a discrepancy than the reasons can be investigated.

Salt and sand/salt mixtures that are spilled outside of storage facilities or within, or adjacent to maintenance yards should be collected and returned to the storage facility as soon as possible following the completion of the storm event.

Spilled materials should be swept up and returned to the pile. Some yards use mechanical sweepers.

Excess salt and sand remaining in the spreader following a storm should be returned to the storage facility and deposited within or as close to the entrance of the salt storage facility as possible. Where materials are off-loaded outside of the storage facility, they must be placed into the storage facility as soon as possible.

Vehicle Washing:

Spreaders should be washed at a location where the wash water can be properly diluted, disposed, or treated. Prior to washing, the spreaders should be swept to remove as much of the residual solids as possible and thereby minimize the amount of dissolved salt and solids in the wash water.

Where possible, vehicles should be washed indoors rather than outdoors to contain the wash water. Where only outdoor washing is possible, it should be done where all wash water can be contained and directed through positive drainage to a water management system. It is preferable to direct wash water to a storage facility where it can be reused for brine production or sent for disposal. Careful consideration must be given to the ultimate receiver of the wash water.

All vehicle wash water should be directed through an oil/ grit separator.

Sand/Salt Mixing:

Sand and salt mixtures should be mixed inside, or on low permeable pad located as close to the salt storage area as possible.

Mixing should be done during good weather. This will reduce salt loss due to precipitation and wind, and minimize the moisture content of the sand/salt mix.

Mixing should be done using a pug mill or some other method to achieve a homogeneous engineered blend. This reduces the amount of salt needed to prevent freezing of the pile.

Sand should be as dry as possible, thereby reducing the amount of salt required to prevent freezing.

After the sand and salt have been mixed, the mix should be loaded into a storage facility as soon as possible. The mixing area should then be swept and the sweepings returned to the storage facility.

Road authorities that purchase pre-mixed should check deliveries to validate that the percentage mix is as specified. Too high a percentage of salt is wasteful and too low a percentage may result in the pile freezing.
Salt Brine Production & Storage:

- Where regulations permit, consideration should be given to using wash water or salt laden drainage water for brine production.
- Where possible, clumps of salt or wet salt can be placed into the brine production plant rather than placing this material in the salt storage facility.
- Where salt brine storage tanks are used, these tanks should be placed above ground, protected from potential impacts by vehicles and periodically inspected for leaks. Secondary containment should be provided where a tank failure could result in environmental damage. Containment may be provided by double-walled tanks or dyking systems. Provincial regulatory agencies should be consulted to determine the containment and handling requirements.
- Periodic inspection of tanks, pumps and pipes/hoses should be carried out and any leaks should be repaired immediately.
- Brine production and storage facilities may need to be flushed periodically to remove sediments. The materials produced from this flushing activity are mostly sand and gravel and can be mixed with the abrasive pile.

Solid Material Storage Facilities

- Any roof leaks, tears, or damage should be temporarily repaired during winter to reduce the entrance of precipitation, with permanent repairs being completed prior to the next winter season. At no time should leaks be allowed to persist when materials are being stored inside.
- The floors should be inspected annually for cracks and repaired/resealed as required.

SALT VULNERABLE AREAS

To the extent possible, maintenance yards should be planned and located away from salt vulnerable areas. This requires sufficient investigations of potential sites to identify salt vulnerable areas and to factor them into the site evaluation process. Where salt vulnerable areas cannot be avoided, special design measures must be taken to prevent salt impacts.

MONITORING

It is important to understand how much salt is being used, where it is going and the resultant environmental impacts. Monitoring will aid in the determination of the extent of the impacts and effectiveness of the mitigation measures taken. Most activities should be focused on preventing, minimizing or mitigating the impacts. Attachment 1 provides a checklist for monitoring maintenance yards. In addition monitoring may include the following:

- Baseline condition (benchmarking) of site and surrounding area for future monitoring comparisons. For new facilities this should be completed prior to the site being commissioned.
- The amount of material used during the year should be monitored and reconciled at year-end.
- The use of weigh-in-motion (WIM) sensors at the entrance and exit to the site to confirm recorded amounts and track dispatches.
- WIM would work well in conjunction with a loader scale sensor so the operator is in control of the load and his good judgment can be confirmed.
- Road authorities should also monitor compliance with good housekeeping policies.
- Providing for an activity code in maintenance management systems specifically for yard housekeeping to maintain a focus on this important activity and not unnecessarily burden other activities.

RECORD KEEPING

The performance measures that should be tracked and monitored include:

- Percentage of sand/salt blends stored under cover.
- Percentage of salt stored under cover.
- Percentage of storage sites with collection and treatment of washwater and drainage.
- Inspection and repair records.
- Stockpiling records.
- Quality control records for brine concentrations.
- Levels of environmental indicators (e.g. chloride levels).
TRAINING

Training should focus on ensuring that those handling salt at the yard minimize the potential to waste salt and impact the environment. Prior to each winter all staff that are handling winter sand and deicing chemicals should receive training. The training program should focus on the following learning goals with respect to maintenance yards:

- Understand that all salt and sand/salt blends should be covered to minimize salt loss.
- Understand that salt spillage is wasteful and harmful to the environment.
- Understand the salt-handling activities that result in wasteful release of salt to the environment.
- Understand how these salt-handling activities should be carried out to prevent the waste release of salt to the environment.
- Understand the maintenance yard salt cleanup procedures that must be followed.
- Understand that timely yard maintenance and repairs are necessary to control salt loss.
- Understand the importance of proper record keeping and how to complete the required documentation on yard maintenance and salt use.

Training should be carried out through the following methods:

- Pre-winter briefings;
- Observation and corrective action; and
- Informal briefings during the season.

SUMMARY AND RECOMMENDATIONS

Most winter operators have an intuitive understanding of what works well in a maintenance yard setting. The practitioner’s advice should be sought in planning changes to facilities or in designing new ones. This consultation can also provide a complementary benefit of having the workers better understand why the facility is constructed the way it is and how it is expected to meet the needs of the winter service to be delivered. In designing a new maintenance yard or designing a major refurbishing of an existing yard, many of the above ideas are worthy of consideration. Information is also available from the Salt Institute and from storage structure suppliers for further guidance.
### ATTACHMENT 1 - Maintenance Yard Inspection Checklist

<table>
<thead>
<tr>
<th>YARD:</th>
<th>DATE:</th>
<th>INSPECTOR:</th>
</tr>
</thead>
</table>

#### STORAGE FACILITIES
- Inspect the roof for leaks and repair [☐]
- Inspect the floor for cracks and repair [☐]
- Inspect the walls for leaks and repair [☐]

#### SOLID SALT HANDLING
- Store salt under cover [☐]
- Deliver salt during dry weather [☐]
- Delivery trucks are tarped [☐]
- Deliver salt directly to the storage facility or place into storage immediately [☐]
- Load spreaders inside where possible [☐]
- Minimize spillage during spreader loading [☐]
- Spreaders are not overloaded [☐]
- Spilled salt is cleaned up quickly [☐]
- Excess salt is returned to storage [☐]

#### LIQUID STORAGE AND HANDLING
- Liquid storage facilities have secondary containment [☐]
- Inspect storage tanks, pumps, pipes and hoses for leaks and repair [☐]
- Train personnel in proper handling of liquids [☐]
### BLENDED ABRASIVE HANDLING

<table>
<thead>
<tr>
<th>Activity</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store blended abrasives under cover</td>
<td></td>
</tr>
<tr>
<td>Deliver abrasives during dry weather</td>
<td></td>
</tr>
<tr>
<td>Mix salt and abrasives inside where possible</td>
<td></td>
</tr>
<tr>
<td>Outdoor mixing only occurs during good weather</td>
<td></td>
</tr>
<tr>
<td>Mix only enough salt to keep the pile from freezing</td>
<td></td>
</tr>
<tr>
<td>Load spreaders inside where possible</td>
<td></td>
</tr>
<tr>
<td>Minimize spillage during spreader loading</td>
<td></td>
</tr>
<tr>
<td>Spreaders are not overloaded</td>
<td></td>
</tr>
<tr>
<td>Spilled blended abrasives are cleaned up quickly</td>
<td></td>
</tr>
<tr>
<td>Excess blended abrasives are returned to storage</td>
<td></td>
</tr>
</tbody>
</table>

### SITE DRAINAGE

<table>
<thead>
<tr>
<th>Description</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean drainage is directed away from storage areas</td>
<td></td>
</tr>
<tr>
<td>Salt impacted drainage is collected, treated and/or sent to proper disposal</td>
<td></td>
</tr>
<tr>
<td>Where collection and treatment is not practical, salt impacted drainage is directed away from salt vulnerable areas</td>
<td></td>
</tr>
</tbody>
</table>

### VEHICLE WASHWATER

<table>
<thead>
<tr>
<th>Description</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle washwater is collected, treated and sent for proper disposal</td>
<td></td>
</tr>
<tr>
<td>Vehicles are swept prior to being washed</td>
<td></td>
</tr>
</tbody>
</table>
Acknowledgements

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9.0 WINTER MAINTENANCE EQUIPMENT AND TECHNOLOGIES

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. This Synthesis is provided as advice to road maintainers for consideration when developing their own Salt Management Plan. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of individual road agencies. Syntheses of Best Practices have been produced on Salt Management Plans, Training, Road and Bridge Design, Drainage and Stormwater Management, Pavements and Salt Management, Vegetation Management, Design and Operation of Road Maintenance Yards, Snow Storage and Disposal Sites and, Winter Maintenance Equipment and Technologies. For more detailed information, please refer to TAC’s Salt Management Guide – 1999.

INTRODUCTION

Winter maintenance operating and research personnel in many parts of the world have identified new methods and technology that have the potential to improve snowfighting efficiency and significantly reduce the amount of road salts used to maintain roads and highways in the winter. Equipment is now available that incorporates these developments to reduce salt use, control the impact on the environment, improve winter driving conditions, safety and mobility, and reduce overall costs.

When selecting and deploying equipment, the best decisions can be made when proper information is available. In order to properly match equipment and service delivery in a way that optimizes winter maintenance performance, winter maintenance personnel need to understand:

- snow and ice control strategies and methods available to them;
- road and weather conditions that exist, that are forecast, and that need to be acted upon; and
- equipment and material availability, capability and limitations in use.

Equipment is a significant cost component (along with labour and materials) in a winter maintenance program. It is understood that it takes time to adjust the fleet and to incorporate an acquisition strategy into an ongoing budget. Further, it is important for an organization to continuously identify and assess new and innovative technology that supports best practices. Also, there are seasonality and frequency of use considerations as well as multi-functionality aspects in evaluating the economics of renewing the fleet. Management must balance all of the competing agendas in choosing the preferred equipment configuration, and a phase-in/out strategy for the fleet, with an understanding of salt use considerations.

RELATIONSHIP TO SALT MANAGEMENT

Winter maintenance equipment is primarily used to prevent or control accumulations of snow and ice. A sig-
nificant amount of the accumulation can be controlled by mechanical methods such as plowing. When mechanical methods alone would be inappropriate or ineffective, deicers must also be used. For a “saltable” road then, the approach is to place an amount of material on the road to prevent snow and ice from bonding to the road surface, to control the accumulation of snow and ice, and to achieve bare-and-wet followed by bare-and-dry pavement within prescribed standards.

Winter maintenance equipment, once optimized, can help an organization meet the 4-R’s of Salt Management:

- the Right Material;
- the Right Amount;
- the Right Place;
- the Right Time

In addition to the 4-R’s, a final key to effective salt management is:

- Keep it on the Road to Work.

Each organization will need to assess the winter materials available, to determine appropriate application rates for a given road network and cross-section, and determine the most timely moment for application in order to achieve the established level of service.

Following a principle of determining what is “right” for a given road authority, considering the 4- R’s will help any winter maintenance operation optimize the use of salt. Road safety will be maintained while controlling the impact of salt on the environment.

**SALT MANAGEMENT PRACTICES**

To optimize salt use, it is important to look continually at new and innovative technology as it becomes available.

Some salt use “optimization factors” to consider when making equipment choices include:

- improved information and decision making tools will allow equipment, personnel and salt to be better utilized and salt applications better timed;
- efficient mechanical control of snow and ice will minimize the amount of snow and ice to be controlled by chemicals;
- proper equipment choices will help operators to place the exact amount of salt required at the precise location where it is needed, at the right time;

chemical applications should occur at a time that prevents bonding of snow or ice to the surface;

- keeping good records of snow and ice control actions taken, along with material usage and a record of changing road conditions, will improve planning and budgeting and limit an organization’s liability;
- the safe and effective use of any equipment requires operators to be properly trained; this is particularly important when introducing new equipment and techniques.

**Information & Decision-Making Tools**

To make the best use of available equipment and personnel and meet the 4 R’s of Salt Management, experienced decision-makers in winter maintenance operations need information to support their judgment.

The critical information required can be divided into three categories:

- forecast information (what will happen), for predicting upcoming storms and potential icing events;
- current information (what is happening), providing road surface temperatures and conditions; and
- status information (what did happen), recording what was done and the Level of Service achieved.

A number of tools are available to help provide the required information. Typical examples follow.

**Road Weather Information Systems (RWIS)**

Sensor-based RWIS has been in use for over 25 years by road and airport authorities around the world. Beyond giving road information and trends, RWIS sites and networks provide information required to develop specific forecasts as well as some service documentation.

RWIS supports winter road operations in the following ways:

- An understanding of pavement temperature forecasts and trends can improve the accuracy of decision-making.
- Sensors embedded flush in the pavement, as well as sub-surface, generate data that can be sent back to central locations allowing trends and forecasts to be developed.
- Pavement sensors can monitor pavement temperature, wet/dry status, freeze point of the solution on the road, presence of chemical and concentration
(for some chemicals), as well as subsurface temperature.

- Tower-based sensors can also provide real-time information of typical atmospheric conditions such as precipitation, relative humidity, dew point, air temperature, and wind speed and direction.

- Weather forecasting services can use road-based information to provide “road weather” forecasts to help the road maintainer make better decisions regarding snow and ice control.

- Salt use optimization is achieved by more accurate deployment of equipment and application of chemicals.

- Other types of sensors and systems can be added to RWIS to further support road maintainers (e.g. road-imbedded device to measure road friction and snow cover, automated liquid deicer application system -Fixed Automated Spray Technology (FAST), - etc.).

**Infrared Thermometers (IRT’s)**

Decisions about material application are improved when information about the current road surface temperature is available and the temperature trend is known. Infrared thermometers are portable devices that can be used to determine the current road surface temperatures while mobile along the road network.

- Both hand-held and truck-mounted versions are available; with the mounted versions measuring ambient air temperature as well.

- Truck-mounted versions allow continuous monitoring of the road surface while the vehicle is moving down the road.

- The data can be recorded and transmitted as part of the data stream of a GPS/AVL system (see Operational Support Equipment later in this document).

- IRTs need to be checked and calibrated to confirm their accuracy and to be confident in the reading.

**Road Surface Traction Measurement**

Freezing precipitation degrades surface friction producing dangerously slippery roads. Road salts and, sometimes, abrasives like sand, are applied to combat slippery conditions and improve traction, increasing the coefficient of friction. Decision about material application can be improved by having better information about the current friction level of the road surface.

- The presence of precipitation or applied winter materials such as sand and salt can provide inconsistent friction across the cross section of the road surface.

- Numerous road authorities around the world are working with suppliers to develop reliable and accurate equipment to measure the available traction on roads.

- There are devices available to measure the degree of friction on the road surface. These have the potential to eliminate the unnecessary use of salt on roads with adequate traction.

- Friction sensors have been used extensively on airport runways, but their high cost is currently restricting widespread use on roads. Alternative designs promise lower cost. The Insurance Corporation of British Columbia has promoted the development of an automated in-road friction sensor that can also record the depth of snow cover.

- In some cases friction sensors are mounted on the spreader vehicles and used in conjunction with on-board mounted pavement temperature measurement equipment to automatically control the application rate of snow and ice control chemicals.

- Alternatively, the device could be mounted on a “smart patrol truck” with other winter maintenance tools.

- Technically, the equipment can be accurate and dependable, and has the potential to eliminate the unnecessary use of salt on roads with adequate traction.

**Residual Chemical Measurement**

After a storm event has passed and the road has become bare and dry, there often is a residue of chemical on the road surface. This chemical will be activated with the next precipitation event. As well the concentration of salt contained in roadway slush is the determinant of the freeze point temperature of the slush. It is helpful for decision-makers to know the residual salt concentration on the road. An RWIS road sensor will provide this information. Portable salinity sensors are available, although their high cost makes widespread use unlikely. Another tool on the horizon is a “chemical presence” sensor that can measure the chloride concentration of road spray in a vehicle’s wheel well.
Using Mechanical Means to Control Snow and Ice

Mechanical removal of ice and snow is usually preferable and this can be facilitated by preventively treating roadways with road salts. Such pre- or early-storm applications will often minimize the overall amount of road salts required to achieve the desired surface friction level. Reacting to a snow and ice event and applying road salts after a bond has formed requires additional salt to be used; proactively treating the road surface just prior to the event, or just as it commences, can prevent a bond, simplify the mechanical removal and expedite the achievement of bare pavement.

Some road authorities choose to leave a small amount of snow on the road before salt is applied in order to keep the salt from bouncing or being blown off the road surface by passing traffic or wind. This can increase the amount of salt required to “de-ice” or melt the snow packed on the road, and is not nearly as efficient in retaining salt on the road as other methods (e.g. slower spreading speeds, pre-wetting, “zero-velocity” spreading, etc.)

Accumulated snow and ice or slush can be controlled mechanically by removing it from the roadway through the use of plows mounted on trucks, motor graders or loaders. Snow blowers are also used in some areas. Repeated plowing operations in areas with limited roadside snow storage will require the snow and ice to be removed and disposed of. The following discussion provides a general overview of this equipment and some advantages and disadvantages of their use.

Snow Plowing

A wide range of plowing options are available including the type of vehicle used to carry the plow, the type of plow and mouldboard and even the type of cutting edge or blade.

VEHICLES

The vehicle type and size must be selected properly to be able to operate in the required area, carry and operate the mounted equipment and provide a safe and comfortable environment for the operator. Vehicles may also be multi-purpose, and be used for other duties during non-storm event times and during the off-season, summer months.

Considerations for typical units in use include the following:

**Trucks**

- Trucks come in various capacities and dimensions, and are commonly referred to as single axle, tandem axle or tri-axle units.
- Smaller, more maneuverable vehicles may be more suited to urban operations, whereas larger, more powerful trucks may be preferred on rural roads.
- Underbody plows can also be mounted on trucks and be used with down pressure.
- Trucks with front mounted plows and wings often provide the best solution as they can operate at higher speeds.
- Trucks can be configured with a hopper or tank to serve the dual-duty role of spreading materials as well as plowing.
- Where appropriate, the higher operating speeds of trucks allow roads to be cleared sooner.
- Trucks operating closer to the speed of other traffic present less of a safety hazard.
- Trucks operating at higher speeds can effectively “throw” snow a sufficient distance back from the edge of the shoulder to minimize snow bank build up.
- Higher operating speeds may be inappropriate in urban areas where snow thrown beyond the edge of pavement could damage roadside features.
- Careful attention must be paid to the truck specification to configure it as a frame-stiffened winter truck of suitable horsepower and hydraulics, rather than simply a generic cab-and-chassis off the production line.
- To ensure adequate traction and load bearing capacity, both front and rear tires must be selected carefully to ensure suitable tread pattern, material and sufficient load rating to handle both the material load and plows.
- Front axle capacity is a consideration, and the vehicle should meet legal weight requirements as necessary.
- Trucks require locking differentials or electronic traction control to prevent traction loss due to a spinning wheel.

**Motor Graders**

- Graders are often fitted with plows and wings to remove snow.
They can be fitted with front plows, including one way and reversible plows, 'V' plows, and side wings, with or without driveways.

Graders can also be mounted with a tooth or stacked-disc ice blade to scarify hard ice-pack and provide improved, temporary friction.

Modern graders, with large glass areas on the sides and front, and a high-mounted operator position, provide the operator with excellent vision of the area around the grader.

Graders are useful when working in tight quarters on urban streets with cul-de-sacs, elbows, bus bays, and varying road widths.

They promote a safer operation when working in the presence of pedestrians and heavy traffic.

Often this equipment is readily available for winter road maintenance as they are widely used by municipalities and contractors during the summer for road construction and maintenance, and are little used otherwise during the winter.

The heavy construction of the grader results in a durable machine for snowplow operations.

Modern graders can operate at much higher speeds than older models but are limited to thirty to thirty-five kilometres per hour and thus are slower than truck mounted plows.

Graders are effective during fall freeze-up and spring thaw when roads are soft and susceptible to digging-in by truck-mounted plows.

Loaders

Loaders are occasionally fitted with plows, wings and snow blowers for snow removal.

Modern loaders with large glass areas on the sides and front, and a high mounted operator position, provide the operator with excellent vision of the area around the loader.

Loaders are useful when working in tight quarters on urban streets with cul-de-sacs, elbows, bus bays, and varying road widths (particularly articulated loaders).

They can also be used to pick up and remove snow on cul-de-sacs, bridges and other tight areas with limited snow storage.

Loaders are readily available for winter road maintenance as they are widely used by municipalities and contractors during the summer for road construction and maintenance and are used extensively to load sand and salt onto spreader trucks at the maintenance yards.

**PLOWS**

The type of plow and cutting edge must be selected properly to be able to be mounted properly on the vehicle, to operate in the required area, and achieve the desired performance in snow clearing.

The selection of the appropriate type of plow, and proper adjustment of the plow will reduce costs and lessen the need to use salt to clear the roadway.

Plows should be operated with sufficient weight on the blade to effectively cut through packed snow and ice, resulting in a near-bare surface, in order to minimize the amount of salt required to fully-bare the pavement.

Plows for high speed operations should be fitted with shoes to prevent the plow from dropping into holes or catching on obstructions.

Plows should be adjusted to minimize the amount of weight carried on the shoes, but the shoes should be close enough to the pavement to absorb the weight of the plow if the plow strikes an obstruction. Castors are sometimes substituted for shoes to minimize wear.

Plows should be fitted with a tripping mechanism that will reduce damage to the plow if it impacts catch basin or manhole covers, curbing or other obstructions. The tripping mechanism will also prevent the truck from being violently deflected from its traffic lane.

Plows with an angle of about 55° between the blade and the road are the most efficient at moving large quantities of snow and cause the least amount of snow to be blown up at the front of the vehicle.

Tests also show that an angle of about 75° between the plow blade and the road provides the most effective cutting of heavily packed snow and ice.

One jurisdiction has used a 40° angle to improve snow pickup.

A rubber extension flap fitted to the top of the mouldboard of a front mounted plow and extends well past the cutting edge, can effectively improve the operators' visibility by trapping some of the snow cloud kicked up by the cutting edge.
Extensive aerodynamic testing is being conducted to develop airfoils that would trap the snow cloud created at the front of the snowplow.

**Front Mounted One-Way Plows That Move the Snow to the Right**
- The front mounted one-way plow provides the most efficient blade available for plowing snow. There are new designs available that improve driving safety by minimizing the amount of snow that escapes into the snow cloud at the point of impact.
- These plows are commonly used for high-speed removal of snow, slush and packed snow.
- They can be used to clear from minor amounts up to approximately 50 cm depths of snow at highway speeds;
- Steel one-way plows can be large and heavy, therefore the truck must be fitted with a high capacity front axle, and heavy duty wheels and tires.
- The size of the vehicle may be a disadvantage when clearing snow in congested urban areas and subdivisions with cul-de-sacs, etc.
- Piston-like cushions are available to reduce the pounding/bouncing of the blade on the road surface, which reduces the impact on both the truck and operator.
- These plows should be fitted with nose points to prevent the plow from catching on bridge expansion joints and cross cracks.
- A thorough training program is required to ensure that the operators are familiar with the adjustments to maximize snow removal and maintain all safety features in a fully functional condition.
- Either right and/or left side plow wings are usually fitted to extend the plowing width (see Wings or Wing-plows).

**Front Mounted Reversible Plows**
- Front mounted reversible plows are used to move snow to the left or right side of the truck and are useful for clearing left hand lanes (especially adjacent to a median) and ramps.
- They are widely used in urban areas because of their versatility.
- These plows work well in low speed operations, but are less suitable for high speed plowing than the one-way plow because the plow shape is less efficient, requiring higher horsepower engines or slower operating speeds.
- The snow is not thrown as far at the outlet end of the plow so more snow remains on the shoulder.
- The shape allows more snow to escape from the mouldboard and contribute to the cloud of snow surrounding the truck.
- Some manufacturers now offer reversible plows with mouldboards that can be reshaped to match the shape of one-way plows when the mouldboard is angled in either direction. These plows have been strongly endorsed by the plow operators, but are significantly more expensive.
- A unique variation of the reversible plow is a centre-hinged-reversible plow that can push left or right, or effectively become a V-plow.
- The plows may be fitted with nose points to protect against catching on minor roadway obstructions, bridge expansion joints, etc.

**Front Mounted “V” Plows**
- Front mounted “V” plows effectively handle deeper accumulations of snow.
- These plows have been designed to lift snow over adjacent windrows and to balance side loading by pushing snow to both sides.
- Their use is now restricted mainly to areas with high snowfall rates and as back-up units to open roads closed during severe storms.

**Wings or Wing-plows**
- Wings are smaller side-mounted plows that can be mounted on a tower or mast near the front of the plow truck, or further to the rear at the back of the cab.
- Wings can be mounted on graders as well.
- They can be mounted on either or both sides of the plow vehicle, and effectively increase the width of the plowed path.
- One disadvantage of wings is that operator visibility can be impaired.
- Wings improve efficiency and allow for increased snow removal, being especially useful in multi-lane clearing and when operating in an echelon formation since they help prevent leaving a windrow of snow on the traveled surface.
- Wings may be inappropriate in some urban settings where they can throw snow beyond the edge of pavement and damage roadside features.
Usually the vertical angle of the plow can be adjusted by a cable/chain or hydraulically, allowing the wing to be used for clearing shoulders or for cutting side banks of snow.

**Underbody Plows**

- The underbody plow is suited to applications on crowded urban streets, urban laneways and back alleys, as well as in some rural settings.
- They effectively serve as a two-way reversible plow and are normally stable.
- They are effective in clearing highly compacted snow and ice – by way of variable down pressure, using the truck’s compressed air system or hydraulic pressure and springs, to maximize effectiveness.
- These plows are limited to clearing snow accumulations up to 30 cm.
- Underbody plows are not normally used with side wings so the plowed path is limited and a laneside windrow of snow is created.
- A rear mounted snow wing is now available for trucks with underbody plows but the plowing width is less than that of a front mounted wing. With this configuration the vehicle might be expected to be less stable than front mounted wings as the side thrust from the wing is located further from the centre of gravity of the truck.
- In some cases the vehicle might be less stable due to excessive down pressure.

**Vertical Plows**

- A recent development in plows is the vertical blade which is flat but hinged in two locations (at third points) so as to push straight, right or left, or to effectively scoop snow by catching it and pushing it forward.
- This plow is usually loader or tractor mounted, and can accommodate a snow load traveling at slower speeds either forward or in reverse.
- A vertical plow is preferred in areas of unique geometry, or where access is tight.

**Cutting Edge or Blade**

- Snowplow cutting edges and blades are available in various designs and configurations for various operations.
- Regular blades are made of heat-treated steel or fitted with tungsten carbide inserts to improve durability (by a factor of up to eighty times in high speed operations).
- Rubber and polymer/plastic blades have been tried to minimize damage to catch basins, bridge expansion joints, centerline pavement markings and raised reflective markers, etc. These blades can be used to effectively “squeegee” the surface to remove slush in areas where the ambient temperatures usually rise above the freezing point during daylight hours after a storm. In areas with colder temperatures the use of these blades has not been as successful.
- Ice blades are used to cut into hard packed snow and ice that cannot be removed with conventional blades.
- Special plow blades with sliding segments that move up and down vertically facilitate the thorough clearing of rough or distorted pavement, reducing the amount of salt required to bare off the pavement. The manufacturers also claim that these blades minimize damage to the plow and truck from hitting obstructions, such as catch basin covers, as less force is required to retract one segment clear of the obstruction. These blades are well suited for high speed and rural plowing.

**Snow Removal and Disposal**

Over the course of a winter and multiple plowing operations snow will build up along roadways. Areas with limited space for plowed-snow storage may develop visual obstructions for drivers, act as a snow fence causing drifts to form across roads, and prevent future plowing operations from being productive once the snow capacity of the area is exceeded. In addition, accumulations next to guide rail, barrier walls and bridge approaches can freeze solid and create unsafe ramping conditions.

The piled snow, containing salt and other road contaminants, may need to be removed and disposed of or stored in an appropriate manner. Refer to the Snow Storage and Disposal Synthesis of Best Practices for more information.

Snow removal is usually considered a fair-weather or clean-up operation, and may entail traffic control considerations. Also, most removal operations often leave some snow on the road that must then be treated with abrasives or snow and ice control chemicals to maintain safe driving conditions.
Various removal methods and equipment are available and should be selected based on local needs. The following discussion provides a general overview of methods and equipment used to remove and dispose of accumulated plowed snow, and some advantages and disadvantages of their use.

**Loading, Hauling and Dumping**
- The most cost effective and easily mobilized removal operation for isolated locations is by means of a loader that fills conventional contractor dump truck(s), which then haul the snow to the appropriate site.
- The capacity of the loader and the truck body will determine the production rate and effective cost.
- Auxiliary equipment may be required to increase the efficiency of the operation. For instance, a grader may “peel” a snow bank into a suitable window in order to accommodate the loader and truck position.
- Since a loading operation necessarily impacts the flow of traffic in the area, traffic control or protection is often required, and consideration should be given to doing this as night work.

**Mobile Conveyors**
- Mobile conveyors are used to load snow from the shoulders or a window directly into trucks for removal.
- They can operate entirely on the shoulder with the unit and the truck being loaded both lined up on the shoulder and not disrupting traffic.
- They are useful in areas with high traffic volumes or limited access.

**Snow Melting**
- Snow melters melt snow that is picked up and place into a heated box. The resulting melt water is usually drained directly to the storm sewer system.
- Melters provide a solution for unique problem areas, particularly tight urban areas with limited snow storage available adjacent to the road on the right-of-way.
- This method of handling snow disposal was developed before energy costs escalated, and has become somewhat more expensive due to rising fuel costs.
- Melters may be an economical solution where the hauling costs are high (i.e. where snow disposal facilities are far from snow removal locations.
- Where sanding is a major activity in your winter operations, there can be a problem with plugging when melting sand-laden snow.
- Snow melters may involve water/waste treatment issues (see Snow Storage & Disposal Synthesis of Best Practices).

**Snow Moving**
- Snow bank accumulations may simply be handled by a conventional plow truck and physically relocated further back beyond the roadway and shoulder.
- High-winging or stepped-winging commonly is used to cut the bank height.
- In a rural and/or urban environment, a grader with or without a wing can be used to move the snow further back to create space for subsequent plowable storm events or to act as a barrier (snow ridge) instead of using a snow fence.
- Alternatively, the bank may be cut forward, toward the roadway, immediately followed by a full speed one-way plow run that effectively throws the loosened snow to the fence line.

**Snow Blowers**
- While blowers can be used during storm conditions, they are a slower production unit than a plow and are normally used for post-storm snow removal.
- Blowers are also used to load trucks for snow removal in urban areas, along roads with limited snow storage space.
- They are often owned by contractors or are a part of an equipment fleet that services a network of open roads in an area with very high snowfall rates.
- Blowers are typically mounted on dedicated trucks, tractors, or are attached to large front-end loaders.
- They are available with hydraulic powered vanes to control the direction of the blower in snow banks.
- They may also have hydraulic controls on the chutes to accurately direct the snow into the trucks used for haulage.
- Blowers can be used simply to widen the snow bank area and relocate the snow by blowing it beyond the bank toward the ditchline (where storage capacity is available).
- All blower operators must be aware of wind direction and the visibility concern that traffic could encounter.
Blowers may leave some snow on the road surface that could be plowed or treated with abrasives or a deicer chemical to maintain safe driving conditions.

**Using Road Salts to Control Snow and Ice**

Preventing a snow and ice bond to the road surface should be the top priority, and destroying that bond must be done as quickly as possible if prevention efforts from early-storm treatments fail. **Road salts prevent and destroy that bond, making removal by plowing easier, and melting that portion of the frozen precipitation that cannot be removed mechanically.** The key is to apply the right amount of the right material, in the right place and at the right time. Various chemical control strategies are available.

The following discussion provides a general overview of methods and equipment used to apply salt and sand, and some advantages and disadvantages of their use.

**Anti-icing/Deicing Methods**

- Anti-icing is the proactive use of any melting agent to assist melting and resist the formation of a bond between snow and ice and the pavement surface.

- Anti-icing can involve application to the roadway of liquids, pre-wetted solid granular materials or dry granular material. Thus, anti-icing is not confined to using liquids.

- Direct liquid applications are efficient since they provide melt action immediately and do not take time to dissolve and form brine. As well, liquids do not depend on the presence of heat from the ground, sunlight or traffic to dissolve (endothermic reaction).

- The timing of the application is not as critical as with granular materials; the principle is that traffic will help the liquid migrate across the road cross-section and yet not develop into road spray.

- If the application is earlier than the onset of a storm, a NaCl brine will evaporate leaving a salt crystal residue in the surface pores/texture of the pavement (and which will redissolve and reform a brine with precipitation); conversely, hygroscopic brines (such as CaCl₂ and MgCl₂) will attract moisture and continually wet the road until they are dissipated.

- The purpose of direct liquid application is to enhance road safety over the life of the storm, however the application of any liquid to the road surface, including rainfall, temporarily lessens the friction, and therefore the safety, of the road. The impact of this temporary effect can be minimized by using the appropriate liquid application method.

- An advantage of using a liquid is that it can be applied in advance of the start of a storm.

- The approach to resisting the bond is not to wet the road, but simply to provide enough chemical to enhance early-storm safety with an application of chemical that stays on the road. The intention is not to “wash” or even fully wet the road with an equivalent chemical loading as that of a granular application.

- Generally, an equivalent weight of salt applied as a liquid (e.g. dissolved in water) performs better than the same weight of dry granular salt because the liquid is fully retained on the road surface. **The cost on a dollar-per-gram basis may be greater for liquid only applications (depending on the liquid used), however the offsetting safety benefits have to be considered.**

- It is acknowledged that a direct liquid application has much less “staying power”, however the use of this procedure lessens overall chloride loadings per storm and allows for bare pavement to be achieved sooner.

- The application of liquids can be triggered by sensors and sprayed on a road or, more commonly, a bridge deck surface via Fixed Automated Spray Technology (FAST). The focus of this discussion, however, is on fleet-based equipment that performs the service over the road network.

- Direct liquid applications can be applied over multiple lanes by trucks traveling at higher speeds (than conventional salt spreading) with due regard for traffic.

- Trucks used for straight liquid applications can range in size, to accommodate frame-mounted or slide-in tanks. Truck configurations may include:
  - small trucks with tanks ranging from those used as patrol vehicles (pickups to two-tons) to vehicles used for vegetation spraying or bridge washing in the off-season;
  - larger trucks used for water applications or calcium dust suppression applications in the off-season;
  - full-size, larger capacity tractor trailer tanker units used for long distance hauling in the off season.
Trailer-mounted tanks may also suit the liquid application requirement.

Custom-built units may be required for specialized high-speed, multi-lane, long-range applications.

Mid-sized trucks used for direct liquid applications can also be outfitted with a plow and wing harness for subsequent use later in the storm.

Tank, pump and nozzle configurations, as well as the controller, will determine the preferred application practice and route range.

Gravity-fed applications also are possible.

The preferred applications make use of "pencil-sized" streams at 200 mm to 300 mm spacing; this prevents misting or atomizing the liquid that then blows away and doesn’t make it to the road surface.

An alternative to pencil-nozzles is the use of tube-trailers that run from each nozzle to the road surface and directly target the liquid without the stream passing through the air; though the tube has to be adequately clamped and will wear from the pavement surface, it better targets the liquid onto the road.

Pre-wetting Methods

Pre-wetting is a commonly used practice to improve retention and keep salt on the road by reducing the effects of bouncing, blowing and sliding of the salt or sand particles. This technique uses salt brine, liquid calcium chloride or other liquid chemical to wet the salt or salt as it is spread on the road.

Pre-wetting also enhances the melt action of the chemical present by speeding the dissolving of salt and the formation of brine.

Spraying stockpiles and truck loads has also been termed pre-wetting or “pre-treating”, but this past-practice is not as practical since the granules are not uniformly coated, the liquid may drain out of the solid material and the performance on the road is not consistent throughout the route. Therefore, pre-wetting should be done by spraying the salt as it is discharged from the chute, or at the spinner.

Practical considerations relate to the gradation of the salt being wetted, the maximum liquid to solid ratio that can be mixed, the amount of mixing action, caking/clumping concerns, etc.

Adjustment of the spray nozzles is critical. Tests by one state department of transportation showed that they never achieved more than 60% coverage of the salt. The remaining 40% of the pre-wetting liquid was effectively being applied directly on the road.

As the wetting agents are corrosive, it is important that corrosion resistant nozzles and non-contact pumps are used to ensure dependable performance.

Extensive testing is currently being carried out to identify optimum liquid application rates.

Pre-wetting provides significant potential for reductions in salt use but can increase the complexity of the required equipment and controller.

Pre-wetting requires additional equipment. Storage tanks for the liquid(s), or brine making equipment are required, along with pumps to load the spreaders.

The on-board liquid capacity and loading time are factors to consider.

The application pumps on the spreaders should be regulated by ground speed controllers to ensure the correct liquid application rate is maintained under all conditions.

Additional maintenance is required such as ensuring that the liquid filters, lines and nozzles are purged and the equipment cleaned at the end of the storm to prevent clogged lines and seized equipment.

Spreaders

The total amount of salt used for winter maintenance is significantly influenced by the characteristics of the spreader equipment.

Spreader controls must be capable of delivering several precise application rates.

The application rate should be consistent whether the spreader is full or nearly empty, regardless of material variations, or temperature changes.

When purchasing new equipment, road authorities should require test results from suppliers to confirm that the equipment will achieve precise application rates under all conditions.

Spreaders must operate in a severe environment of low temperatures, high moisture, poor visibility, and corrosion, often with limited maintenance.

Controllers must be easy to load, and simple to operate.
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- Ideally, a spreader should be adaptable for other tasks, or the hopper should be easily removed so the trucks can be used for other operations during the summer.
- Hoppers must be constructed so that all sand and salt can be easily removed from the body.
- Spreader should be fitted with screens to ensure that frozen clumps of material or other contaminating material that would jam the chain/conveyor mechanism are not loaded into the spreaders.
- Cab shields should be fitted to assist in loading the spreaders to ensure that all loaded salt enters the box, and material is not spilled over the truck.
- Spreader should be manufactured from a material that will resist corrosion. Special chlorinated rubber primers and epoxy-based primers will increase coating life. Stainless and galvanized steel and fiberglass bodies are available but can be relatively expensive. High strength, low alloy self-coating steel, used with good surface preparation and special primers have been proven to provide a cost effective body life of up to fifteen years. Manufacturers also supply spreader bodies constructed of fiberglass. These bodies are lighter and thus provide increased payload possibilities, but are also more expensive than steel.
- Electrical wiring for controls and lighting, and hydraulic components must be enclosed in vapour proof, or sealed systems.
- Neoprene spinners are frequently used to improve durability and spreading efficiency.

Spread Patterns
- Salt and sand application methods can be modified to meet differing requirements.
- Salt use sometimes can be reduced by applying the salt in concentrated locations (e.g. windrowed on the crown), rather than being spread uniformly or broadcast across the entire road surface.
- In most cases solid or pre-wetted salt should be applied in a continuous narrow windrow along the centerline of the road. The concentrated mass of material minimizes the tendency of the material to bounce or be blown off the road by passing traffic. Salt going into solution drains down the crossfall of the road, and can migrate under packed ice and snow; a uniform section of road is then bare off initially along the centre of the road to provide two-wheel stability for traffic.
- Application in a windrow is achieved without using the spinner, by dropping the material from a chute.
- Windrowing on the centreline will not work if the crown of the road is not consistently on the centerline, or the road surface is badly deteriorated which could cause the salt brine to pond in some areas.
- Centreline application is not appropriate if the entire road surface is slippery and immediate de-icing is required. In these situations, higher salt application rates may need to be spread across all traffic lanes.
- Application ahead of the drive wheels can provide improved traction under the drive wheels of the spreader vehicle. Application close to the driver’s cab also enables the driver to monitor the application to ensure that material flow has not been impeded.
- One argument in support of rear-discharge spreaders is that the drive wheels should not have enhanced friction if the steering wheels do not also have the benefit of improved friction. Otherwise, the driver may not be able to control the steering as the front wheels slide while the drive wheels continue to push forward. This is not normally an issue on bare-pavement policy roads unless there are significant grades in the area.
- Spreaders designed with discharge at the rear can allow for a slide-in capability that can be mounted and dismounted quickly.
- Discharge at the center-rear of the vehicle is simple but may restrict the vehicle to treating the lane in which the vehicle operates; some designs allow for the spinner “throw” to place the material at an offset from the vehicle.

Spread Types
- Manufacturers provide different spreader types to meet various requirements. The various designs have different characteristics that must be considered when a spreader is selected for a particular application. These include hopper spreaders, tailgate spreaders, reverse dumping spreaders, and some new variations of these types.

Hopper Spreaders
- Hopper spreaders have provided optimum performance and durability in the past.
- These spreaders are usually installed on trucks during the winter and removed and replaced by
standard dump bodies or other equipment for the summer (e.g. water tanks, concrete mixers, etc.).

- The design incorporates steeply sloping sides to eliminate material hanging up.

- A conveyor chain, belt or auger is used to move the material to the discharge location. Conveyor chains have proven over the years to be more trouble free than belts, and both are more accurately calibrated than augers.

- Augers have shown very high wear and poor accuracy in material control.

- The application rate of the material being spread is controlled by adjusting both the speed of the chain used to convey the material to the chute or spinner and the gate opening on the body.

- A constant source of power to drive the hydraulic pump was once provided by an integral small gasoline or diesel engine. Though a few are still in use, these engines are problematic and a constant source of downtime and maintenance. Reliable hydraulic pumps, driven from the truck engine, are now common.

- Conventional hopper spreaders provide good control of material application and dependable service. However, they are the least versatile for other operations during the off-season.

- New hopper designs, including rear-discharge, slide-in units with a longitudinal agitator bar and belt conveyor are gaining popularity, particularly for pre-wetted applications.

Tailgate Spreaders

- Tailgate spreader units mount on the rear of the truck dump box and are filled by raising the body and dumping salt into the integral hopper. The salt is then conveyed to the centre line of the road by a chain or auger and applied to the road in a window or spread over the lane surface using a spinner.

- These spreaders are considered a simple and dependable unit. They are used extensively in areas where storms are less frequent and the trucks can be used for other purposes, or as backup units for hopper spreaders.

- Their primary limitation is the inconvenience of raising the dump box and the possibility that the box will not be raised high enough to ensure that sufficient material is dumped in the hopper to provide consistent delivery.

- The rear discharge restricts the operator view of the operation and ability to ensure that the material is being discharged at the right location.

- The vertical clearance and the upward and rearward shift of the centre of gravity when the box is raised can cause instability and is a safety concern in some areas.

Reverse Dumping or Dual Dump Spreaders

- These spreaders were developed to overcome problems identified for tailgate spreaders while still providing a multi-purpose spreader that could be used year round.

- They function as regular rear dumping bodies when not being used to apply winter maintenance materials.

- The pivot pins can be repositioned so the standard hoist can be used to raise the rear of the body. This moves the salt or sand to the chain conveyor at the front of the body that moves the material to the distribution point ahead of the rear wheels.

- These spreaders have the advantage of providing year round service and can be switched from hauling construction materials to winter maintenance use with no adjustments required.

- Disadvantages of this spreader are the high weight compared to a regular dump truck, and the need to raise the body while driving to move the material to the front of the truck. This reduces the truck’s stability and care is required by the operator to ensure that sufficient material covers the cross conveyor at the front to maintain a precise application rate. The pivots have been a source of failure and replacement is expensive.

- A variation of the reversing dump body is the side-tipping floor. The floor and passenger side of the box are raised to move sand or salt to the driver’s side of the truck where a longitudinal conveyor moves the material to the front of the box for distribution ahead of the rear wheels. This arrangement eliminates the strong weight shift to the front of the vehicle and the material is distributed ahead of the rear wheels where the operator can easily monitor the application. The complexity involved in ensuring that the box is tipped far enough to cover the conveyor is a disadvantage. Some problems have been encountered with body integrity, as the full support of the contractors dump box is not avail-
able. The vehicle is also more heavily loaded on the driver’s side and braking on slippery roads could be affected.

**Multipurpose Spreaders**
- Multipurpose spreaders incorporate most benefits of the other spreaders.
- They use a longitudinal conveyor to transport salt or sand to the front of a large modern contractors’ dump box.
- A recent design makes use of a U-shaped box to ensure that no material hangs up in the box and that all material can be easily removed from the box at the end of the shift.
- A lateral conveyor at the front transports the material to the left or right side of the body for distribution ahead of the rear wheels.
- The material is either discharged in a windrow using a chute for concentrated action, or spun across the lane using spinners.
- The spreader provides precise application rates and all the advantages of distribution in front of the rear wheels.
- The cross conveyors are easily removable during the summer so that there is no tire weight penalty.
- The units are lightweight and provide year-round use.
- The body can be easily switched to carrying construction materials (simply by installing a pan or tray across the floor conveyor).
- These units can carry substantial loads so care must be exercised to ensure that adequate truck components, axles, springs, and wheels, are specified to carry the load. This is particularly important on combination units that are also equipped with snow plows.

**Rearward Casting Spreaders (e.g. Zero Velocity)**
- With normal spreaders, a high percentage of the dry salt applied to the road bounces off the road due to the combination of the impact of the granules hitting the pavement, and the speed of the spreading vehicle.
- Most road authorities now theoretically constrain their spreading speed to avoid wasting salt due to the scatter effect at higher speeds. In practice however, speeds of 40 km/hr and more are not uncommon. If salt could be applied at higher speeds, combination units would be much more productive as the unit could apply salt at plowing speeds. This would allow for safer operating condition since trucks could move at the speed of traffic.
- Casting material rearward has shown potential for salt use reduction by increasing the percentage of applied salt that is retained on the road, and in the required location on the road.
- This is a concept by which the salt is discharged rearward at exactly the same speed as the spreading vehicle is traveling forward. The two velocity components cancel each other causing the salt to drop on the road as if the spreading vehicle was standing still.
- To-date, the available equipment has experienced some operational problems such as material caking, uneven discharge and mechanical complications (fan/blower) under certain conditions.
- One manufacturer makes use of a shielded-spin- ner at the mid-chassis discharge location, discharging at a point just beyond the width of the rear wheels where the material is “flung” rearward.
- Another manufacturer used a high-speed blower to discharge the salt rearward. This results in a large cloud of salt that can be hard to control and may be affected by side winds.
- Also, the spreader units may not suitably handle pre-wetted material or finer sands.
- Though useful for salt applications, there is no good way to spread sand with these spreaders.
- Modifications are being developed and it is anticipated that further refinements will enable road authorities to reduce application rates and increase application speeds using this concept.

**Rear-discharge Spreaders**
- Based on the premise that no salt particle should be placed dry onto the road surface, and that fine salt is the gradation of choice for prompt dissolving and melting, certain spreader design characteristics cater better to liquid and fine salt use in pre-wetted applications.
- The salt must be of a fine gradation in order for it to retain the brine moisture content and fine salt does not travel as easily on certain chain-type conveyor systems.
Increased liquid use can have detrimental effects on equipment when the discharge location is other than at the rear.

These spreaders allow a “high-ratio” salt application rates up to 255 litres per tonne of salt, or at a ratio of 30:70 liquid-to-solid by weight. This requires a large capacity of liquid onboard and adequate pumping capability which may not be possible or practical on a conventional retro-fitted unit.

They are either frame-mounted or slide-in, rear-discharge v-hoppers can stand on self-contained still legs in the maintenance yard, and remain tarped until needed.

In one design, an internal longitudinal agitator bar meters salt from the hopper, while breaking down chunks in the load, onto a belt conveyor that moves the material to the rear-discharge location.

Calibration by weight can be done accurately off the rear belt.

Pre-wetting liquid can be applied directly on the spinner, that is designed to spread the material across a given area of the road cross section.

Though some units are considered to be well-built, they cost more than conventional spreaders.

One consideration is that areas that only have access to coarser salt may find that the liquid component must be reduced since saturation can be achieved with less liquid.

One model has a spray bar at the rear for direct liquid runs as well as pre-wetted or dry applications.

Another model can perform liquid only applications from the spinner without a spray bar.

Overall spreader designs are evolving and are worthy of continual investigation.

**Electronic Spreader Controls**

All spreaders require an accurate electronic controller to ensure that the appropriate application rate is achieved.

Simple hydraulic circuits, used to maintain a steady application rate, are still in use in many road authorities. This equipment starts to exceed the desired application rate as soon as the truck speed drops below the design speed and an excessive salt application is then dumped on the road.

Early models of the electronic controllers were not dependable and required extensive maintenance. The new models are improved but can still require some patience.

Modern spreaders use electronic groundspeed spreader controls to provide consistent, accurate application rates. The truck speed is monitored from the truck’s speedometer drive, and the spreader output is adjusted to maintain a steady output at the set rate per kilometre. Both open loop and closed loop systems are available to monitor material flow and provide increased accuracy of the spread rate (closed loop systems provide confirmation of the actual application rate).

Electronic controllers automatically increase the output rate if a second spinner is actuated (if so equipped) to treat truck climbing and turning lanes.

With some electronic units, calibration settings can be applied electronically using infrared controls.

Information that is captured and logged can include: amount and type of material applied, gate position, run time, blast information, average speed, spread width/symmetry, etc..

Manufacturers can now provide units that record, for printing, information about the amount of salt used, the time it was used, and the associated application rate, for analysis and control by the road authority.

Units are also available that incorporate global positioning systems (GPS) for automated vehicle location (AVL) and to identify where the material was discharged (either generating a passive history or a live transmission).

One caution is that there is no industry standard format in place for this information reporting; it is difficult to compare and combine the information from the units supplied by the various manufacturers.

Controllers may or may not be required for direct liquid applications; volume-distance distribution rates may suffice for certain jurisdictions.

**Calibration**

Regardless of the spreader chosen, the service provider must have faith that the application rate settings are indeed accurate. A calibration policy should be established to assure the material settings are correct. Preferably, if application is by weight, then calibration should also be by weight. Calibration checks or recalibration
should take place several times during the season, including:

- after repairs;
- when distribution calculations show a discrepancy between theoretical and actual;
- spot-checks on units in the fleet throughout the season.

**Operational Support Equipment**

Various types of equipment support the winter maintenance program either by helping manage the operations by generating useful data or by supporting the service delivery itself. Such equipment includes the following functions:

**Material Usage Monitoring**

**Loader Mounted Electronic Weighing Equipment**

- Loading extra material onto a spreader can lead to overloading or the temptation to over apply the salt. In the past, operators tended to load a little extra salt as there was no exact method of determining the amount of material loaded, and they did not want to run out without completing the route. Overloaded trucks also contribute to contamination in the area of the salt storage facilities. Salt heaped above the side boards is thrown off the trucks as they negotiate curves to exit the yards.

- With electronic scale control systems operators can more precisely load the right amount of salt.

- This device is a relatively inexpensive, durable, and accurate weighing device consisting of a transducer load cell mounted to the loader bucket arm.

- These devices can measure a predetermined load size for the scheduled route (length of route x application rate + a limited contingency amount for bridge decks, intersections, etc.).

- Models are available that will record with the loader in motion so that the loader operation is not impeded.

- The units will record the amount loaded for future printing and analysis.

- Though the equipment can be overridden, it provides the operators with a mechanism to accurately measure and control the amount of material loaded on the spreaders.

**Truck Scales**

- Weighing the trucks as they enter and leave the maintenance yard is one way of determining the material loaded and the resulting spread rate for the serviced route.

- This function can be automated with a weigh-in-motion pad that tracks the equipment movement and can serve to reconcile the data from the spreader controller and other documentation.

**Liquid Meters**

- Pump meters will likely be used to measure delivered brine, but not likely be on each pre-wet unit.

- A meter should be in place at the brine supply facility, whether the source is hauled brine or manufactured brine, in order to track loading times and quantities.

- A cross reference should be incorporated in the electronic log to identify the truck loaded for future reference.

**Automated Vehicle Location (AVL)**

- Tracking equipment movements along with the services provided is possible via proven GPS receivers/transmitters and software.

- This electronic record can be actively followed real-time or can be passively recorded for later analysis.

- AVL can support a route optimization exercise, to rationalize the number of trucks required and thus the expected salt to be used on the roads serviced.

- This equipment can provide operational support to greatly enhance the monitoring of salt usage, to demonstrate prudent usage and to correlate with the achievement of the required level of service.

**Material Loading and Handling**

**Bulk Salt Handling by Loaders**

- Extensive environmental contamination has been identified in the area of salt storage yards. Much of this contamination results from poor salt handling practices.

- Conveyors are available which are designed to allow salt trailers to dump directly into the conveyor for movement into the storage facility.

- Loaders used to fill spreader vehicles are often fitted with buckets that are too large for the spreader hopper bodies. This results in spillage. Though
they have a slower production rate, smaller buckets are available for most loaders, or side dumping bucket attachments can be used which provide quick precise loading.

**Bulk Material Conveyors**

Various bulk facilities are in use as follows (and are further described in the Maintenance Yard SoBP):

- Pre-loaded drop-hopper loaders meter salt into spreader trucks.
- Overhead silos can be pre-filled with salt to similarly meter salt into spreader trucks.
- Pneumatic handling equipment can handle fine material that is used for either direct application onto the road or for blending with sand.
- Whatever equipment is used for moving salt, it should provide a way of tracking the flow so the quantities can be reconciled.

**Sand/Salt Blend Mixers**

- Salt is normally blended into stockpiled winter sand for the main purpose of keeping the sand free-flowing and to prevent it from freezing in the winter.
- High-ratio mixes are rarely necessary; an exception might include anticipated periods of rapid temperature fluctuations.
- Ideally, blended winter sand stockpile are put up in favourable, dry conditions.
- Relatively dry sand stored indoors should not require more than 1-2% salt by weight; more moisture in the sand may require more blended salt (up to 5%), but the purpose still is to keep the sand free-flowing, and not to support melt action.
- Traditionally, blending took place on the apron to the storage shed, with several buckets of sand spread level, followed by one bucket of salt trickled on the surface; the resulting blend was loaded in the dome, and the process was repeated.
- Though highly inefficient, it was also highly inaccurate, and produced sporadic result on the pavement surface.
- Equipment to support high-production stacking and uniform, light blends now involves a form of dual-auger pugmill or a twin conveyor feed. In either case, two supply lines are metered to an accurate ratio and the final conveyor stacks the completed mixture.

**Brine Supply Equipment**

- The following two sections discuss aspects of brine production and delivery. Further issues on brine supply and liquid storage are contained in the Design and Operation of Road Maintenance Yards SoBP.

**Brine Production Equipment**

- Several manufacturers offer equipment to manufacture salt brine for pre-wetting and liquid anti-icing applications.
- Both batch plants and higher capacity continuous flow plants are available.
- Water is added to rock salt in the batch plants to produce a saturated brine solution.
- In the continuous flow plants, normally water is forced through salt under pressure. Solution strength can be metered and controlled automatically.
- Overhead drop-hoppers can slowly meter the salt into the water for quicker dissolving.
- In all cases, the concentration should be checked with a hygrometer to measure the specific gravity of the solution. The percent of saturation is determined by reference to specific gravity charts for the specific solution temperature.
- Water supply flow rates are a critical factor. Production sites may require cisterns to ensure adequate water supply where well production rates are poor.
- Most salt supply specs allow for some insoluble contaminants in the salt. This can amount to approximately 100kg of waste grit when using a 96% pure salt source per one-bucket (2m³) or 10,000 litre brine batch. Clean-out time should be accounted for in production rates.
- Manufactured salt brine can be pumped directly into tanks mounted on the spreaders or transferred to holding tanks at the maintenance yards.
- Stored brine will normally stay in solution as long as there is not evaporation or a drop in temperature below eutectic.
- Corrosion inhibition requirements can complicate the brine manufacturing process.
- Additives such as rust inhibitors may complicate long-term storage, in which case agitation or recirculation could be considered.
Brine Delivery Equipment
- Unlike brine production, no special equipment is required for liquids that are delivered.
- Sampling containers and a refractometer or hygrometer should be available for sampling and testing the concentration.

SALT VULNERABLE AREAS
Having proper equipment and effectively using this equipment are the most effective ways of ensuring that the right amount of salt is placed at the right time and in the right location. Road authorities should strive to improve their fleet as quickly as possible given their fiscal realities.

As new equipment is phased in, priority should be given to allocating the new equipment to roadways adjacent to salt vulnerable areas, and reallocating less salt-efficient equipment to less sensitive areas.

MONITORING & RECORD KEEPING
The data logging and reporting capabilities of loader scales, electronic controllers and GPS/AVL systems can assist road authorities in more accurately tracking their salt use. Progress in implementation of best salt management practices can be measured in improvements to the fleet. Monitoring and record keeping should include:
- type and amount of winter materials being placed;
- percentage of fleet equipped with electronic spreader controllers;
- percentage of fleet equipped with pre-wetting;
- percentage of fleet equipped with direct liquid application;
- percentage of fleet calibrated annually; and
- percentage of staff trained in equipment use.

TRAINING
Traditionally, equipment-related training focused on equipment maintenance and the safe operation of the vehicle. This was followed by specific training on the differences between vehicles, which covered the spreader controller features and how to change settings, etc.

These aspects of staff training are still essential to the safe and effective use of equipment. Further equipment-related training, however, should also emphasize the impact of the operator’s decisions made along the route, the range of settings and methodologies available to the operator, and tie these to her/his roles as a “snow and ice controller” and “decision-maker.” Equipment training is integral with other winter maintenance topics such as the science of salt and record keeping.

In the past, a plow operator could be forgiven for only plowing, just as a spreader operator might only spread. That was the job after all. With today’s understanding of best practices for snow and ice control and with the more sophisticated equipment that is available, operators need to understand that “decision-making” means choosing to spread when appropriate, and – equally important – choosing not to spread when it is not required. It is also important to choose to plow the accumulated snow and slush, but also important to not prematurely plow salt-laden slush before the salt has done its job.

To ensure operators are confident in their duties and in using the assigned equipment, they should have training in such equipment-related topics as:
- route familiarization (preferably during daylight);
- pre-season driver training;
- spreader calibration;
- “circle-check” procedures;
- spreader controller operation;
- brine equipment operation;
- equipment washing procedures;
- minor equipment repair;
- good housekeeping practices;
- record keeping;
- use and interpretation of pavement sensor data and forecasts;
- infrared thermometer use; and
- agency policies.

The following equipment-related learning goals should be included in a training program:
- Understand the concept of putting out the right material, in the right amount, at the right time, and leaving it there long enough to do the job.
- Understand how the electronic controller and gate settings on each spreader must be set to achieve the specified application rate.
Understand how to calibrate each spreader to ensure that the right amount of material is being spread.

Understand how to recognize when re-calibration is necessary.

Understand the importance of timely plowing.

Understand how to efficiently plow each beat/route.

Understand the role and effective placement of snow-drift control devices (structural snow fences, snow ridging, agricultural stubble, living snow fences).

Understand how to fill spreaders and anti-icing units with liquid chemicals.

Understand the health, safety and environmental precautions that need to be taken when handling liquid chemicals.

Understand how to measure brine concentrations.

Understand the components and purpose of RWIS installations.

Understand how to properly mount a truck-mounted IRT so as to avoid erroneous readings.

Understand that IRTs are for measuring temperature trends not exact temperatures.

Understand precautions about handling and using IRT's.

Understand the importance of proper record keeping and how to complete the required documentation on equipment maintenance and salt use.

**CONCLUSION**

Modern snowfighting equipment used to clear roads in winter, including snowplows and spreaders, has improved significantly in recent years. Using new technologies, together with implementation of anti-icing and the expanded use of liquid materials, winter road maintenance can be completed to the same or higher standard and with a substantial reduction in salt use.

Equipment is available to facilitate precise controlled applications of material, at the newly reduced rates established as a result of extensive research and testing. This equipment is much more sophisticated, durable, and easier to use, but the potential benefits can only be realized if maintenance staff are thoroughly trained and material use is closely monitored.

In the future, application rates may be tied into sensor based information systems including real time data, forecasts, road friction measurements, road surface temperature measurements, and global positioning equipment. As the use of this technology evolves, considerable planning, organization and evaluation are required to ensure the best use of the equipment that is available now.

A transition strategy will be required to shift from the existing fleet to a new fleet that incorporates available technology. This changeover cannot happen overnight, but the shift can occur strategically. For instance, the spreaders on the highest salt routes or in proximity to vulnerable areas could be targeted first for replacement, and the most versatile mechanical removal equipment could be stationed where it will help lessen salt loadings. To gain experience in new methodology, new equipment could be assigned to preferred “champions” in the organization for demonstrated use on less significant roadways until there is confidence in the new practices.

Review your organization’s equipment needs and fleet management strategy regularly, and stay current with changes in the business.
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