Smart Salting for Parking Lots & Sidewalks

August 2022

MINNESOTA POLLUTION CONTROL AGENCY

Table of contents

List of figures

List of tables

Disclaimer

The MPCA Smart Salting Training Program provides instruction and guidance about the most current best management practices and technologies intended to provide safe surfaces while minimizing the negative impacts of chloride on the environment and infrastructure. Clear policies that include maintenance considerations such as service level, reasonable professional care, and appropriate use and documentation of best practices may help to reduce potential liability risk. The instruction or resources provided in the Smart Salting trainings are not a substitute for professional legal advice. Always consult a legal professional before implementing a comprehensive liability risk reduction plan.

Acknowledgements

This manual is dedicated to helping Minnesotans protect the environment. The *Winter Parking Lot and Sidewalk Maintenance Manual* was based on the *Minnesota Snow and Ice Control Field Handbook for Snowplow Operators*, prdoduced by the Minnesota Local Technical Assistance Program Center, and the training materials for the MPCA Smart Salting for Parking Lots and Sidewalks training. This manual has evolve since 2005, as has the winter maintenance industry. This manual is intended to accompany the MPCA Smart Salting for Parking Lots & Sidewalks certification training. It can be found at: **www.pca.state.mn.us/water/salt-applicators**

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Manual purpose

The purpose of this manual is to deliver practical winter maintenance best practices and advice to those managing parking lots and sidewalks on their own, or who hire it out. It offers proactive, cost-effective, environmentally conscious choices in winter parking lot and sidewalk management. This knowledge will provide the opportunity to become a leader in the industry by operating more efficiently and reducing environmental impacts.

A single approach will not work for the range of conditions we experience in Minnesota. A variety of strategies are needed for different regions and constantly changing weather conditions. We encourage continuing to test, document, and refine the practices from this manual.

Throughout the manual environmental tips will be shown with a fish symbol. These tips will reduce environmental impacts from snow and ice control operations.

Throughout the manual cost-saving tips will be shown with a dollar symbol.

Environmental impacts of chloride

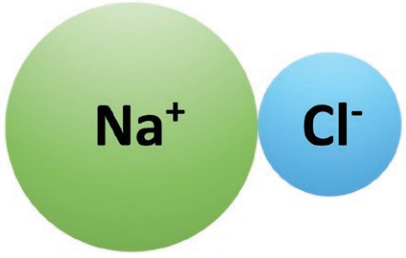
Minnesota has a growing salty water problem. Chloride is a permanent pollutant. It does not breakdown or degrade over time and will persist in our waters. Chloride is a pollutant of concern because it is toxic to freshwater fish, amphibians, insects, and plants. Once used, it seeps into lakes, streams and groundwater. It is far too expensive and difficult to remove with current technologies (such as reverse osmosis). Salt is used widely and is an important public safety tool in winter conditions. The Smart Salting program is not about decreasing public safety, but instead is advocating for smart salt use practices, based on the best science to inform decisions.

Did you know? Chloride is a permanent pollutant.

Salt vs. chloride

When referring to salt in this manual, we are talking about chemical compounds that contain a chloride ion (Figure 1). These compounds include sodium chloride (NaCl or rock salt), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) and potassium chloride (KCl or potash).

Figure 1: Depiction of a sodium chloride (NaCl) compound



"Salt" and "chloride" are often used interchangeably when referring to this type of pollution.

Background information

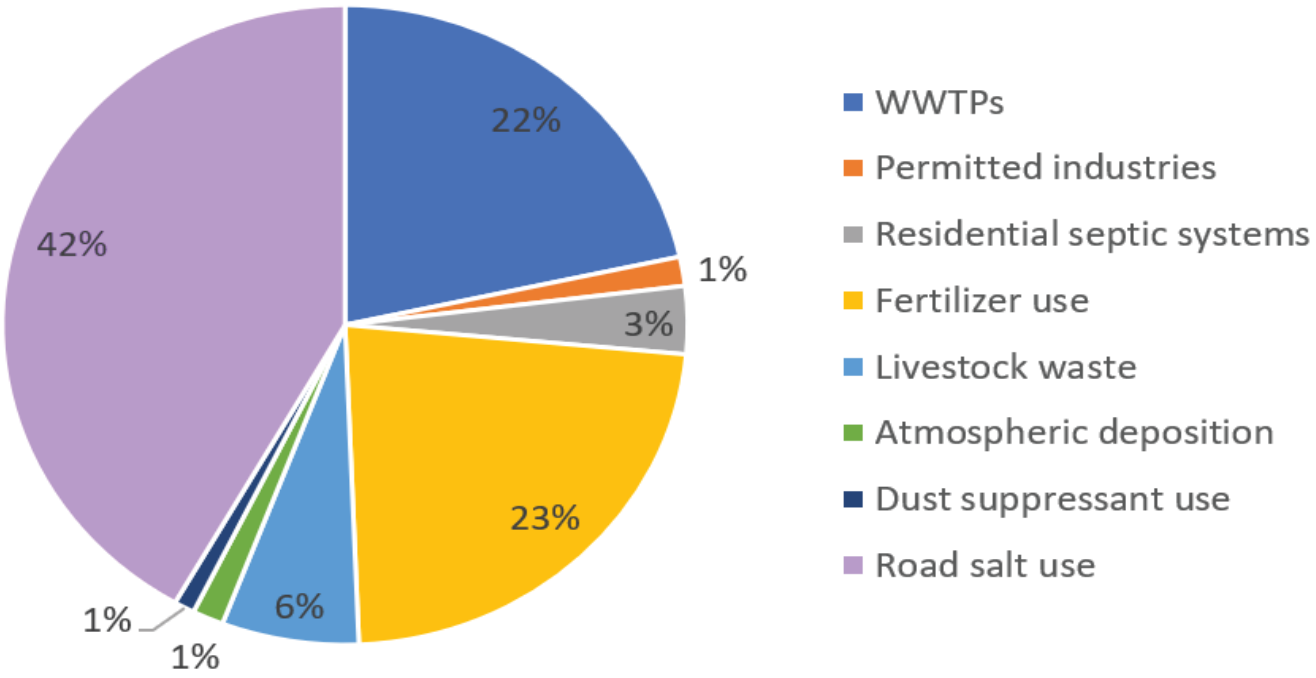
Statewide Chloride Management Plan

The MPCA issued a Minnesota Statewide Chloride Management Plan (CMP) in 2021. Minnesota is the first state to issue a statewide CMP. To address chloride impacts to Minnesota water resources, the MPCA has worked with local stakeholders to develop the CMP; designed specifically to minimize chloride use in the state of MN. The CMP asks everyone statewide in Minnesota to reduce their salt use. The CMP is intended to be useful for understanding the importance of chloride reduction across Minnesota.

This manual and the accompanying Smart Salting Certification Training can help winter maintenance professionals understand how to comply with the CMP.

There are several sources of chloride to Minnesota water resources: 1) salt applied to roads, parking lots, and sidewalks for deicing; and 2) water softener brine discharges to municipal wastewater treatment plants are the largest sources to date.

Figure 2: Annual chloride contributions from major sources State of Minnesota. From major point and non-point sources. Deicing salt is the #1 source of chloride use in Minnesota. (Overbo et al. 2019)



Good business choices

Customer service and reliability are the key to success. Best management practices (BMPs) and using the latest technologies will help keep parking lots and sidewalks safe and provide reliable service while reducing environmental impacts. There are several reasons to involve your customers in your strategy as early and often as possible.

Once you evaluate your winter maintenance strategy through this training, educating your property users and staff on the your proposed methods for snow removal and ice control can create a good and long-standing relationship. Providing a well-planned and well-executed winter maintenance program will have a positive impact. Customers want to hire educated winter maintenance professionals. This manual along with the MPCA Smart Salting for Parking Lots & Sidewalks certification training, will provide increased knowledge on how to implement winter maintenance best practices.

Implementing progressive winter maintenance practices will save time and money, and is a good reflection on you and your organization

Customers and the public want safe parking lots and sidewalks. Understanding the level of service goals and using the appropriate materials and application rates for the weather conditions, allows you to efficiently give your customers the service they have requested.

Clean and neat parking lots and sidewalks are important to the public. By using less material and increased winter sweeping, there will be less tracking into buildings and less damage to flooring.

Proper snow storage makes debris removal in the spring easier. Covered storage of deicers will reduce loss of material, protect water, and is more aesthetic. Using best practices such as these will keep parking lots and sidewalks looking neat.

Customers want affordable snow and ice control. The use of sophisticated chemicals, equipment and improved strategies may require education and a larger budget up-front; however, these costs are quickly recovered by reduced operation and maintenance costs.

The protection of lakes, streams, and wetlands is important. Educating customers on your sustainable winter maintenance approach will allow them to have a hand in protecting our water.

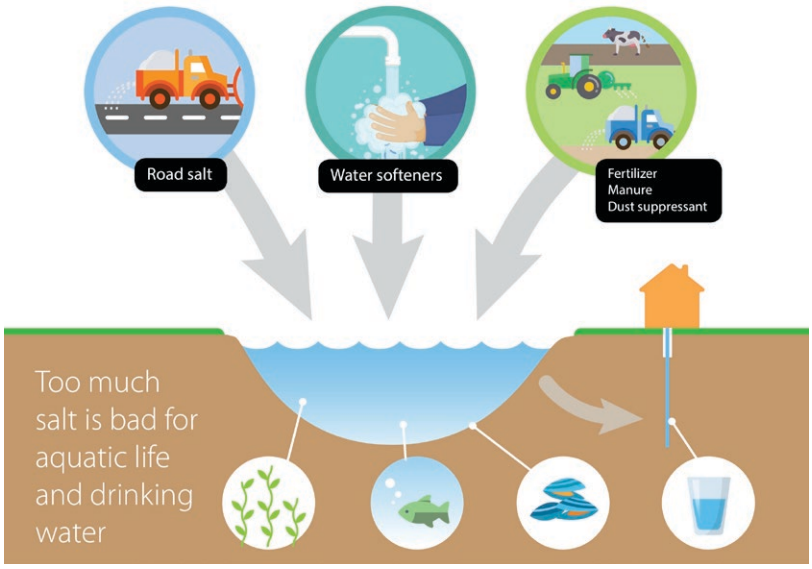
Using less material will help protect our water resources. It is difficult to fix problems caused by deicers or abrasives once applied.

Sources of chloride

Chloride pollution to Minnesota water resources comes from several sources: Deicing salt, water softeners, dust suppressants, and in fertilizers/ manure. Deicing salt applied to roads, parking lots, and sidewalks and water softener brine discharges to municipal wastewater treatment plants, are large sources of chloride pollution that have created visible problems to date, particularly in more populated areas.

Deicing products include: rock salt/ sodium chloride (by far the most widely used product), the often used calcium chloride and magnesium chloride, and the lessor used potassium chloride. The distribution of road salt use in the Twin Cities metro area is in the figure below, adapted from Sander et al., 2007.

Figure 3: Infographic: Sources of chloride in Minnesota



How much deicing salt do we apply?

Deicing salt is the #1 source of chloride use in Minnesota. An estimated 403,600 tons of road salt is applied in Minnesota and 249,100 tons just in the Twin Cities metro area each year (Overbo et al., 2019). A University of Minnesota study found about 78% of salt applied in the Twin Cities for winter maintenance is either transported to groundwater or remains in the local lakes and wetlands (Stefan et al., 2008).

Figure 4: Distribution of road salt applications in the Twin Cities Metropolitan Area. (Stefan et al., 2008)

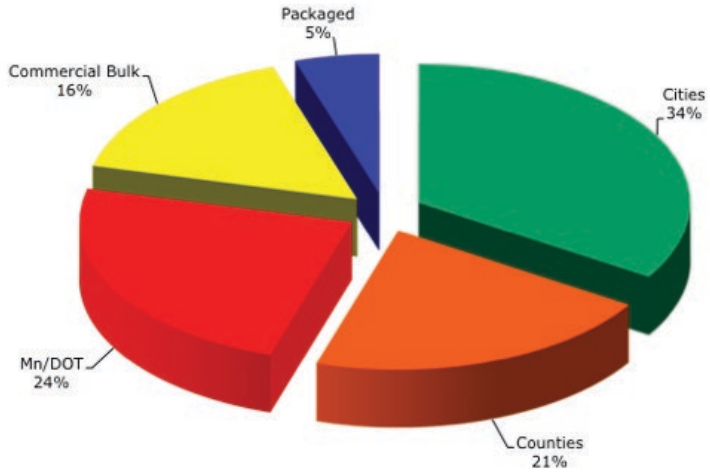
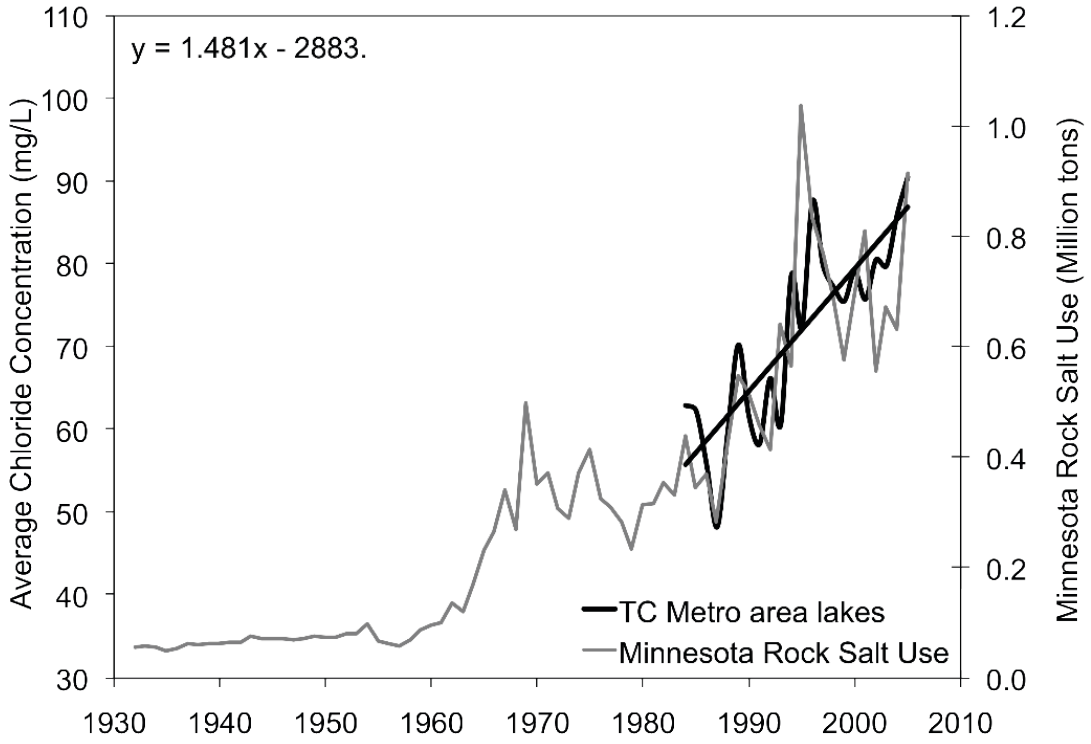


Figure 5: Comparison of lake chloride concentrations in 39 Twin Cities' area lakes and rock salt purchases by the State of Minnesota. (Sander et al. 2007).



Water softener salt

There are currently nearly 100 communities in Minnesota that have high chloride in their discharge from municipal wastewater treatment plants that do not have the technology to remove salt from that wastewater. About 75% of Minnesotans receive their drinking water from groundwater, which most of Minnesota has hard to very hard groundwater. Because of this, people soften their water to make water heaters operate more efficiently, prevent hard water spots on dishes, and make soaps lather more. In most communities, salty brine from water softeners drains to the local wastewater treatment plant, and the salt passes directly through the plant to a local water body. Septic systems also do not remove salt; it likely ends up traveling toward private wells or through the soil to nearby lakes, streams and wetlands.

Deicing salt is the top source of chloride pollution in MN

Fertilizer/manure application and dust suppressants

Agricultural fertilizer is a large chloride pollution source in Minnesota (Overbo et al., 2019). Chloride land-applied for agriculture, is likely transported to lakes and streams through runoff and shallow groundwater infiltration (MPCA, 2020b). The chloride from potassium chloride, or potash, is a common fertilizer ingredient. Potash applied on turf grass and ornamental plants also makes its way to surface and groundwater. Chloride concentrations can be very high in animal manure (Overbo et al., 2019). Surface and groundwater near feedlots, or where manure is applied, may be at risk of chloride pollution.

Chloride in Minnesota's water resources

Only 2.5% of the water on this planet is freshwater (not saltwater). Of that, less than 1% is available for use. The majority of the freshwater is frozen in the glaciers (Freshwater Crisis n.d.) Planet earth receives no new water. Our existing water is reused and recycled over time as illustrated below from the Minnesota Department of Natural Resources (DNR), "Healthy Rivers: a Water Course" (Healthy Rivers 2004).

Deicing salt runoff is creating water quality problems, especially in developed areas with many paved surfaces. Overall, chloride concentrations are increasing in many surface waters and groundwater across Minnesota.

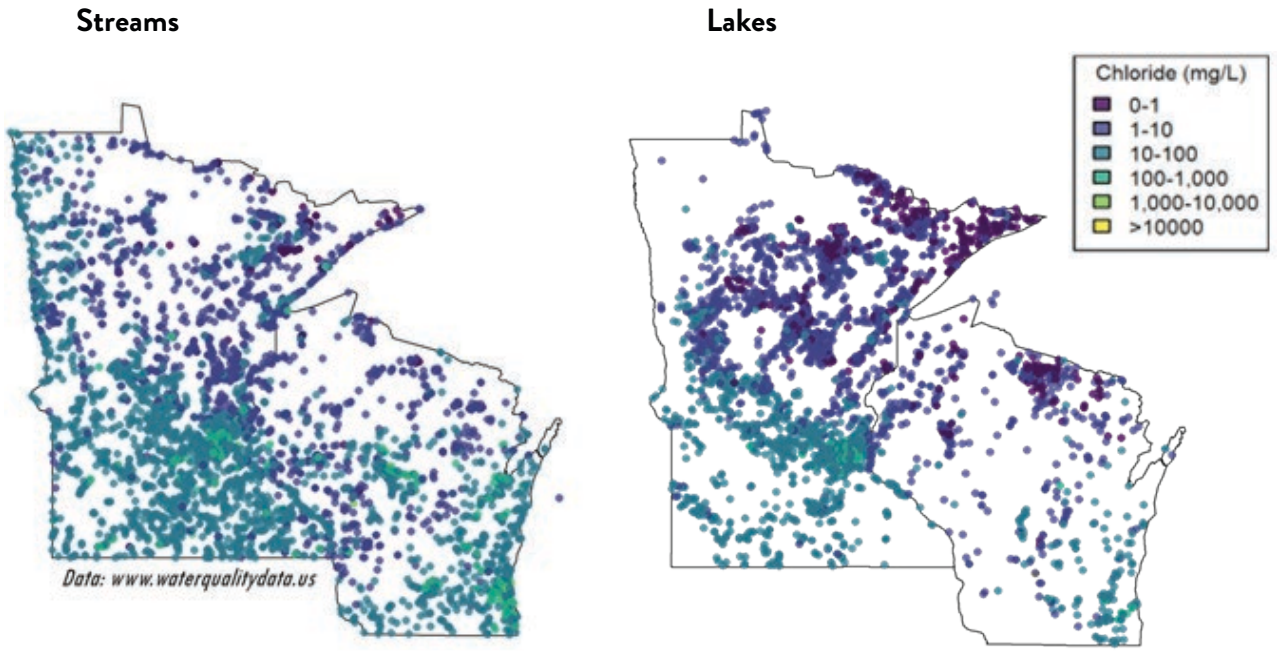
Chloride in lakes and streams

There are 54 impaired water bodies in Minnesota that exceed the chloride standard designed to protect fish and other aquatic life on the 2022 impaired waters list, (MPCA, April 2022). Minnesota follows federal water quality standards of 230 mg/L (chronic) and 860 mg/L (acute), to protect fish and other aquatic life from chloride pollution (EPA, n.d.a). When concentrations exceed that, the water is called 'impaired'. There are another 75 water bodies classified as 'high risk' for exceeding the chloride standards (within 10%). Minnesota has many lakes and streams in Minnesota that are testing for chloride (Figure 7). However many of our waters have never been tested for chloride.

Figure 6: Water and teaspoon salt.

It only takes 1 teaspoon of salt to permanently pollute 5 gallons of water.

Figure 7: Chloride levels in Streams (left) and Lakes (right) in Minnesota and Wisconsin.



The lighter the dots, the saltier the water. Data from these maps comes from www.waterqualitydata.us (Dugan, 2018)

Groundwater and drinking water

Groundwater is an important Minnesota resource. About 75% of Minnesotans rely on it for drinking water (MPCA 2019). Groundwater contributes flow to lakes, wetlands, and streams, and can release elevated concentrations of a number of pollutants into surface waters. Deicing salt application is resulting in high groundwater chloride concentrations. MPCA ambient groundwater monitoring collected from 2013-2017 found 16% of monitoring wells tested in shallow sand and gravel aquifers in the Twin Cities Metropolitan Area (TCMA) exceeded the state chronic standard for surface waters of 230 mg/L for chloride. This was even higher than monitoring wells sampled near gas stations (Kroening, Vaughan 2019). Wisconsin is starting to see chloride effects in shallow groundwater releasing chloride into surface waters in the Yahara Watershed, due to applications in Madison, Wisconsin (Wenta 2018). In New York State, it has been estimated 24% of private wells are impacted by deicing salt (Pieper et al. 2018). The EPA has set a Secondary Maximum Contaminant Level (SMCL) of 250 mg/L for chloride in drinking water, which is a guideline for protection based on taste (EPA 2014). The cost of mitigating groundwater contamination is substantial. A 1991 report stated $10 million a year is spent nationally on mitigating groundwater salt impacts (Transportation Research Board 1991).

When snow and ice melt, the salt has to go somewhere. It flows directly into ditches and storm drains and into lakes, streams, wetlands, and groundwater.

The environmental costs of chloride

Aquatic life

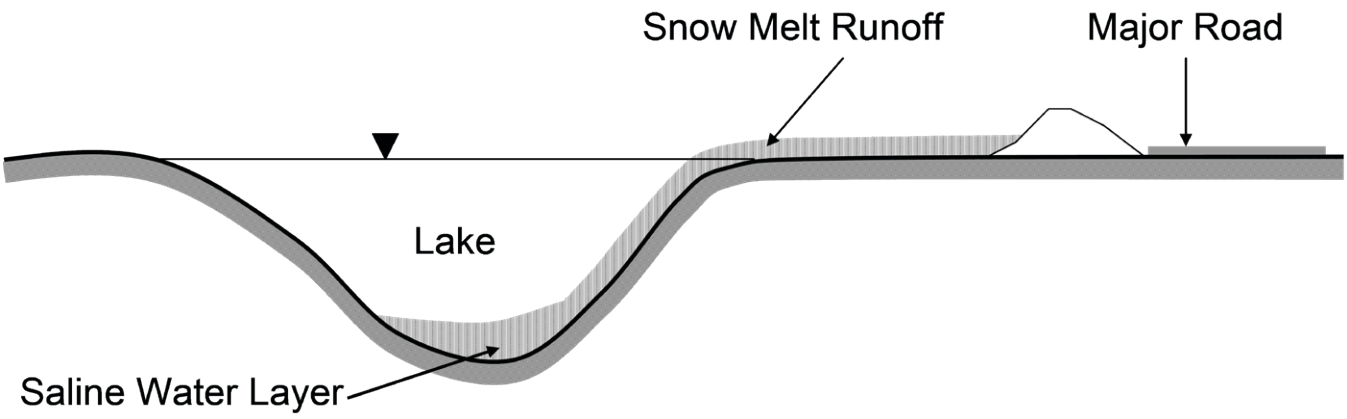
Elevated chloride levels are toxic to fish, aquatic bugs, amphibians, and plants. Chloride reduces fish and insect community structure, diversity and productivity. High levels of salt exposure can compromise the immune response of dragonfly larvae (Mangahas et al 2019). Amphibians have been shown to be more sensitive to salt-induced mortality and deformities (Tiwari and Rachlin 2018). In particular, amphibian eggs are permeable, making them especially sensitive to salt exposure. In other words they dry out and often die. (Jones 2015). Even as low levels of chloride are toxic to fish eggs, wood frog tadpole's survivability drops (Tiwari and Rachlin 2018). It lowers invertebrate resiliency to outside biotic stressors. Developmental delays, physiology changes, resistance to disease, altered food webs, and predation pressures, further impact native species ability to survive and thrive. Chloride in streams, lakes, and wetlands harms aquatic vegetation and can change the plant community structure (MPCA, 2016).

Invasive species of fish, such as Carp, have been shown to have a greater tolerance for chloride pollution and are destined to survive and overrun native Minnesota species. This is likely to have a long-term impact on recreational fishing in Minnesota.

Lakes

Only 2.5% of all the water on Earth is freshwater. Of that, less than 1% is available for use. Most freshwater is frozen in glaciers (Freshwater Crisis n.d.). Chloride pollution is slowly and irreversibly turning Minnesota's lakes from freshwater into saltwater. We need to prevent impaired waters from getting worse, and preserving the water bodies that are not. Chloride concentrations have been going up in North America's lakes region since 1985. Impervious land cover and road density surrounding lakes is a contributing factor. Dissolved chloride increases water density, which can prevent the natural, seasonal mixing of lake waters (Novotny et al. 2008). Chemical stratification is when salt water is heavier than freshwater and sinks to the bottom of lakes. This changes the lakes natural mixing process. (Stefan et al. 2008). The natural mixing of lakes increases oxygen levels required by aquatic life to survive; thus oxygen is low when it does not mix. Denser chloride- impacted water locates below less dense fresher water toward the surface above. The impact of persistent stratification in lakes may be leaving the deepest parts oxygen-deprived. This could result in increased phosphorus release into the water (Novotney and Stefan 2012).

Figure 8: Schematic of a saline water intrusion into a lake.



Streams and rivers

There is increasing trends in chloride concentrations and specific conductance in streams across North America, specifically in urban streams within watersheds with high percentages of impervious surface and in northern parts of the country where deicing salt use is abundant. This can have adverse effects on riverine aquatic ecosystems as chloride can be directly toxic at certain concentrations, but also be considered a stressor to sensitive species at lower concentrations. There are strong observed negative correlations between increasing chloride trends in streams and declines in abundance and diversity of freshwater communities, with deicing salts being a primary driver in northern states (Moore 2020). Chronic or persistent stream salinization has also been shown to affect the aquatic communities in general, with declines in community wide metrics such as richness and diversity (Timpano 2018). Research has shown that elevated chloride levels has an effect on aquatic communities at all trophic levels and has an influence on the food web and energy flows (Hintz and Relyea 2019). In general, elevated chloride concentrations can have adverse impacts at the ecosystem, community, and species level.

Stormwater pond function

Chloride cannot be removed by stormwater ponds. The same stratification has been observed in stormwater ponds, where persistent layers of high chloride were found (Herb et al 2017). Research suggests stormwater ponds release heavy metals and phosphorus stored in sediment in the presence of high chloride levels. (Finlay, 2018). The presence of increased phosphorus is known to cause increased algae blooms. There is ongoing research to determine the potential impacts of chloride loading and phosphorus release from stormwater ponds specifically.

Vegetation

Deicing salt spray and run-off can damages or kill plants and trees along roadsides, sidewalks, and parking lots. This salt spray can damage a plant's leaves, buds, and small twigs, which in turn can reduce a plant's cold hardiness, making tissue more susceptible to freeze damage (Beckerman and Lerner 2009). Plans taking up salty water directly through their roots can also be harmed. Depending upon species-specific chloride tolerance, soil chloride concentrations as low as 68 mg/L can be detrimental to growth and reproduction (Wegner and Yaggi 2001). Tree growth alterations, like witches broom, are a result of salt spray on the terminal buds of trees (as shown in Figure 9 below) Many are familiar with the perennial 'vegetation burn' common along sidewalks, parking partitions, even in rain gardens. The cost to replace dead grass, plants, and trees can add up quickly in maintenance costs, particularly if it's an annual habit. Unfortunately, rain gardens have seen increased maintenance and replacement costs, as they tend to be a common snow storage area.

Figure 9: Left: "Witch's broom" branching. Right: Vegetation burn.

Excess salt can damage trees and burn vegetation. Reduce salt use first, then consider salt tolerant plants in damage-prone areas.

Our goal is to reduce salt, but there may be unavoidable impacts in certain areas. One way to save time and money is to choose plants with higher salt tolerance. Resources for selecting salt tolerant plants:

- **MNDOT Plant Selector** https://plantp.dot.state.mn.us/plant/
- **MPCA Stormwater Manual salt tolerant plant list:** https://stormwater.pca.state.mn.us/index.php/Minnesota_plant_lists**.**
- **Best management practices for establishment of salt-tolerant grasses on roadsides (Eric Watkins 2017)** http://dot.state.mn.us/research/reports/2017/201731.pdf

Pets and wildlife

Pets may consume deicing materials by eating them directly, licking their paws, or by drinking snow melt and runoff, which can be harmful to pets. Exposure to deicing salt can cause pets to experience painful irritation, inflammation, and cracking of their feet pads. There are no standards for deicer packaging, thus any company could label their salt "pet friendly". It is best to keep deicers away from pets. Some birds, like finches and house sparrows, have an increased risk of death if they ingest deicing salt. Deer and other large mammals consume the salt on roadsides and roadside ponds to fulfill their sodium needs, resulting in increased traffic incidents (Environment Canada 2001; Amundsen 2010). Deicing salt may also cause a decline among populations of salt sensitive species, reducing natural diversity.

Soil

Salt-laden soil can lose its ability to retain water and store nutrients and be more prone to erosion and sediment runoff (which also harms water quality). Soil near roads and parking lots exposed to deicing salt have exhibited soil structure change, nutrient imbalance, accelerated colloidal transport, mobilization of heavy metals, and more (Amundsen 2010; Michigan DOT 1993). These changes cause reduced plant growth and increased erosion of sediment to surface waters (Kelting and Laxson 2010).

Water distribution safety

Chloride causes corrosion and consequently affects water distribution infrastructure and drinking water quality (Stets, et al. 2017). Specifically, copper and lead are the focus of corrosion control in water distribution systems, and this control is made more difficult when source waters have high chloride concentrations. Stets, et al., found a strong link between increasing chloride concentrations in urban surface waters and increased potential for corrosivity in water distribution systems. This link was found in urban settings, where the majority of chloride was assumed to be from deicing salts. Since most water treatment facilities do not have RO systems in place due to cost, dissolved chloride from the source water is generally distributed to consumers. This is of particular concern for municipalities that use surface water as a source.

Non-chloride materials

Chloride is not the only material used in winter maintenance. All materials applied in winter maintenance have some impact on the environment.

Non-chloride deicers

Acetates, formates, urea and organic (e.g. beet, corn) additives do not contain chloride, but do have some environmental effects. While these products are generally short-lived in the water and biodegrade, some effects can still be serious. They can deplete oxygen in water and soil, and add nutrients, potentially causing algal blooms or fish kills.

Non-chloride materials are typically less corrosive to steel and safer for vegetation. The environmental effects from these products may potentially be remediated by holding ponds, rain gardens and other nutrient traps.

Anti-caking additives to rock salt can cause additional stress and can accumulate in the environment to a potentially toxic level (Wenck 2009).

Abrasives

Abrasives have impacts to the water by clogging drainage systems (storm sewers and ditches). They fill in wetlands and ponds, and can form deltas in lakes and streams. Abrasives are carriers for other pollutants such as oil found on parking lots and roads.

Truth in labeling

There are no labeling requirements for deicer packaging. Beware of labeling claims such as 'environmentally or pet friendly'. No deicers are environmentally safe nor will work in all conditions. It is the buyer's responsibility to fully research products and make decisions accordingly. Request vendors to provide detailed ingredient lists, guidance on the pavement temperature range for optimal product use, and proper storage and handling.

Know what you're buying. Many labels don't list ingredients or exaggerate practical melting ranges. No deicer works in all conditions.

The true cost of salt

Infrastructure damage

Salt costs much more than the initial purchase and application. Salt damages building interiors and exteriors, roads, bridges, parking lots, sidewalks, steps, handrails, curbs, vehicles, vegetation, soil, surface and ground water. Salt tracked indoors ruins carpets and flooring. For property managers, this means costly, maintenance and repairs. The total cost of infrastructure damage from one ton of salt is estimated to be between $800–$3,300 (Fortin Consulting, 2014).

Business reputation

Winter maintenance professionals and businesses often field complaints from those that hold to the notion that the crunch of salt equates to a safer surface. Yet more and more people are expecting you to use less, and want clean and neat parking lots and sidewalks. Chloride pollution is gaining more local news attention. Along with increased education efforts, people are starting to associate over-salting with environmental damage. The perception is shifting. More people now believe excess salt on your sidewalks or parking lot looks unprofessional and reflects poorly on your business. Educating customers on your sustainable winter maintenance approach will allow them to have a hand in protecting Minnesota's valuable water resources. Customers are now searching for, or requiring the use of, Smart Salting certified winter maintenance professionals. Customers want affordable and reliable snow and ice control. Creating a well-planned and well-executed winter maintenance program, accompanied by appropriate material use, the latest technologies, and customized application rates for the weather conditions, allows you to efficiently give customers the reliable service they need on your properties.

Education on best practices and managing customer expectations is key. There are many educational resources to help manage customer expectations. See Resources section.

The use of sophisticated chemicals, equipment and improved strategies may require education and a larger budget up-front; however, these costs are quickly recovered by reduced operation and maintenance costs. There are MPCA 0% interest loan programs to help small businesses and local governments purchase equipment or provide education. Email smartsalting.pca@state.mn.us for more on loan programs.

The total cost of infrastructure damage from one ton of salt is estimated to be $800-$3300 annually!

Success stories

Precision Landscaping

Precision Landscaping is making a move into using liquids. The company began with one liquid capable truck at one site in 2018. In 2019 because of the success Precision Landscaping had with reducing the amount of product needed, the company added two more trucks with liquid capabilities to use the technology on more sites. The company also added 3 off-site reloading locations to increase the number of properties treated with liquids.

Additionally, the company is working to educate their clients about the effects of salt as part of their push to reduce their overall salt use for winter maintenance.

In September of 2018 Precision Landscaping held a Smart Salting for Parking Lots and Sidewalks training at their office for their entire staff. This has led to a team effort on salt awareness and reduction. Salt impact and reduction is now a significant part of training and discussion for their team both when preparing for and throughout the season. The company involves the majority of staff in calibrating salters (instead of just a few people) so that everyone is aware of the process and how the equipment works.

In addition to regular reminders to try to use less salt, Precision Landscaping bought fewer pallets at the beginning of the season with the goal to meet site safety needs while reducing salt and without needing to make another salt purchase. Having a smaller supply has made staff more conscious about how they are using product. The discussions helped create plans identifying areas on sites that may not need to be salted each time it snows. From the changes made during the 2018 season, Precision was able to cut back 20% on salt per event from the previous season while still maintaining the same amount of pavement and quality standards. On one 14-acre site, their salt usage was down by about 60%, and they saw less vegetation and landscape damages to the property when the snow melted.

Precision Landscaping will continue to look for ways to offer great service to their customers and reduce salt use in the years to come.

Edina Public Schools

Edina Public Schools serves 8,000 students and over 205 acres of property. Its 10 sites include 6 elementary schools, 2 middle schools, the Edina High School & the Edina Transportation Center. Buildings are often open 7 days a week.

Edina Public Schools estimates they have reduced their salt use 60% since 2014. It has been a district-wide effort to minimize the harmful effects salt has on our groundwater and the environment. The school district has made several changes to their snow and ice practices. This includes purchasing less product, educating staff, researching and purchasing more efficient equipment, and being more conscious of the weather.

The salt reduction began in 2014 as the District began the purchase of snow removal equipment such as brooms and drop spreaders that could clean more efficiently and better control salt distribution. Prior to 2014, the District was purchasing and utilizing 45 pallets of salt. Salt was freely applied throughout the winter with little or no regard to the changing weather conditions or current condition of the walkways and parking lots.

In 2016, the grounds crew began attending the MPCA's Smart Salting training. This led to discussion and planning for how they could reduce salt use on the grounds. Currently all grounds crew, along with several building staff, are certified in Smart Salting.

In 2019, the District purchased 16 pallets of salt, and used only a small portion of it. The grounds crew, transportation, building staff, and administration are all tuned into the weather and are quick to respond when steps can be taken to prepare walkways and parking lots prior to inclement weather. The crew also created their own salt-brining system that has been used throughout the district especially on high traffic walkways. Many areas prone to refreeze and several unsafe walkways/stairways are completely closed during the season to reduce salt and risk. The building staff has been equipped with small hand spreaders that distribute salt in entryways and stairs in a responsible manner.

It is the Edina Public School District's hope that they can continue to improve and minimize the negative effects their district has, on the groundwater and on the environment.

Mayo Clinic

At the conclusion of his first two winters as Grounds Maintenance Supervisor for Mayo Clinic, Nick Queensland was proud of what his crews had accomplished in terms of productivity and safety. However, he was bothered by the amount of salt applied to their paved surfaces in order to obtain these results. Immediately following winter 2017-2018 he went to work determined to maintain Mayo Clinic's excellent level of service while prioritizing salt reduction.

While doing research on salt reduction methods, Queensland continued to see the MPCA's Smart Salt Training. He committed to have all his in-house grounds maintenance staff attend the Smart Salting for Parking Lots and Sidewalks training together, including leadership. This was an excellent decision! His crew was energized about reducing salt use after learning facts about the negative environmental impacts of salt and fresh alternatives to current practices.

The day after the Smart Salting training, Queensland gathered his crew and they made a list of methods they could implement to reduce salt use on Mayo's campus, which consists of 15 miles of sidewalk, 300 doorways, and 120 acres of parking lot and roadways. Queensland focused on parking lot and roadway salting, as he felt he could get the greatest tonnage reduction there and had the most room for improvement.

They began with calibrating the salt application equipment used on the property. Mayo Clinic had never done this in the past ,and was surprised that nobody knew what rate of salt was being applied. Knowing the rates of the spreaders was important to lowering salt use. When the clinic directed the contractors to apply salt, they could specify a rate instead of the contractor applying a moderately heavy blanket of salt every time.

The other significant change was to incorporate liquid salt brine into their ice control toolkit. They had experimented with liquid salts in the past with limited success and had abandoned this method. The salt brine applied correctly allowed them to plow snow and not have to apply rock salt at all for several storms. Public education, such as the sign above, prevented injuries.

Calibrating contractor equipment and incorporating liquids in practice along with Smart Salting for Parking Lots Training resulted in a 60% salt reduction for Mayo Clinic in a winter where they received a record amount of snow and a normal amount of ice. This number exceeded expectations. This was not easy, change never is, but Queensland found it was well worth efforts both in environmental impact reduction and budget savings.

An ‘Epic’ success story

Epic is a healthcare software company with a 1,100-acre campus headquartered in Verona, Wisconsin.

Epic’s salt diet began in the winter of 2016-2017 after key staff attended a training held by Wisconsin Saltwise. Starting that winter, Epic implemented anti-icing on some of the main roadways, tracked the amount of salt used for each event, calibrated all equipment, and equipped each operator with application charts for each piece of equipment.

Table 1: Epic’s salt savings

Salt Savings at Epic

Year	Bulk salt total (tons)	Bag salt total (tons)
2014-15	224	22
2015-16	134	22
2016-17	94.4	12
2017-18	62.4	8.4
2018-19	87.7	9.1

Before making all of these changes, operators would go out and put down salt ‘by eye’. Now they follow application rate charts. They’ve made some challenges with modified equipment to put down less salt, but have gotten some spreaders close to the low rates they are looking for.

Each year Epic has a team meeting at the beginning of the season to go through any changes to the program, and share any new information with the team. The company has also reached out to their nearly 10,000 employees letting them know that the maintenance team is not compromising safety, but reducing salt output, and it might take a little time for salt to work.

Despite having more challenging winters recently, the salt use has continued to stay low! They hope to continue to educate our staff and keep making reductions where they can.

Share your success! We want to promote those who have realized the benefits of smart salting. Send your success story to the MPCA Chloride Reduction Program at smartsalting.pca@state.mn.us.

Prepare for winter operations

Winter policy and planning

Successful winter maintenance requires year around planning and preparation. Making time in the fall of the year to transition from summer maintenance to winter maintenance is especially important. It will bring you into the first event with your equipment calibrated and ready to perform, your strategies developed, your brine made and your staff trained, just to name a few advantages to getting organized ahead of winter.

Reduce liability. Establish a maintenance policy, follow it, and document your actions. If your profit center is based on the amount of material you use, protect your company and change your business model.

Policies and plans

Start now—develop a maintenance policy or plan that guides winter operations. A little planning and communication up-front can help achieve better results throughout the season and reduce your liability.

- Develop a maintenance policy or plan.
- There is a model snow and ice management policy available on the MPCA's statewide chloride resources webpage, created by a group of winter maintenance professionals and written by the attorneys from Smith and Associates LLC.
- Review the maintenance policy and/or plan with the crew.
- Inform customers of your high-level plan.
- Follow the plan.
- Document maintenance activities to prove you followed the plan.
- Review and update the maintenance policy and plan annually.

Figure 10: Plan for responsible winter maintenance.

Documentation

After establishing a game plan, set up a system to document your actions. Train staff and contractors to document their actions. Documentation of the good practices that follow your snow and ice policy can provide a great defense. It's also a powerful tool to help understand strategy effectiveness and provide information to help refine practices.

Continue to reference your documentation, record your activities, and analyze after each event and end of season. You will benefit from a better understanding and gain further insight to improve. Take time to share your analysis and post storm reports with your crew. It can be a useful tool in moving operations forward. There are some examples of documentation in Table 13 and Table 14.

Reduce liability. Establish a maintenance policy, follow it and document your actions.

Winter maintenance contracts

You are encouraged to review and implement the model contract on MPCA's statewide chloride resources page. This is a template for a lower salt but not lower level of service agreement. It showcases other strategies to bill for services instead of billing by the ton or gallon of materials applied. This contract was created by winter maintenance professionals and property managers and written by the attorneys from Smith and Associates LLC.

If your profit center is based on the amount of material you use, you will likely have less profits in the future as the MN Chloride Management Plan asks every person in MN to reduce their salt use. Consider adjusting your billing or payment strategy to bill for services not materials.

Our waters are threatened by contracts which are based on fees for material use. This encourages overuse of materials.

Our waters are threatened by contracts which are based on fees for material use. This encourages overuse of materials.

Training

Reduce risk by having a solid winter maintenance policy and training program. Schedule training for supervisors, staff, property managers and subcontractors.

The MPCA has four Smart Salting Certification training classes available:

1. Smart Salting for Roads: If you apply salt and maintain high and low speed roads, you can learn how to reduce salt use, save money, and protect Minnesota's lakes and streams while maintaining safety.

2. Smart Salting for Parking Lots and Sidewalks: If you apply salt and maintain private/public walkways and/or parking lots and service roads, you can learn how to significantly reduce salt use, save money, and protect Minnesota's lakes and streams while maintaining safety.

3. Smart Salting for Property Management: If you manage properties, influence winter maintenance activities or want high level information to make more informed decisions, this class is for you.

4. Smart Salting Level 2: Organizational certification available for public and private organizations. Using the Smart Salting Assessment tool, you can complete the best management practices and salt savings assessments and obtain certification online. (See Appendix D)

Check the MPCA website for upcoming training opportunities and the list of those certified.

Laws and ordinances

State and local laws and ordinances may restrict or influence winter maintenance strategies. As chloride reduction efforts continue, more rules and ordinances are likely to be established. Being aware of your requirements is important; don't let it take you by surprise. A detailed list of Minnesota laws and ordinances can be found in Appendix E, including the ones listed below. There are some MPCA permit programs that include chloride specific requirements that may impact you. Riley Purgatory Bluff Creek and Nine Mile Creek Watershed Districts, located in the Twin Cities, both require a salt management plan, certified applicator and contact person on record to obtain certain land-disturbing permits. Bassett Creek Watershed has joined them in requiring a winter maintenance plan prior to some development/redevelopment. MPCA published a Chloride Reduction Model Ordinance that includes a suite of ordinances, such as required training, salt storage regulations, chloride management plan requirements, and sweeping regulations for excess deicers. These ordinances may be adopted by governing organizations in your area. Often organizations and contractors will require Smart Salting certification with the MPCA Smart Salting certification training.

- Do not push snow directly into a water of the state. Discharges to waters of the state: https://www.revisor.mn.gov/rules/7053.0205
- Liquid deicer storage regulation: https://www.revisor.mn.gov/rules/7151/
- General requirements for aboveground storage: https://www.pca.state.mn.us/sites/default/files/t-a1-02.pdf
- Aboveground storage tank factsheet: https://www.pca.state.mn.us/sites/default/files/t-a2-07.pdf
- Snow removal and chemicals restricted: https://www.revisor.mn.gov/statutes/cite/160.215
- Street sweepings: https://www.revisor.mn.gov/rules/7035.2855/. MPCA factsheet: https://www.pca.state.mn.us/sites/default/files/w-sw4-54.pdf
- MS4 general permit applies to organizations that have a Municipal Separate Storm Sewer (MS4) permit with the MPCA and has new chloride requirements: https://www.revisor.mn.gov/rules/7090/. More on the new MS4 chloride language can be found in Appendix E.
- Industrial stormwater information: https://www.pca.state.mn.us/business-with-us/industrial-stormwater
- Minnesota water pollution statute: https://www.revisor.mn.gov/statutes/cite/609.671

Afraid of lawsuits?

Fear of lawsuits is one reason salt is over-applied. Not understanding the science behind winter maintenance is another reason salt is over-applied. A long-time common belief is that more is better when it comes to salting, but that is not often true. Oversalting has many costly impacts to infrastructure, vegetation, water and can negatively impact safety as well. (Figure 11). By being trained and certified in Smart Salting, integrating winter maintenance best practices into your operations, creating maintenance plans, communicating those plans to all of those working on the site and documenting that you follow the plan, you have increased the professionalism of your work. You also have a track record of what you did that will prove valuable in case of a dispute.

Figure 11: The sidewalk on left with excess salt is no safer than the stairs on the right cleared of snow and ice without excess salt.


Photo credit: FCI


Photo credit: FCI

Storage

Snow Piles

- Store in an area where the solids can be recovered after the snow melts.
- Locate snow piles down-slope from salt and sand storage to prevent snow melt from flowing through salt or sand storage areas.
- Push snow to areas where melt water will not run across your parking lot or sidewalk. Pushing snow to the highest elevation in the parking lot is asking for problems.
- When designing parking lots, design in snow storage areas.
- State Law: Do not push snow into a water of the state (wetland, lake, river). MINN. R. 7053.0205 (2017)

Figure 12: Incorrect salt storage: uncovered and placed in path of melting snow pile.


Photo credit: FCI

- You are allowed to push snow into rain gardens or holding ponds but it is not advised. You will increase your maintenance cost of these retention or infiltration areas.

Salt and Salt/Sand Piles

- Provide summer storage for salt. If your contractor does not have summer storage for salt, you are likely to get plenty of salt on your surfaces toward the end of winter. This will accelerate infrastructure, vegetation and water damage at your site.
- Do not skimp on proper storage. Storage areas often cause water contamination. These problems can be easily tracked back to the source.
- Piles should be covered. Inside a shed, building or container is best.
- Store on an impervious (waterproof) surface.
- Indoor loading area is preferred but not required
- Sweep loading areas back into the pile.
- If your salt pile drains into a pond or storm drain, know that this does not get rid of the salt, it just moves it into our water.
- Store salt away from wellhead protection areas and water resources.
- Storage area should be sloped so salt/brine stays inside. For example, a birdbath shape is designed with the lowest area in the center of shed.
- Area adjacent to salt shed should be sloped so water does not run into shed.

Professionals have summer storage for salt which prevents over application to "get rid of it" as spring approaches.

Figure 13: Keep salt contained in pile. No rivers of salt should be seen flowing from your storage areas.

Photo credit: FCI

Salt storage areas are often a source of groundwater contamination. To reduce risk, have a covered storage area on an impervious pad.

Storm drains lead to the nearest lake, river, pond, or wetland. They do not go to a treatment plant.

Packaged material

- Protect from rain or snow.
- Store covered in an area with a waterproof floor.
- Most bagged products contain at least one hydroscopic deicer and if bags are not sealed over the summer they will continue to pull moisture out of the air and ruin the deicer.

Salt savings tip: City of Hopkins has a drop off bin so residents can get rid of unwanted salt at the end of the winter. They add it to their salt pile so no salt is wasted

Some have found ordering smaller size bags of salt result in using less overall salt. Many use a full bag no matter what size the bag is.

Liquids

- Know the freezing point of each liquid. This will determine if it can be stored outdoors. Salt brine (NaCl) will freeze at -6° F. Each liquid has a different freeze point.
- Salt brine has a low level of concern compared to many substances stored in above ground tanks. Nevertheless, MPCA does have guidance for all above ground storage tanks. A few highlights of MPCA's above ground storage tank requirements are listed below. For more information visit: above ground storage tank systems
  - Product compatibility – Liquid must be compatible with the tank material.
  - Labeling – Each tank must be labeled with substance, capacity, unique tank ID and all components labeled.
  - Secondary containment – To protect against spills or to catch spills, tanks must be double walled or stored within a containment area to catch 100% of spills plus 10% if exposed to precipitation.
  - Tank inspection – Inspect the tanks and the components regularly for degradation, cracking, leaking, ensure connections are properly closed and all equipment maintained.
  - Contact signage – post a sign if a person is not on site 24 hours a day with the name, address, and telephone number of the facility owner, operator or a local emergency response contact

Sand piles

- Winter sand is typically mixed with some deicer to prevent freeze-up of the pile; therefore, sand pile storage should be the same as salt pile storage.

Weather

Know existing and potential weather conditions for a successful snow and ice control operation. Monitor the weather closely to prepare to act early in storm situations. Check the National Weather Service http://www.noaa.gov, local TV stations, or website weather. A Road Weather Information System (RWIS) is available for free on-line at www.rwis.dot.state.mn.us. The RWIS provides real time pavement temperatures and other information from locations around the state.

Pavement temperature

Pavement and air temperature are different. Know the pavement temperature to determine the proper amount and type of material to apply.

Air temperature measurements are generally the same in a given area, but pavement temperatures can vary greatly. Pavement temperatures are influenced by exposure to sun, pavement type, subsurface materials and the weather history.

The same air temperature in November and January will often accompany very different pavement temperatures.

Figure 14: Hand-held temperature sensor.

The hand-held temperature sensors are inexpensive to purchase and easily available. Some temperature sensors only monitor in the warm temperature range such as devices that are used to test ovens. Make sure yours measures in the cold temperature range.

Vehicle-mounted temperature sensors are wonderful tools. They are less likely to be lost or stolen and no need to stick your hand out of the window. They continually display air and pavement temperature inside the cab. They are expensive for contractors but even a few on supervisors' trucks can be a big help, then they could communicate out to the crew.

Newer equipment may have a computer screen inside the cab that displays pavement temperature. No need to buy an add-on piece of equipment.

You can also purchase pavement sensors that you can mount on a pole or on buildings that provide continuous site information to you back at the shop. These do not give subsurface pavement temperatures but do provide great information and you choose where to put them.

Figure 15: Mirror mounted pavement temperature sensor and temperature sensor display inside a vehicle's cab.

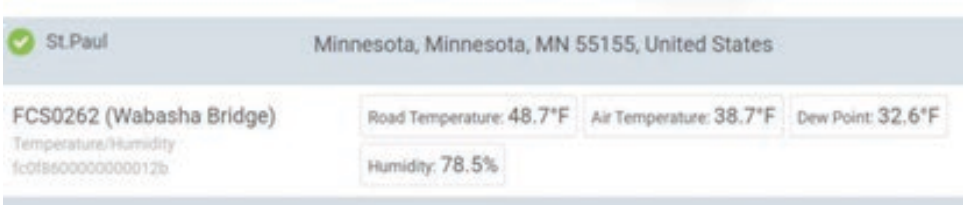
Photo Left : Force America, Right photo FCI

Getting prepared for winter

Winter maintenance is a year round task. Those who excel at it work non-stop to learn current strategies and techniques, train crews, update equipment, communicate with customers and so on. Professional snow and ice management is similar to professional sports, there is a performance season but it requires year-round training and preparation to play to compete at the highest level. On the other hand anyone can play in a pick up game of basketball just like anyone can put a plow on their truck, but we know the results are not the same.

Image credits: City of St. Paul

Figure 16: Mounted pavement temperature sensor and temperature sensor display.



Knowing the pavement temperature and trend allow you to make better decisions on material selection and application rates.

This list is not intended to be a complete list of activities needed to prepare for winter but rather an example of things to add to your list. The list will grow and change with your operations. Under each task illustrated below are many subtasks not listed.

- Tune up equipment.
- Calibrate equipment.
- Record the area of the parking lots, service roads, and sidewalks. The amount of deicer needed is based on the size of the parking lot.
- Associate a target level of service for each area.
  - Agree on level of service goal with customer or set it and communicate it to customer.
- Document size and level of service goal and give to crew. Mapping it makes it easy to interpret.

Professional snow and ice management, like professional sports is a year-round effort of practice, training and preparation for the season.

Table 2: Example of maintenance areas and level of service goals

Maintenance areas and level of service goals				
Location: Joe's Shoe Shop	**Area (Sq. ft)**	**Target**	**How fast**	**Notes**
Sidewalks from parking lot to front door	7,935	Bare pavement	24 hours after snow	Shop is open M-F 8- 4
Service road and handicap parking	16,082	Bare pavement	48 hours after snow	
Main parking lot	21,229	Patches of bare		20 parking spots near door needs bare pavement
Overflow parking lot	46,477	Compacted snow		Low priority

- Understand the properties of various deicers. Vendors should be able to provide detailed product information including composition, minimum effective temperatures, application rates, and storage/handling guidance and tips.
- Equip your shop with a variety of materials so you will have a tool that will work well no matter what the conditions might be. If you don't store materials at your shop, identify the vendors where you can purchase each material.
- Train your crew and hire trained and certified subcontractors.
- Inspect sites for poor drainage areas. Map these and communicate drainage problems to the property manager.
- Note existing conditions of curbs and other items that might be damaged or influence your winter maintenance process. Document and communicate with the property owner.
    - Concrete heaving could be not only a problem for winter maintenance but a general safety hazard. It makes it hard for a blade to clean the surface.
- Mark islands, fire hydrants, storm drains and other landmarks that could be obscured by snow.
- Assign routes and sites to the person or team of people who will act as lead.
- Once routes or sites have been assigned, the operators, especially those operating motorized equipment should review those areas and note or mark all catch basins, manholes, sidewalk segments that may cause a hazard to the equipment and the operator.
- Clean out storm drains and conveyances.
- Determine snow and salt storage areas.

Design

Find ways to integrate winter maintenance professionals into the design or design review of parking lots and sidewalks. Many winter maintenance challenges could be alleviated with practical insight in the design process.

Do your designers and architects understand the need for snow storage, for removing snow plow obstacles, for ice problems that balconies create above walkways, for downspouts directed to sidewalks, marble steps on the north side of the building, for locating storm drains at handicap parking spaces or blowing and drifting snow considerations? Your maintenance crew does. Take advantage of their expertise to improve your design and lower your salt use.

Figure 17: Poor design, handicap parking spot at storm drain.

Poor design is a winter maintenance nightmare. No amount of salt can compensate for poor design.

Drainage

Inspect storm drains in the fall. Remove obstructions such as leaves, sticks, and trash to prepare for the spring melt. Because storm drains lead to lakes, rivers, ponds, and wetlands, never use salt to open frozen storm drains. Use proactive methods such as plowing all the way to the curb to prevent ice build-up. If Ice forms, use non-chemical methods such as heat to open drains.

State Law: Nothing can be dumped into storm drains. MINN. STAT. 609.671 (2019)

Poor drainage areas are high maintenance, high salt, high risk for users and with the high salt use comes degradation of the infrastructure, vegetation, and water. To remedy this, inventory the site and note drainage problems. Make a checklist so drainage problems can be fixed in the summer. If the site you maintain is not yours, report drainage problems to property management.

Examples of drainage problems:

- Roof that drips on the steps.
- Downspout discharging on sidewalk.
- Sidewalk segments sloped into a V.
- Potholes or low spots in parking lots.

Salt free idea: ***"Lightly sprinkle straw on the problem ponds of water that form on your sidewalks. It freezes in and gives a visual cue to pedestrians that something is different, and they avoid walking on it. In the spring use a leaf vacuum to pick up the dry straw."***
Chip Smith – Grounds Maintenance, Allina Health

Equipment

Aim to remove snow and ice so well that salt use is no longer required.

The trend in winter maintenance is better equipment, better training and better strategies so we can use less material to accomplish the same results. Below are a few tips, but there are many other innovations in the equipment area that can help to lower or eliminate the use of salt.

- Purchase pavement sensors.
- Subscribe to weather service that forecasts pavement temperatures.
- Check into higher performance cutting edges. Segmented blades for uneven surfaces, reversible rubber blades for less sidewalk damage, multi-layer blades, under body blades and more.
- Better hand tools
- Broom attachments
- Buy equipment that can deliver very low rates of granular products.
- Outfit equipment with ground speed controls so that the application rate changes automatically as the speed changes.

"We use brooms extensively on our sidewalks. Because of this, salting of sidewalks is only as needed and is not a common practice."
Nick Queensland – Unit Head, Facilities Operations Mayo Clinic Rochester, MN

- Modify existing equipment so that it can discharge the application rates described in the "Application Rates" section. Older equipment often applies more salt than recommended.
- Outfit sidewalk spreaders with shields to narrow the spread pattern.
- Invest in equipment that can deliver liquid deicers.
- Obtain a tank for liquid storage.
- Obtain a brine maker or find a source to purchase liquid deicers.
    - If there are any sophisticated brine users near you, keep an eye open for when they upgrade their systems. You may be able to buy their old equipment from them or at auction.
- Purchase tracking and documentation systems for salt use.

Calibration

Calibration is an essential procedure to understand how much material will be discharged at a given setting. No matter how sophisticated or simple the operation, calibrate each piece of equipment in the fall of the year. It generally takes a team of two or three people to calibrate equipment.

Simple calibration for salt spreaders

- Calibrate each year.
    - Industry leaders calibrate again mid-winter and whenever a piece of equipment is acting up or has gone through repairs that may affect application rates.
- Calibrate every piece of equipment that will spread salt, sand or liquids.
- Calibrate for each setting you intend to use.
- Calibrate for each product you intend to use, as they all flow differently.
    - Rock salt may come in different gradations so look at each delivery, if its particle size are noticeably different than what you have been using, recalibrate your spreaders.

Calibration tells how much material will be applied at each setting.

Closed loop spreader controls

Closed loop spreader controls are located in the cab in the truck. The computer is tied into the speedometer, along with external sensors, such as the auger RPM, pre-wet flow meter and anti-ice flow meter. This allows the computer to maintain an accurate material output based on the ground speed of the truck. After the operator selects the desired amount of material in the computer, the controller will maintain that target regardless of the vehicle speed. Not only will it maintain a constant output, but it will also record the amount of material that was applied. This information can be logged and used to monitor material output and identify where and when excess is used. Most equipment used for winter maintenance of roads in our more populated areas have these more efficient ground speed controls. The equipment for parking lot and sidewalk maintenance is also moving towards more accurate delivery systems like these.

Calibration allows accurate deicer use. Top performers calibrate their equipment.

The equipment vendor will have specific calibration instructions based the type and brand of equipment. Contact them; it is in their best interest to provide instructions to calibrate their equipment so it can be used to its full potential. The basic principle behind calibrating a ground-speed controlled spreader:

- The speedometer input (sensor) lets the controller know how fast or slow the truck is traveling. Smaller application equipment could also use a GPS sensor rather than speedometer input.
- The auger or conveyor input (sensor) tells the controller how fast or slow the auger is turning.
- To calibrate a ground speed controlled piece of equipment, put it into calibration mode and perform a salt catch test.
- Enter the weight of the catch test into the computer.
- Once the computer knows what was actually discharged compared to what was asked to be discharged, it will self-adjust. The computer will generate a "pounds per revolution" of the auger. This is how it calculates how fast to turn the auger based on the speed and pounds of salt that come out per turn of the auger.

Closed loop spreader controls? Contact manufacturer for calibration protocol.

Manual controlled spreaders

Manual controlled spreaders fall into two categories.

- Those that have an auger or conveyor
- Those that are gravity fed

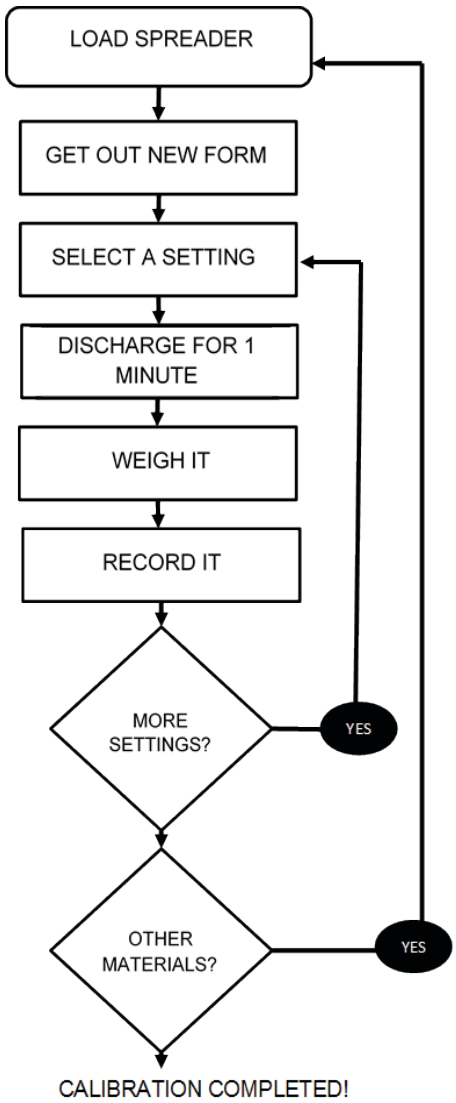
They operate by selecting a setting that changes the size of the discharge opening and/or the auger or conveyor speed. More or less salt may be discharged depending on the speed of travel and the spreader setting. Most parking lot and sidewalk spreaders are manual controlled spreaders.

The basic principle behind calibrating an auger/conveyor spreader is shown on the flow chart below.

Figure 18: Calibration card zip tied to push spreader.

Photo credit: FCI

Figure 19: Steps for calibrating an auger or conveyor system



Calibration forms and exercises

Step #1, blank calibration form

See Table 9 for a full size form to copy for calibration. (Keep a stack of these on a clipboard or a file on your computer when ready to begin the calibration.)

Step #2, calibration form filled out during calibration

Fill in the header information, start your equipment and discharge material for 1 minute, collect and weigh the material, fill in the pounds per minute for each setting you plan to use during the winter.

Table 3: Blank calibration form

CALIBRATION CHART FOR AUGER OR CONVEYOR SYSTEMS

DATE _____ SPREADER # _____ MATERIAL _____

SETTING	POUNDS PER MINUTE	5 MPH (x12)	10 MPH (x6)	15 MPH (x4)	20 MPH (x3)
1					
2					
3					

Table 4: Example calibration form with discharge and header information filled out

CALIBRATION CHART FOR AUGER OR CONVEYOR SYSTEMS

DATE 4-8-20 SPREADER # A4219 MATERIAL Rock Salt

SETTING	POUNDS PER MINUTE	5 MPH (x12)	10 MPH (x6)	15 MPH (x4)	20 MPH (x3)
1	10				
2	22				
3	34				

Step #3, calibration form ready to put in truck for road application

Back in the office, do the calculations to fill in the rest of the blanks. Multiply the weight in column 2 with the multiplier in the top row. This provides the pounds per mile that needed to fill in the table.

Table 5: Example calibration form with pounds per lane mile filled out

CALIBRATION CHART FOR AUGER OR CONVEYOR SYSTEMS

DATE 4-8-20 SPREADER # A4219 MATERIAL Rock Salt

SETTING	POUNDS PER MINUTE	5 MPH (x12)	10 MPH (x6)	15 MPH (x4)	20 MPH (x3)
1	10	* 120	60	40	30
		**			
2	22	264	132	88	66
3	34	408	204	136	102

* top half of each row = lbs/lane mile. To get this number, multiply lbs/min by the factor shown for each speed.

** bottom half of each row = lbs/1000 sq.ft. To find this, divide the number in the top half by 63.

If you are spreading on roads or paths, you are finished. Your calibration card is now ready to be laminated and put in the truck or UTV. It can also be zip tied to any equipment.

Step #4, convert from pounds per lane mile to pounds per 1000 sq. ft. for parking lot and sidewalk applications.

Divide by 63 to convert pounds per lane mile to pounds per 1,000 square feet.

Table 6: Example calibration form with lbs. per 1,000 sq. ft without lbs per lane mile

CALIBRATION CHART FOR AUGER OR CONVEYOR SYSTEMS

DATE 4-8-20 SPREADER # A4219 MATERIAL Rock Salt

SETTING	POUNDS PER MINUTE	5 MPH (x12)	10 MPH (x6)	15 MPH (x4)	20 MPH (x3)
1	10	*120	60	40	30
		**1.9	1.0	0.6	0.5
2	22	264	132	88	66
		4.2	2.1	1.4	1.0
3	34	408	204	136	102
		6.5	3.2	2.2	1.6

* top half of each row = lbs/lane mile. To get this number, multiply lbs/min by the factor shown for each speed.

** bottom half of each row = lbs/1000 sq.ft. To find this, divide the number in the top half by 63.

Step #5, Delete pounds per lane mile information

Table 7: Example calibration form with pounds per 1,000 sq. ft. filled out

CALIBRATION CHART FOR AUGER OR CONVEYOR SYSTEMS

DATE 4-8-20 SPREADER # A4219 MATERIAL Rock Salt

SETTING	POUNDS PER MINUTE	5 MPH (x12)	10 MPH (x6)	15 MPH (x4)	20 MPH (x3)
1	10				
		**1.9	1.0	0.6	0.5
2	22				
		4.2	2.1	1.4	1.0
3	34				
		6.5	3.2	2.2	1.6

* top half of each row = lbs/lane mile. To get this number, multiply lbs/min by the factor shown for each speed.

** bottom half of each row = lbs/1000 sq.ft. To find this, divide the number in the top half by 63.

If you are spreading on parking lots and sidewalks, you are finished. Your calibration card is now ready to be laminated and put in the truck or UTV. It can also be zip tied to any equipment.

Gravity flow equipment

This is applicable for equipment that does not have a motorized delivery system. This type of equipment might be a tailgate mounted spreader, gator mounted spreader or a hand push spreader. Gravity flow equipment is typically controlled by gate opening and speed of travel. A blank form for calibration of gravity flow equipment is in Table 8.

Step 1: Calculate discharge rate

- Mark out a 10-foot stretch of pavement. (By increasing the size of the test area i.e., the longer the test area, the more accurate the results will be).
- Sweep it clean of sand or any other material.
- Using a constant speed, try to match the speed you would expect to go during an application in the field. Apply one pass of material to the test area.
- Measure the width the material is spread or bounces, in feet.
- Sweep up and weigh the material that is within the marked 10-foot stretch.
- Record the lever position/setting for the gate/chute. If there are no numbers for the positions, make permanent marks on the equipment to identify the positions.
- To improve accuracy, repeat two more times and calculate the average weight of material applied.
- Record results in columns A, B, C, and D (Table 8).

Step 2: Repeat step #1 for any setting you plan to use in the winter.

Step 3: Back in the office, finish filling out chart.

- Fill out columns E, F, and G (Table 8).
- If using more than one type of material, repeat the test for each material.
- Place the completed calibration chart with the equipment.

Shortcuts:

- Put down a tarp over the application area; this makes it quicker to recover and weigh material.
- After the first pass, put a bag around spreader discharge area to catch material before it hits the ground. After walking/driving for 10 feet, take off the bag and weigh it. (The first pass is needed to determine the spread width.)

Calculate application rate

Table 8: Example calibration chart for gravity flow equipment

Equipment: _____ Material: _____ Date: _____

A	B	C	D	E	F	G
Speed	Lever position or gate setting	Pounds spread in 10 feet*	Spread width in feet	Coverage area in sq. ft. **(D x 10)***	Application rate in lbs./1000 ft^2 **(1000/E x C)**	Application rate in lbs./lane mile (12' width) **(F x 63.4)**
.....EXAMPLE.....						
20 MPH	Half-closed	0.4 lbs.	13 feet	130 sq. ft.	3.1 lbs. per 1000 sq. ft.	196 lbs./mile

* If changing the test strip length, adjust the title in column C and the multiplier in column E.

What if calibration is not a practice?

Even without calibrating the equipment, the amount of material to use can be determined. Know the pavement temperature, material you intend to use and the size of the area to be treated. By consulting the application rate chart (Table 16) and doing the math you can figure out how much material to use. With this knowledge you can figure out your own method for distributing it evenly over your area. (Note that if your operations typically use twice the amount of salt recommended in the chart, you should make that adjustment in your calculations.)

This approach may work well for treating sidewalks using the "chicken feed" method. For example:

- 20°F degrees pavement temperature and rising
- Using dry salt
- Sidewalk is 2,000 square feet
- Table recommends 2.25 lbs. per 1,000 square feet (for this situation)
- Measure about 4.5 lbs. of salt
- Figure out a way to spread it evenly over the 2,000 sq. ft. surface

Calibration charts

Table 9: Blank calibration chart for gravity flow equipment

Calibration Chart for Gravity Flow Equipment						
Vehicle or spreader number:					**Date:**	
Material Type:				**Calibrated by:**		
		A	**B**	**C**	**D**	**E**
Speed	Lever position or gate setting	Lbs. Material recovered in 10 feet	Spread width in feet	Sq. ft. covered with material **(B x 10)**	Application rate in lbs./1000 ft^2 **(1000/C x A)**	Application rate in lbs./lane mile (12' width) **(D x 63.4)**

Table 10: Blank calibration chart for auger or conveyor manual controlled spreaders

CALIBRATION CHART FOR AUGER OR CONVEYOR SYSTEMS

DATE _____ **SPREADER #** _____ **MATERIAL** _____

SETTING	POUNDS PER MINUTE	Quantity / Area	5 MPH (x12)	10 MPH (x6)	15 MPH (x4)	20 MPH (x3)
1		lbs/lane mile				
		lbs/1000 sq.ft.				
2		lbs/lane mile				
		lbs/1000 sq.ft.				
3		lbs/lane mile				
		lbs/1000 sq.ft.				
4		lbs/lane mile				
		lbs/1000 sq.ft.				
5		lbs/lane mile				
		lbs/1000 sq.ft.				
6		lbs/lane mile				
		lbs/1000 sq.ft.				

Materials

Think about your workbench. How many tools do you have? Some tools may be used only once a year yet when you need it, it makes the job easier. The same goes for the materials we apply to our winter surfaces; the bigger the variety, the better suited you are to face a variety of conditions. All products have pros and cons, use the one that will get the job done with the best results and require the smallest amount of work and product! A great way to reduce impacts, save money and maintain customer satisfaction is to:

- Know what is in the product.
- Know the product's practical melting range and use it only when it will be effective.
- Use the minimum amount needed to get the job done.
- Apply it in the optimal spread pattern.
- Apply it at the optimal time
- Apply it at the optimal intervals (cycle time).

No materials are safe for the environment. Choose the one you can use the least of to get the job done. The more tools you have to choose from, the easier your work will become!

Abrasives

- Do not melt snow and ice.
- Provide traction on top of packed snow or ice.
- Abrasives and deicers typically work better alone, rather than together.
- A small amount of salt is often mixed in the sand to prevent freezing in the pile (less than 10%).
- Under the right conditions, a little liquid deicer can sandpaper the abrasives to the surface.
- Are good for super cold pavement temperatures.
- Are good for areas that do not require bare pavement.

Deicers

- Melt snow and ice and/or change the snow/ice structure to keep them from packing.
- Lower the freezing point of water from 32° F to a colder temperature.
- Must be dissolved to work; therefore, liquids often act faster than solids.
- Have different melting characteristics, depending on the product.
- Two basic categories of deicers: Chloride based deicers (salts) and non-chloride based deicers.

Salts:

- Sodium Chloride, Magnesium Chloride, Potassium Chloride and Calcium Chloride.
- Road salt (NaCl) is a granular product and is mined from the earth.
- Magnesium Chloride ($MgCl_2$) and Calcium Chloride ($CaCl_2$) can naturally occur as liquids.
- $MgCl_2$ and $CaCl_2$ are hydroscopic, drawing moisture from the air to themselves.
- Salt brine (NaCl) is optimal at a 23.3% concentration. A 23.3% concentration will stay in solution and will not freeze in your tanks or hoses until -6°F. A stronger or weaker solution will freeze sooner or cause more settling in your tanks.

Acetates, formates, urea and other non-chloride deicers:

- Are chemically manufactured which is why they tend to be more expensive.
- Most are less corrosive than salts.
- Most cause less damage to vegetation than salts.
- They have a wide melting range, depending on the product chosen.

Organic additives (corn, beet, or other organic additives)

Organic additives may be added to salt or salt brine to change its performance. Clear Roads, a national resource consortium of state transportation agencies, has studied this issue in project 13-02.

- Often have very low ice melt capacity.
- Can reduce corrosive properties of deicers.
- Are sticky and may help material stay on the surface longer.
- Reduce the freeze point of liquid deicers.
- Can be very effective when combined with conventional deicers (e.g., rock salt) because the salt initially melts the ice, then the ag-based additives prevent refreeze better than salt alone.
- Interferes with ice crystal formation and refreeze (cryo-protectant). Ice cream has sugar in it (plant-based ingredient) and it allows us to easily eat it because the ice crystal formation is soft. Compare it to eating an ice cube that has no plant-based ingredients. Both are stored in the freezer at the same temperature.

Brine blends

Brine blends are dominated by salt brine but there are a wide range of products that can be added to the base brine to change its freeze point, ice melt capacity, corrosion factor, visibility, and stickiness. The industry is trending towards brine additives in more difficult melting conditions or in anti-icing with more lasting power in the face of traffic.

- Additive options are varied but common ones are:
  - Calcium chloride only.
  - Organic additive only.
  - Combination of Calcium chloride and organic.
  - Combination of Magnesium chloride and organic.
  - Pre-packaged additives sold under many names and trademarks.

Measure brine additives carefully to prevent problems

Waste stream products

Much talk has been going on about using pickle or cheese brine for deicing. The idea of reusing waste stream products is very tempting and can be encouraged only if:

- The waste stream product has consistent properties. This means product testing for a batch will yield the same results for all batches received.
- The product has been thoroughly investigated and tested to avoid unforeseen side effects (e.g., Will it discolor or harm asphalt? Are any ingredients or degradation products toxic to humans, mammalian wildlife, birds, or aquatic species? Does it have any offensive odor when it degrades? Does it have high BOD? pH? Potential unwanted contaminants?)
- It has been tested to ensure it can melt snow/ice or add to the properties of deicers.
- Understand how to combine it with other products to get good results.
- Obtain any necessary permits or permissions to apply this material.
- Understand availability of market supply (e.g., is it seasonal?).

Ice melt capacity

The amount of snow/ice each product can melt varies from product to product and we cannot change the ice melt capacity of a chemical. For example, 1 pound of product x can melt 50 pounds of snow and ice whereas 1 pound of product y can melt 55 pounds of snow and ice. We tend to apply more deicer than is needed to melt the available snow/ice in an effort to speed up melting.

A better way to speed up melting is to select products that work well in your pavement temperature range, by using granular products with smaller particle size or by using liquid products. This will result in faster results, and less overall salt used.

Don't be fooled, ice melt capacity and ice melt speed are 2 different things. Adding more of the same is a poor way to speed up melting!

Speed of melting

Will the rock salt you apply have enough time to work before it is kicked off the sidewalk or blown off the road? This chart will aid in making that decision.

Table 11: Speed of Melting

Pavement temperature °F	One pound of dry salt (NaCl) melts	Melt times
30 25 20 15	46.3 lbs. of ice 14.4 lbs. of ice 8.6 lbs. of ice 6.3 lbs. of ice	5 min. 10 min. 20 min. 1 hour
10 5 0 -6	4.9 lbs. of ice 4.1 lbs. of ice 3.7 lbs. of ice 3.2 lbs. of ice	Dry salt is ineffective and will blow away before it melts anything

How fast will your product work?

Below is an oversimplification of the melting processes but will convey a very basic concept.

Fastest – Liquids
Fast – A lot of liquid added to a little granular
Medium – A little liquid added to a lot of granular
Slow – Granular, small size granules
Slowest – Granular, large size granules

Don't use dry salt at pavements below 15°F. It takes too long to work!

Practical melting temperature

Be cautious when reading about the melting temperature on packages of deicers. The package often lists the eutectic temperature, which is the lowest temperature at which the product is stable in solution. At this temperature, it would take a very long time to melt ice. Instead, use the lowest practical melting temperatures in Table 12 or ask the supplier for the practical melting temperature range and the time it takes to melt ice at that those temperatures.

It should be noted that there is not a standard measure for determining the lowest practical melting temperature. Across the literature there are a range of values.

Table 12: Lowest practical melting temperature (From *Minnesota Snow and Ice Control: Field Handbook for Snowplow Operators* (2022), Acetate information from Cryotech)

Lowest practical melting table			
Chemicals	**Lowest Practical Melting Temp.**	**Eutectic Temp.**	**Optimal Concentration**
NaCl (Sodium Chloride) — Delivered as rock salt, can be made into a brine. The basis of many bagged blends. Corrosive. Inexpensive. Very available. Most commonly used without a corrosion inhibitor added, but corrosion inhibited products are available.	15° F	-6° F	23%
$MgCl_2$ (Magnesium Chloride) — Delivered mostly as a liquid, other forms available. Used for anti-icing, pre-wetting and stockpile treatments. Corrosive. Higher cost. Often has a corrosion inhibitor added. Can be added to salt brine.	-10° F	-28° F	27 to 30%
$CaCl_2$ (Calcium Chloride) — Delivered as flakes, pellets, or liquid. Corrosive. Very effective ice melter as very cold temperatures. Sometimes used incorrectly to open storm drains. Higher cost. Often has a corrosion inhibitor added. Often added to salt brine.	-20° F	-60° F	30%
CMA (Calcium Magnesium Acetate) — Delivered as pellets. CMA can be made into a liquid solution on-site using instructions and guidance available by contacting the vendor. Non-corrosive to steel, biodegradable. Alternative for areas where chloride use must be limited. Tends to work differently than conventional deicers in that it doesn't form a flowing brine so much as changes the structure of ice/snow crystals to prevent packing. Safer for new (<1-yr-old) concrete and specialty stone. (Consult vendor to verify before using, though). Very high cost.	20° F	-18° F	25%
KAc (Potassium Acetate) — Delivered as a liquid. Often used on fixed automated bridge deicing systems and airports. Use for anti-icing, deicing. Non-corrosive to steel, rated as "Relatively Harmless" by US Fish & Wildlife scale, biodegradable. Very low effective temperature. Alternative for areas where chloride use must be limited. Higher cost.	-25° F	-76° F	50%
NAAC (Anhydrous Sodium Acetate) and NaFo (Sodium Formate) — Delivered as pellets. These deicers are more commonly used at airports, but are often used on roads, bridges, parking structures as well. Non-corrosive to steel, nonhazardous, biodegradable. Alternative for areas where chloride use must be limited. Low effective temperature. High cost.	0°F	-7°F (NAAC); -16°F (NaFo)	NAAC and NaFo are not commonly liquefied.

Blends — Both chlorides and acetates exist in blends. Talk to the supplier and determine the lowest practical melting temperature, the optimal concentration, and the basic components in the blend. Most blends are centered on rock salt since it is cheap.			
Winter Sand/Abrasives — Winter sand has salt mixed in it to keep it from freezing. Abrasives should be used for cold temperatures when deicers are not effective. Want to minimize salt % in sand.	Never melts — provides traction only		

Testing

When creating or purchasing liquid deicers make sure to test it (measure its density). If it is NaCl brine it should be 23.3%. If it is another liquid, check to make sure it meets the vendor's recommended density or density range. Hydrometers are a very common and inexpensive tool for testing the density of liquids. They read like a floating thermometer. Take the density reading at the top of the liquid. If you are blending materials into your brine, make sure your percentages are accurate and follow the instructions of your supplier. Incorrect mixing ratio is a recipe for trouble.

Figure 20: Salt brine being tested with salt brine hydrometer.

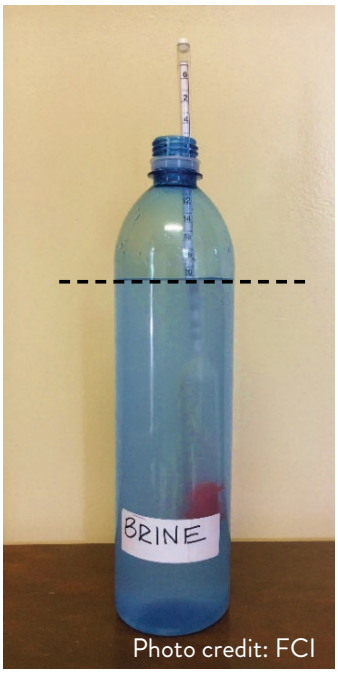


Photo credit: FCI

Standard salt brine should be 23.3%. Float the hydrometer and read at the top of the brine level.

Reading the label

There are no laws in place controlling what information is shown on the label of deicers. The information can be accurate, exaggerated, or downright wrong. Product labeling is confusing, some list eutectic temperature, some the lowest practical melting temperature. The list of ingredients may or may not be included and may or may not be accurate. Often, the percentage of each ingredient is not included. Some claim to be "pet friendly" but there is no "pet friendly" standard established. Talk to your supplier and find out what is in your product, what is the recommended temperature range for most effective use and what are the potential effects to pets, vegetation, and infrastructure. If your supplier does not want to share that information with you, look for a different supplier or product line. Some leading manufacturers have opted to truthfully disclose ingredient list and associated percentages. Hopefully more will follow their lead.

Vendors should be able to provide you with a Safety Data Sheet and written guidance for product use as well as storage and handling.

Cost and availability

Of the deicers, NaCl is typically the cheapest and easiest to find. Because of this, it is widely used and overused. Dry sodium chloride is only effective at pavement temperatures above 15°F. At temperatures lower than 15°F degrees, switch to a different deicer or an additive to increase the performance of NaCl.

What is in your bagged blend? Without labeling conventions, we may never know but since the cheapest deicer is NaCl, one might assume that the lower the price of your bagged blend, the more likely it contains a high percentage of NaCl.

Non-chloride deicers are more difficult to find and often cost more. They are frequently used in areas with expensive infrastructure like airports, bridges and parking ramps. The upfront cost in these areas is justified due to reduced infrastructure damage. Local airports' winter operations personnel may be able to provide recommendations for sourcing and provide good advice, reviews, and tips about the use of these products. Get familiar with how they work and identify target areas where they will give you the best results or solve a specific problem, such as bridge corrosion.

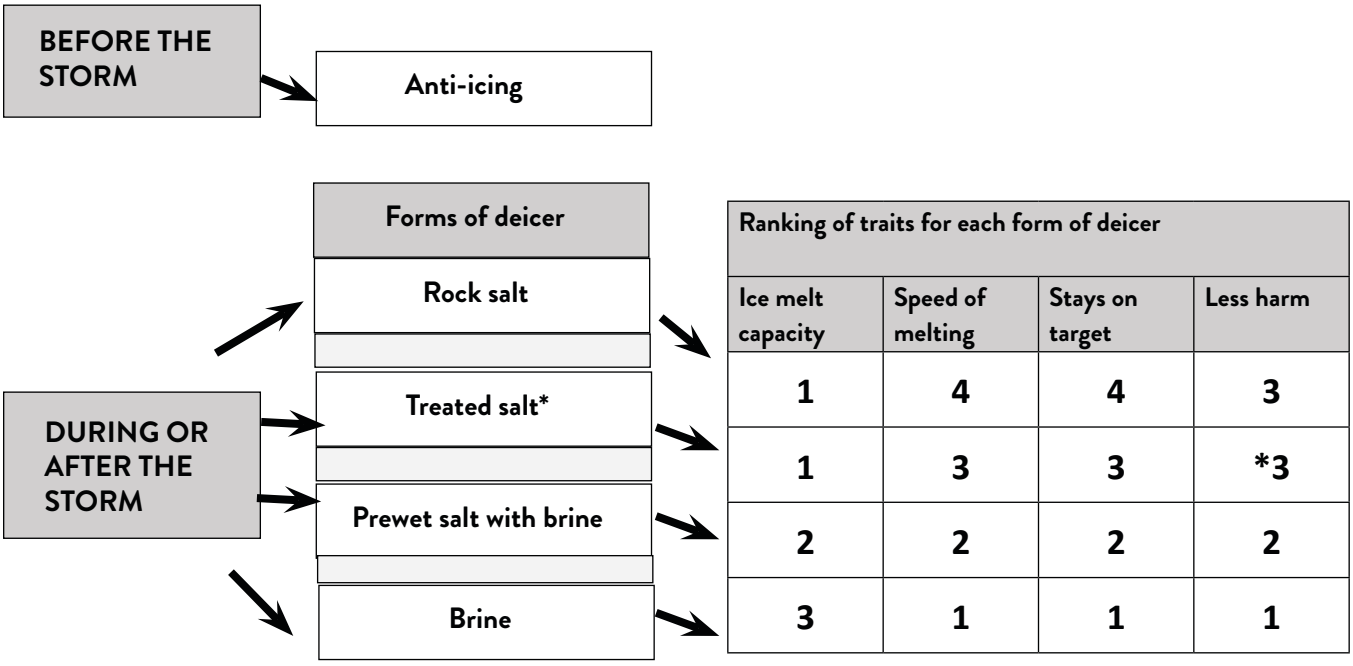
Using 50/50 salt/sand mix is generally half right or half wrong. Using a salt/sand mix leads to over application of both materials.

Salt sand mixes are commonly used to stretch the salt budget. This is an ineffective practice. Salt and sand work against each other. To save money, use deicers when melting is needed and sand for temporary traction, to buy time at temperatures too low for deicers to be effective, or in areas with low level of service targets. There are always exceptions to the rule. For example, sand pre-wet with brine has shown to be effective in keeping sand in place longer on icy surfaces as it "sandpapers it to the ice".

Winter operations

Overview of deicer strategies

Figure 21: Overview of deicing strategies. Ranking of traits is based on a fixed volume, say 1 lb of material. 1 = best.



Ranking of traits for each form of deicer			
Ice melt capacity	Speed of melting	Stays on target	Less harm
1	4	4	3
1	3	3	*3
2	2	2	2
3	1	1	1

These rankings are over simplified, meant to illustrate a general concept. Exceptions can be found in every category, especially when considering type of liquid and type of granular products, pavement temperature, liquid to granule ratio, granule size, and various additives. The less harm is based only on the simple concept that less material used, less harm caused.

*Treated salt is assumed to be treated with compounds other than brine. These compounds change the product's performance, usually for the better so less product is needed. There are a variety of compounds used to treat salt in the stockpile; each have their own unique environmental impacts.

Anti-icing: Before the storm

Anti-icing


Anti-icing is a liquid only application of deicer before the storm. It can save you time, money and work!

If your target level of service is bare pavement then anti-icing should be one of your tools. Anti-icing involves putting down a small amount of liquid deicer just before the storm. With this small amount of deicer, a micro layer of melting will occur. This micro layer of melting will help prevent the snow from bonding to the pavement and you will be able to recover your surfaces faster.

Anti-icing is like frying eggs: grease the pan before you add the eggs and the eggs do not bond to your pan, they come out easily with no mess to clean up.

Anti-icing requires about ¼ the material and ⅒ the overall cost of deicing. It can increase safety at the lowest cost and is effective and cost-efficient when correctly used and approached with realistic expectations.

Anti-icing prevents formation of frost. It can be effective for up to several days. How long it lasts depends on application rate, type of material used, traffic and weather conditions.

Figure 22: Anti-icing wet/dry pattern.

Photo credit: City of St. Anthony Village, MN

Anti-icing is quick. It is possible to treat a parking lot in a matter of minutes. It is an excellent strategy for saving time.

Get started in anti-icing

What to do

- Calibrate your equipment so you can hit a targeted application rate.
  - Make sure all nozzles are working
- Use application rates suggested in Table 15 or work with your vendor for specific application instructions.
- Apply chloride products with stream nozzles to maintain dry areas between sprayed areas to reduce slipperiness.

Stream nozzles give a wet dry pattern. The dry pavement (with good friction) is a safeguard for you in case something goes wrong.

- Fan nozzles are a riskier practice. If you blanket a dry pavement with a liquid and you lose friction, you have created a hazard.
  - Acetates are more frequently applied with fan spray in anti-icing operations. Acetates have low surface tension and tend to coat in a thin film on pavement surface without loss of traction
- Read some of anti-icing guidelines in the References section of this manual.
- Talk to others who have experience with anti-icing.
- Test the rates and spray pattern to gain confidence if preventing a bond without creating a slimy or slippery situation. Be careful not to over apply to avoid tracking.

What not to do

- Do not re-apply if there is still salt residue.
- Do not apply $MgCl_2$ or $CaCl_2$ to a warm surface. It can become "greasy" as it pulls moisture to the pavement. These liquids do not always become greasy, but there is a higher potential in warmer temperature, higher application rates and higher humidity.

Too little $CaCl_2$ or $MgCl_2$ is safer than too much.

- Do not over apply $MgCl_2$, $CaCl_2$,or KAc.
- Do not anti-ice before a heavy rain as they will wash away. However, they work great for freezing fog, freezing mist or extra light freezing rain.
- Do not apply in drifting/blowing areas. The snow will stick to your lines instead of blowing across your surface.

Anti-icing tips

- Many prefer to anti-ice in the lowest traffic conditions possible, in hopes that it will dry before traffic moves it around too much.
- Some users advise against spraying the service road in front of buildings and instead spray traffic lanes and back service roads to allow the traffic to spread the liquids near the building where foot traffic is higher. This can reduce tracking into the building and over-application in a high-traffic area.
- Anti-ice when weather forecasts indicate a need. Do not anti-ice on a regular schedule, e.g., every Friday unless you have a persistent problem like an area that often gets frost or black ice.
- Pretreated or pre-wet materials are not as efficient as liquids for anti-icing. These require more material overall than with liquids. The pre-wet granular materials don't stay in place as well as the liquids. Pre-wet granular solids can work if applied at extremely low application rates as the event is starting.
- If you are getting icy refreeze try an organic additive to your brine, the refreeze is typically more slushy than icy.

Anti-icing requires less overall salt use. Using less salt doesn't have to reduce safety, but it does protect the lakes, streams and groundwater.

Equipment

- Anti-icing unit, e.g., transport vehicle with tank, spray system, transfer pump, hoses and fittings
- For larger trucks: Stream nozzles (minimum eight holes), 8-inch spacing, bar height 12 to 14 inches from surface, 30 to 35 psi at the bar. These can be purchased or constructed.
- Solid stream – fan spray is more apt to make slippery conditions.
- A handheld pump sprayer or backpack sprayer can be used for sidewalks. Remember to leave a pattern of wet and dry to reduce the chance of creating slippery conditions.
- There are many ways to retrofit a pick-up truck or ATV with a tank and one of the following: booms, spray bar, or hose reel with sprayer.
- A shutoff switch within easy reach.

Figure 23: This is an easy way to get started with anti-icing.

Photo credit: Rodger Bannerman

Liquid only treatments are expanding to during and after the storm. If you want to be set up for full storm liquids, bar pressure will become more important.

Snow removal

Physical removal of snow and ice from surfaces is the number one most effective way to reduce the amount of deicer needed to create safe winter conditions on sidewalks and parking lots. Physical removal should always be done before applying any deicer, never treat an unplowed surface. When trying to decide, "Is it worth it" to plow or sweep before treating, ask yourself if you'll get any snow off the surface to be treated; if the answer is yes, then it's worth it! Only once snow and ice has been removed down to the pavement, or what remains is hard-packed to the surface, is it time to treat with deicers.

Timing

Plan your snow removal to reduce compaction. This will depend on the traffic levels in the area you plan to treat. Often the approach is to "wait until its done snowing" before doing any physical removal of snow to maximize efficiency. While this may seem to save the most time, if the snow gets too compacted to plow off and requires multiple applications or high amounts of deicer, it's not as efficient as you might think. Only in areas with low or no traffic where snow does not get compacted to the surface should you wait until the end of the event to begin snow removal.

In areas with higher traffic, consider removing snow on a time cycle or to take place just before a time of highest traffic. During the storm, provide snow removal in high service level areas every one to three hours. This is a time to be physically removing the snow, not attempting to just salt it all off! Store entrances, outdoor stairs, and handicapped parking spots are all examples of places where a cycle time during storms can lead to a higher service level while reducing chloride in these areas commonly over treated.

In parking lots, consider if there is a "rush hour" or time of peak travel such as a place of employment getting finished for the day, or an evening rush at a grocery store or restaurant. Try to time physical removal just before these peaks of traffic to maximize your efforts in keeping your lot in good shape and free from hard pack. This could apply to parking lot entrances and drive lanes as well as near building entrances, it doesn't necessarily need to be the entire parking lot or sidewalk you are responsible for.

Equipment

Match the equipment to the space and traffic level and make it convenient to use. Consider shovels, scrapers, and single stage snowblowers to keep high traffic walks snow free near buildings where larger equipment may not be as safe to use when the area is busy. Keep these items located close to the job so they are the first tool of choice rather than a barrel of salt and a spreader.

In parking lots, choose equipment that optimize visibility and maneuverability. A front-end loader with a fifteen foot plow may be a great choice when the parking lot is empty at three in the morning, but may not fit down the drive lanes when cars still occupy the parking spaces. UTV's, tractors, and skid steer loaders may be a better choice when working around higher traffic levels. Be patient and considerate when trying to work during busy times, consider everyone around you as your customer as they support the business that issues your contract.

Make sure your equipment is in good condition and up to the job of removing as much snow and ice as possible. Hand tools in rough shape from years of service should be replaced. Plow blades that have worn uneven will often leave excess snow behind that will require treatment. Broom bristles worn short may not completely meet the surface especially in dips and curves. Keep your equipment in a condition that maximizes its snow removal effectiveness to reduce the need for treatment after snow removal.

Consider keeping multiple tools in your snow removal toolbox, don't get stuck in a rut and take a, "It's just how we've always done it" approach. Power brooms often do a far better job removing snow than blades and blowers, in high service level areas brooms should be your go-to tool even if you need to plow or blow heavy snows off before sweeping. Sweeping will often leave a surface clean enough that it will not require treatment, or a light, direct liquid application will be sufficient. Brooms come in many sizes for mowers, UTV's, skid steers, tractors and loaders. Match the size of the equipment to the job. And don't be afraid to try sweeping in parking lots too! Larger brooms are available that can handle small to medium sized parking lots in lighter snows; while they may take more time than plowing, the time saved if no deicer treatment is needed can still result in gains of productivity overall and a higher service level.

Take a look at segmented plow blades. Blades such as Joma and PolarFlex are becoming more popular. They have short segments mounted with hard rubber so that they can move independently and match the small imperfections of the surface. They work more quietly improving issues with driver fatigue, clean the surface more effectively than straight carbide blades, and wear more evenly giving a much longer life before requiring replacement. The higher up-front cost of these blades can be recovered through savings in deicer treatments and the extended blade life that will be achieved over straight blades.

Plow first, treat as needed

Remember, physical snow removal should always come before treating with deicers. The greatest opportunity for salt savings doesn't need to come from expensive new technology or complicated liquid potions you're not familiar with (although they're nice too)! It comes from using the right equipment for the job, keeping it in good condition, and making sure to time your snow removal to minimize hard pack, so that blades, blowers and brooms can get the job done rather than relying on deicers. The goal should always be to do such a great job removing snow and ice that deicer may not even be needed, or a much smaller application than might be usual is possible.

Deicing: During and/or after the storm

Deicing is a reactive operation where a deicer is applied to the top of snow, ice, or frost that has accumulated on the pavement surface.

- The application rate table (Table 15) has been designed to match with the rates recommended for highways, county roads and city streets in MN. Minnesota Snow and Ice Control Field Handbook for Snowplow Operators. (2022, January). https://www.mnltap.umn.edu/publications/handbooks/documents/snowice_2022.pdf
- These rates should be viewed as a target to aim for, not a starting point. Many organizations use a much higher rate; it would be a shock to move from a high to a low rate in one step.
- Adjust your winter maintenance strategies, tools and chemicals and as your performance improves, your salting can decrease. You will find yourself moving closer to the target rates.
- Most over-salting can be prevented by using calibrated spreaders, adjusting spread pattern, using good judgment in selecting materials and application rates based on pavement temperatures.
- Don't try to melt all the snow on the surface with salt. This is an overuse of materials. Apply just enough to loosen the bond between the pavement surface and the snowpack so it can be plowed off.

The goal is not to melt everything. The goal is to penetrate through the ice and snow and break the bond so the pavement can be plowed.

Better snow removal = less deicers!

Figure 24: A sign your operations need fine tuning.

Photo credit: FCI

Dry material: Rock salt and packaged products

These are the most used products in winter maintenance. Granular deicers have the greatest ice melt capacity thus can melt more snow and ice per volume of product used. That is an advantage in areas with heavy compaction or considerable snow to melt, however today's standards get us out early and often in the storm to remove snow. Granular products are less effective and frequently overused because of these challenges:

- Slow to work
- Moves off target easily

Granular products cannot melt snow and ice until they turn into a liquid. This takes time, often more time than we are willing to wait. We try to speed up melting by adding more of the same product, that is often a wasteful and ineffective strategy. If your sidewalks are covered with salt after the storm is it because you tried to speed up melting? It can also be traced back to other problems in your operational strategy.

Salty surfaces after the storm = time to improve your maintenance strategy.

Melting can be faster when:

- Adding or switching to a liquid deicer
- Pavements warm up
- Switching to a granular deicer that works better in your pavement temperature range

It is often a poor choice to try to speed up melting by:

- Adding more of the same product

It is difficult to get granular products to stay on target. They bounce and scatter as you apply them. The granules that end up on target soon get displaced by traffic. Vehicles and pedestrians scatter the salt off your surfaces before it can do the job.

Due to the speed and accuracy problems associated with granular materials they are often applied over and over again to get the same effect as using a liquid product or a liquid/granular combination product in a much smaller amount.

Another challenge to granular products is a lack of moisture. Consider a surface that has been swept but is just a little slippery, granular products won't brine out because there's not enough residual moisture, a great time to use direct liquid application (DLA)!

As the winter maintenance industry catches up with the sophistication found in the agricultural industry the trend will be similar. More liquid and less granular products.

Granular products are like the logs in the bonfire. They are slow to get started but if you can keep them in place, they will last a long time.

Pretreated stockpiles

The term "Pretreating or pretreated stockpile" refers to a rock salt stockpile that has a liquid product mixed in. It does not refer to applying liquid deicer down before a storm. Pretreated salt can be purchased as a product already mixed and ready to use or can be created on site. To create a pre-treated stockpile, add liquids conservatively. The dry material can only hold so much liquid before leaching occurs. Watch the storage area to make sure it can contain the wet salt pile. Test mixing skills and observe the amount of leaching on a small stockpile before doing this on a large scale.

Treating the salt stockpile

It is easier, safer for the environment and more likely to get a premium product if you purchase pretreated salt than mix your own. But if you have a contained area and an efficient way to blend the products you can be successful.

Your salt pile must be dry before trying to create a treated stockpile. If your salt is wet, the liquid you add will run out of the pile.

- Mix rock salt with liquid deicing chemical or additive (not brine).
- Apply at about 6 gallons/ton or the amount recommended by your supplier. The wetness of your salt will determine how much liquid you can add without leaching.
- To minimize leaching, mix up pretreated salt per storm event, not per season.
- Because leach risk at a treated stockpile is increased, proper storage is critical.

Treated salt application

- Pretreated salt can be applied with almost any type of equipment used for dry salt.
- Remember to turn down the application rate; it requires less material than dry salt.
- It typically works at a colder pavement temperature than rock salt (depends on the additive).

Pre-wetted salt

Pre-wetting salt involves a tank and a hopper. The liquid and the granular salt come together at the point of discharge. Liquids applied to dry salt jump-start the melting process and penetrate ice and snow pack faster. Wet materials stick to the pavement and are less likely to end up off target.

When integrating liquids, make sure to decrease the application rate of the granular product. This is a common mistake made by new users of liquids. Typically, you can turn down the rate by ⅓ and get the same result.

Figure 25: Dry salt vs. wet salt.

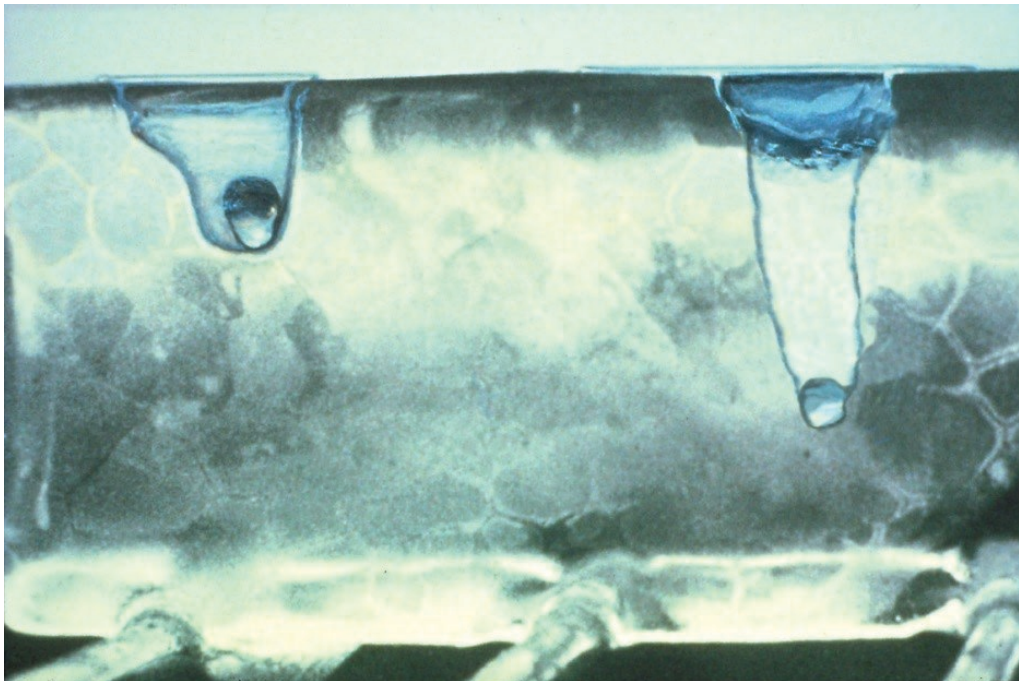
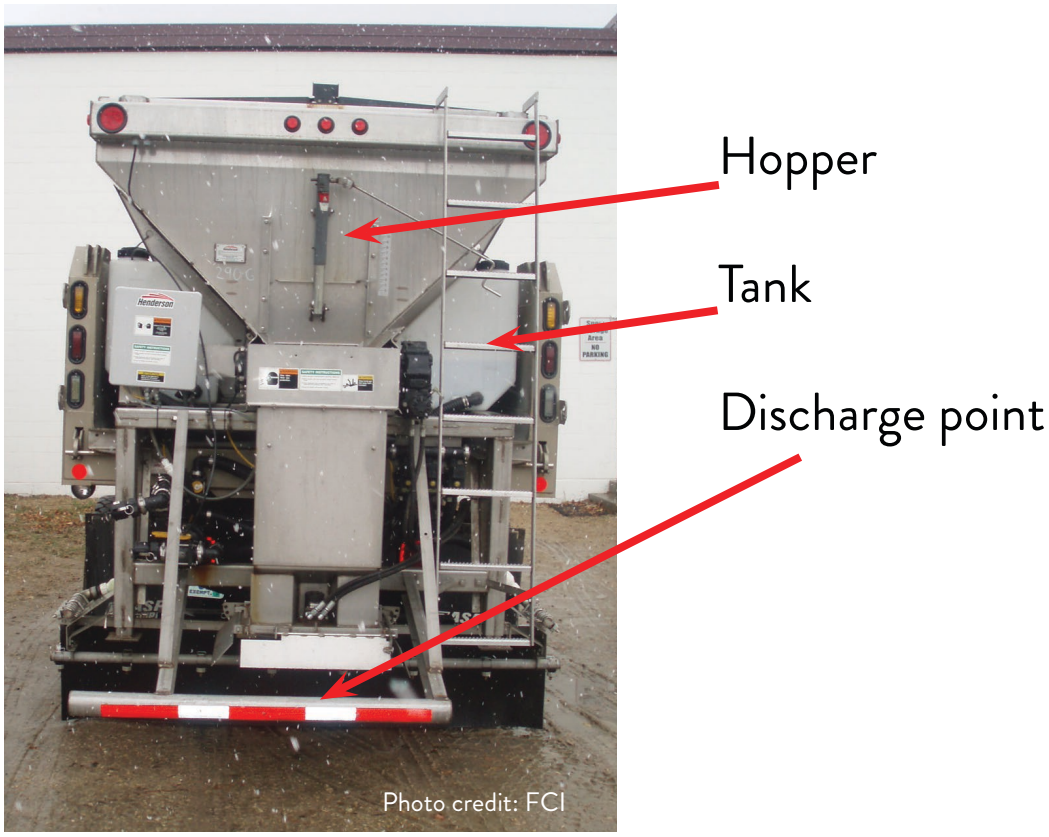


Photo credit: Wisconsin DOT transportation bulletin #22

- Adding liquid deicers to dry salt as it is applied will speed up melting.
- Salt brine is the most commonly used pre-wetting agent.
- Brines can contain other ingredients (additives) to improve performance or reduce corrosion.
- Pre-wetting rock salt with magnesium chloride ($MgCl_2$) or calcium chloride ($CaCl_2$) will work at colder temperatures. It is OK to use potassium acetate, too. It is chemically compatible with salt as a pre-wetting agent.
    - Don't mix potassium acetate with concentrated chloride BRINES together. It can form a kind of gel due to microscopic solid salt particles falling out of solution in the mixture.

Generally, it is possible to use 1/3 less material when using a wet salt, and it works faster than dry salt!

Figure 26: Truck set up for pre-wetting.



Guidelines for pre-wetting

While pre-wetting requires some equipment changes, it provides flexibility to switch the amount and type of liquid. This makes it an extremely valuable tool!

Liquids are like lighter fluid. If you want something to happen fast use liquids!

Goal:

- Adjust type of liquid to match pavement temperature and trend.
- Adjust the ratio of liquid to granular to speed up melting and decrease overall application rates.
- Look for ways to ramp up the liquid to granular ratio. You will get better performance at lower cost. (Bigger tanks, smaller hoppers)

Tips:

- Turn down the application rate; 1/3 less material is needed compared to using dry salt.
- A common application rate used on the roads is 8 – 14 gallons/ton for salt brine
  - Approximately 0.5 – 1 oz of liquid/lb of salt
- The higher the liquid to granular ratio, the faster it works and the more it sticks to the surface.
  - Some go up to 60 gallons per ton (approximately 4 oz/lb of salt)
- Pre-wetting with a chemical other than salt brine can improve cold weather performance.
- Consider the amount of moisture in the snow, both as it fell and in the hard-pack to be melted. Was it

a dry fluffy snow, or heavy cement snow? Dry snows often plow off cleaner and benefit the most from higher liquid to granular ratios because the temp is usually colder (slower for granular to work) and there is less moisture available to brine out the salt granules. Pre-wet helps solve both these problems.

- Pre-wetting is most practical with a dump truck. Use of a pickup truck may be limited due to the weight of the material.
- The better you can mix your liquid and granular before it hits the ground the better it will work.
- Make sure you are following vendor instructions for brine making and blending. Measure your products carefully. The eyeball method of measuring will not work.

Direct Liquid Applications (DLA)

DLA refers to the use of a liquid only application of deicer (no granular). DLA practices include anti-icing and liquid only applications during and after the storm. DLA practices before the storm are well studied and practiced across the industry.

DLA practices during and after the storm are the new frontier for winter maintenance professionals. It is considered an advanced use of liquids and is not a recommended starting point for those just starting to use liquids.

Liquids always work from the bottom up. You must get the liquid under the snow and ice to break the bond between the snow and pavement.

Successful DLA requires an adjustment of speed of travel, application rate, bar pressure and appropriate choice of deicer to get under snow and ice and start the melting process (Figure 27). If you do not get the liquid under the snow/ice it will likely melt and refreeze on top of the snow and ice producing fast ice, like the work of the Zamboni (Figure 28).

Application rates have not been agreed upon for efficient use of DLA for storm and post storm treatments, however this is what much of the discussion has been:

DLA is more successful with:

- Warm and warming pavements
- Micro layers of ice
- Higher application rates than anti-icing
  - Many double the rate
  - Micro ice, freezing fog many use anti-icing rates
  - Some use crazy high rates. This does not help our chloride problem.

Figure 27: Successful DLA application.

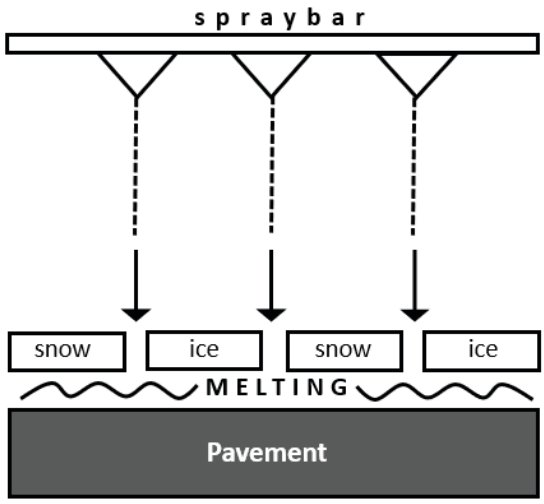


Figure 28: Incorrect DLA application.

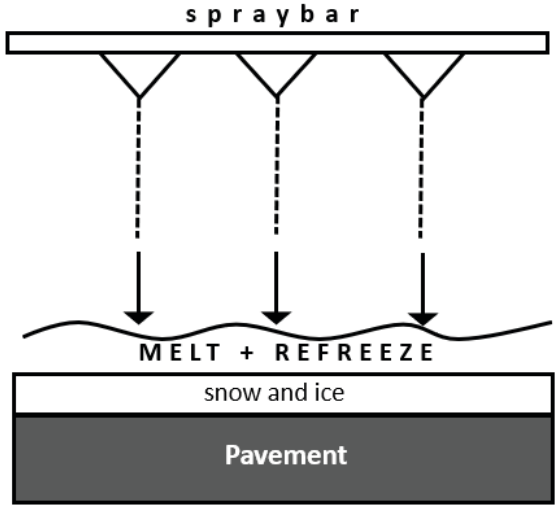


Image credits: FCI

Most who have tried this caution you to:

- Have shorter cycle times so you can get back and monitor your treatment
- Use DLA as one of the tools, it is not for all conditions.

Clear Roads has published preliminary DLA guidance for roads. Look in the future for DLA application rates for parking lots/sidewalks to be published. None exist today that are widely accepted.

Traction

Use of winter sand and other abrasives are great tools when temperatures are too cold for deicers to be effective or in areas that do not require bare pavement. Abrasives provide temporary traction only when it is on top of snow and ice. When sand is in contact with the pavement, sweep it up. It is no longer useful and can only reduce pavement traction, clog up your drains and cause other problems.

Advantages of sand (abrasives)

- Short-term traction: for curves, hills and intersections. Also helpful for foot traffic in areas where bare pavement is not required.
- Useful in very cold temperatures when chemicals will not work.
- Useful on gravel roads, paths or parking areas.
- Easy to find
- Inexpensive to purchase

Disadvantages of sand

- It does not melt snow/ice.
- It will be tracked into buildings.
- Must be swept and disposed of properly.
- Once sand is used, the particles become much finer and can cause air quality concerns.
- Will diminish effectiveness of pervious asphalt, pervious concrete, or pervious pavers, which is very expensive to clean and/or replace. Do not put sand on permeable hard surfaces.

Sweeping

Sweep parking lots midwinter as well as in the spring. Trailer-type power sweepers are available that can be hauled behind a pickup truck. Smaller power brooms or sweepers may be used on sidewalks. A bucket broom for a skid loader also works well. Personal Protective Equipment (PPE) should be used to avoid inhalation of the fine dust particles.

- State Law: Sweepings from streets, sidewalks or parking lots that are not screened for trash and debris are considered industrial solid waste and must be disposed of or stored in accordance to the law. MINN. R. 7035.2855 (2006)
- Used sand may be contaminated with pollutants such as oil, grease, metal, and rubber.
- Sweepings often can be brought to a landfill.

- Keep children from playing on the sweeping piles.
- Sweepings may be reused by some industries.
- Before reusing sweepings the trash, leaves and other debris should be removed. This is often accomplished by screening. When screening sweepings for reuse, use a small mesh for the final screening to ensure that all of the larger debris has been removed. (A 3/4-inch mesh will screen out much of the debris.) Dispose of trash and debris removed from the sweepings by recycling it (e.g., aluminum cans), composting it (e.g., leaves), or sending it to a sanitary landfill.

Sidewalk tips

Remove snow prior to applying deicers. Plow, blow, shovel or sweep and don't be afraid to do them all in the same event!

- Sidewalks are the most over-salted areas in winter maintenance.
- Clear sidewalks with melting/refreeze problems more than full width so as the snow melts it stays in the rock beds or landscapes rather than spreading across pavement.
- Brooms are an excellent tool for sidewalk maintenance. For a light snow just a broom for a heavy snow broom after plowing.
- Deicers can harm heated sidewalks.
- Abrasives and deicers can harm permeable pavers or permeable concrete which can be more susceptible to freeze/thaw cycles causing hydraulic pressure in pores. Use drop spreaders, not rotary spreaders. If using a rotary spreader, install shields to restrict the spread pattern. This minimizes the application rate and protects the vegetation.
- Pavers: textured pavers seem to respond better to DLA than to anti-icing
- Many slip and falls occur within 10 ft. of the curb lines. Adjust practices to include proactive measures like anti-icing and make sure curb lines are clean near sidewalks in high use areas.

Save money by applying liquid salt before the snow to reduce bonding of snow and ice to pavement.

Building entrances

Building entrances are over salted with good intentions. Untrained people using the salt bucket by the doorway are trying to keep things safe but instead their heavy use of salt causes damage to door jams, indoor rugs and flooring. It causes problems outside of the building with deterioration of concrete, vegetation and metal structures. Over applying deicer costs more money than necessary, pollutes the water, and does not provide any additional safety. The right amount of deicer and proper mechanical removal of snow and ice will yield better results.

A free short video for small site winter maintenance is available at: https://www.pca.state.mn.us/water/chloride-salts. It is designed for those that do winter maintenance of small sites such as stairs, curb cuts, and handicap ramps. The video is a visual instruction tool useful for those who apply granular deicer to small areas outside building entrances. It recommends:

- Conduct site assessments, document drainage problems, and fix them in the summer (e.g., roof that drips on steps, downspout that drains to sidewalk).
- Remove snow prior to applying deicers. The less snow, the less deicer required for a safer walking surface.
- Use the proper tool for snow and ice removal:
  - Push shovel (no sides) for pushing snow.
  - Scoop shovel (sides) for lifting snow.
  - Broom or blower for light fluffy snow.
  - Ice scraper for use under ice and compaction.
  - Ice chisel for breaking open compaction, or under ice and compaction.
- For wider areas use hand-held spreaders that disperse particles evenly such as grass seed or fertilizer spreaders instead of the "coffee can" method to disperse deicers. Spreaders:
  - Provide more even distribution.
  - Reduce amount needed.
  - Reduce tracking into buildings.
  - Save money and infrastructure with reduced salt application.
- For narrow areas, use shakers and apply a light spread pattern not a mound of salt.
- Look for opportunities to close extra building entrances or redundant sets of stairs during the winter, but still maintain them enough for emergency exit. High maintenance, non-essential entrances or duplicate stairways are perfect candidates.

For those who do maintenance as a small part of their job, it is unlikely they will ever use an application rate chart. Here are some guidelines to get them closer to the proper rates.

- Spread deicer with space between the granules. For NAAC and CMA (acetates), each pellet melts an area about the size of a quarter to a 50 cent piece, so to keep the pellets about that far apart on average
- No piles of deicer
- No deicer on dry pavement
- No deicer in vegetation
- Avoid spreading deicer all the way to the edge of sidewalks or in areas where foot traffic is unlikely. Concentrate deicer use in traffic lanes but not all the way into the building. Some deicer will move off target and get into low foot traffic area without you intentionally spreading it there.
- If you have a known hazard area, mark it, flag it, or sign it and let your sidewalk or stair users know it is a slippery area. This action alone has been shown to reduce maintenance costs and slip and falls significantly.

Figure 29: Caution slippery stairs sign

Photo credit: Mayo Clinic

Doorway salt buckets

If you do not want the public to use salt in your salt buckets, label it for trained staff only or put it where public cannot easily access it.

If you are placing it in a doorway for public use:

- Provide guidance on proper salt use and extra salt recovery.
- Provide shovels for removing snow before salting.
- Provide a way to spread salt lightly. Hand spreader, push spreader, small cup, shaker.

Figure 30: Label for salt bucket.

Image Credit: Minneapolis Park Board

Try handheld spreaders and shakers, use little not big scoops in salt buckets. Many have seen 50% salt savings with these simple steps.

- Provide guidance on spread pattern. Poster of desired spread pattern. Image of spread pattern on cup in the salt bucket.
- Provide guidance on how much salt for that maintenance area (i.e. No more than 2 blue cups of salt for the stairway).
- Provide a clean-up kit for extra salt on sidewalk after the storm is over.
- Encourage users to salt only if necessary. If salting, apply in a light spread pattern in icy areas (spot treat).
- Warn users of side effects (harms lakes, plants, building infrastructure).
- If you often see excess salt use, ramp up your training or communication strategy.

Figure 31: Small scoop with application guidance.

Photo credit: FCI

Parking lot tips

- Always plow before applying materials.
- All winter long, sweep up excess salt and sand.
- Handicap parking spots should get the same amount of salt or sand as other areas. More is not better.
- Place snow piles towards low end, not high end of the lot. There will be less melt and refreeze across your maintenance area.
- Avoid pushing snow into the rain gardens or nearby stormwater ponds to reduce maintenance costs of these structures.
- After plowing check to make sure storm drains are free of snow/ice/debris.
- Anti-icing has been shown to be less effective in poor quality parking lots with poor drainage and/or broken up asphalt.

About 1 tsp of salt will pollute 5 gallons of water... forever! (Federal Chloride standard is 230 mg/L).

Evaluate the effectiveness of actions

Documenting and charting

Good documentation leads to reduced use of materials, more effective snow and ice control, reduced environmental impacts and cost savings.

- Track the material use. Learn to record what and how much is applied at each site, from each visit. Be prepared to analyze and adjust the process based on what is learned.
- Use electronic or paper forms to record and track your work (Table 13 and Table 14).
- Record what you are doing and the results of your actions. This is the information you need to make strategic improvements to your operation.

After the storm

After each storm, evaluate what was done, what worked, and what could be changed to improve operations.

Figure 32: Cleaning up extra salt.

Photo credit: FCI

- Analyze the documentation provided by your operators
  - See what went well
  - See what went not so well
- Have an after-the-storm discussion with the maintenance crew or post the results for all to see.
  - Let them know what the success and learnings of the storm were. For example: (Truck with the pre-wet at 10 gallons/ton got the best results, DLA experiment did not work. Will adjust speed and rates for next event).
  - Use post storm meetings to build a culture of learning and improving.
- Consider holding an after-the-storm debrief with the customer. For example:
  - Down spouts near front door are causing problems.
  - Anti-icing before the storm allowed us to use less overall salt.
- Based on all aspects of the storm fighting experience, look for ways to improve practices and inspire your team.
- Clean, check and repair all equipment.
- Make sure salt storage areas have been cleaned up and secured.

Figure 33: Fine-tuning the program.

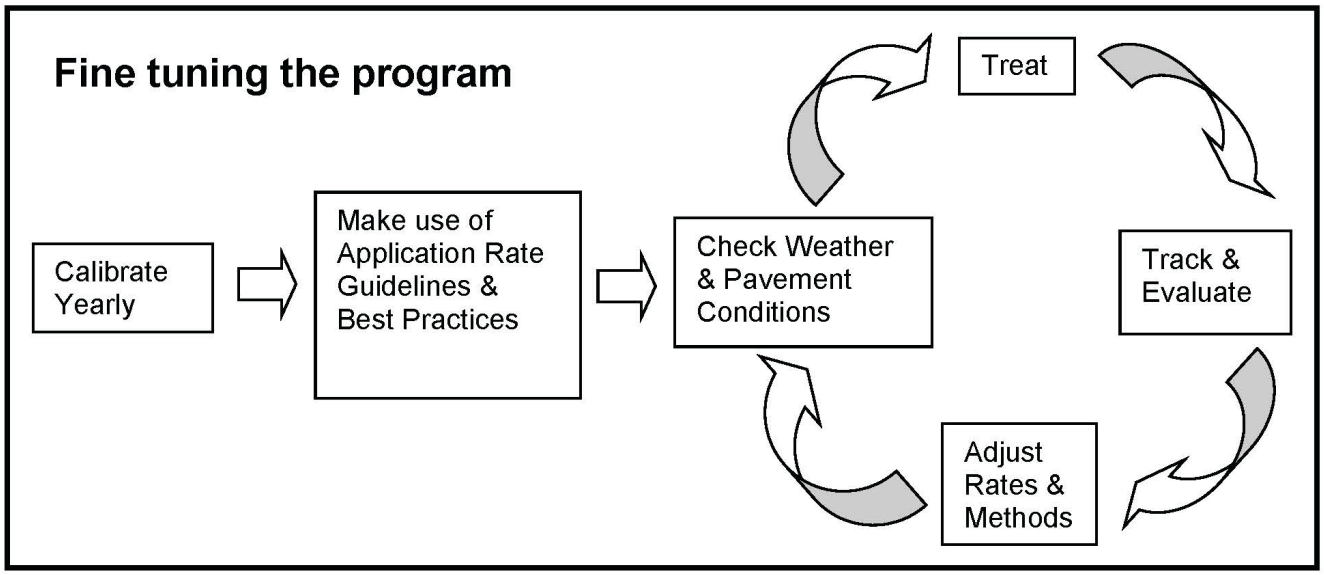


Photo credit: FCI

There is no management of what is not measured.

Following best practices and documenting actions will help prove the professional is doing the best job possible and may reduce liability.

After the winter

Winter maintenance is a year-round activity. The list of activities contained in this manual is a sampling of what is needed to prepare and perform well during winter. After the season much work and planning is required to get prepared for the next winter. Here are a few of the many things you should do when closing up the chemical use for the winter.

- Empty deicing trucks and return usable product to storage.
- Sweep up salt and cover bulk product to keep it clean over the summer.
- Wash equipment with hot soapy water and dry completely prior to storage. Make sure to include truck hoses, pumps, inside and outside surfaces.
- Check bulk storage warehouses for water-tightness.
- Do a post-season review, look at storm records, and make changes to the winter maintenance plan and winter emergency procedures.
- Make sure all SDSs for products are up-to-date and complete. Make sure all employees are trained in the chemicals they will be storing.

Documentation form for anti-icing

Table 13: Documentation form for anti-icing

Anti-icing Data Form

Location:
Date:

Air Temp.	Pavement Temp.	RH*	Dew*	Sky*

Reason for applying:

Location:

Chemical:

Application Time:

Application Amount:

Observation (1st day):

Observation (After event):

Observation (Before next application):

Name:

***RH**- relative humidity, **Dew**- dew point, **Sky**- sunny to cloudy

Documentation form for deicing

Table 14: Documentation form for deicing

Deicing Data Form			
Operator:			
Location:			
Event began:	Date	Time	
Event ended:	Date	Time	
Event type:	snow	rain	both
Total precipitation:			
Pavement temp.:		Air temp.:	
Dew point:			
Temperature trend:			
Material used:			
Amount used:			
Application rate:			
Observations:			

Application rates for reduced environmental impacts

Effective application rates are based on many factors, including type and rate of precipitation, pavement temperature and trend, humidity, dew point, type of surface and subsurface material. The application rate tables below have been taken from the Minnesota Snow and Ice Control Field Handbook for Snowplow Operators, Third Revision (LRRB 2022) and converted from gallons or pounds per lane mile to gallons or pounds per 1,000 square feet.

These application rates are not perfect, but are to be used as goals to work toward. Develop specific application rate tables to standardize performance. Track application rates to measure and improve performance. Modify the practices incrementally over time to fit the needs.

One application rate will not fit all situations. How long an application lasts depends on: Pavement temperature, application rate, precipitation, type of material applied, salt moved off target, etc.

Anti-icing application rate guidelines for parking lots and sidewalks

Table 15: Anti-icing application rates

Anti-icing application rate guidelines These are a starting point only. Adjust based on experience.			
	Gallons/1000 sq. ft.		
Conditions	**$CaCl_2$ or $MgCl_2$**	**Salt Brine (NaCl)**	**Other products**
1. Regularly scheduled applications	0.2 – 0.4	0.3 – 0.6	Follow manufacturers' recommendations
2. Prior to frost or black ice event	0.2 – 0.4	0.3 – 0.6	
3. Prior to light or moderate snow	0.2 – 0.4	0.3 – 0.8	
CAUTION: Too high an application rate may result in slippery conditions or tracking.			

How to use the anti-icing rate table above:

1. Determine the parking lot or sidewalk area in square feet.
2. Divide the area by 1,000 (chart is based on a 1,000 square foot area).
3. Find the application rate: Choose the condition in the first column of the table and follow sideways, stopping at the anti-icing chemical being used.
4. Determine how many gallons needed: Multiply the application rate by the answer in #2.

Example: The parking lot is 20,000 sq. ft. The chart tells how much to apply for 1,000 sq. ft. The plan is to apply brine prior to a light snow. Do the calculation to see how much brine is needed:

1. Divide the parking lot size by the chart size (20,000/1,000 = **20**).
2. Application rate from chart **is between 0.3 to 0.8** gallons.
3. Then multiply 20 x 0.5 = about 10 gallons are needed.

Tip: To convert from gallons to ounces: multiply the result by 128.

Which chemical to use for anti-icing?

These are not recommendations rather a way to share common practices in the industry today. Talk to your vendor. Products are changing and improving, and your vendor is a good source of updated information.

- Straight brine
- Must be at 23.3%.
- Good for pavements 15 degrees and warmer.
- Apply in wet dry pattern.
- Some switch from brine to brine blends anywhere between 20 and 15 degrees and falling.
- Application rates are not as picky, if you have blended your brine properly, anti-icing with brine at higher or lower rates are unlikely to cause problems with pavement friction.
- Brine blends
- All blends are different. Check with your vendor to understand mixing requirements and pavement temperature range for product use.
- Check with your vendor to understand problems that can be caused by your blended product if used in the wrong temperature range, spread pattern or application rate.
- Start with brine at 23.3%.
- Measure exact amount of additive. Flow meter is suggested.
- Most brine blends work at slightly colder pavement temperature ranges than straight brine.
- Many turn to their favorite brine blend when pavements range between 15 and 20 degrees and falling
- Some have a variety of blend recipes and use them to adjust for colder pavements.
- Many use the same application rate for brine blends as they do for brine.
- Some select brine additives that do not need much agitation. They are looking for storage performance in addition to deicing performance.
- Straight $CaCl_2$ or $MgCl_2$
- Good for cold and trending colder pavements 0 to 15 degrees.
- Can be used up to 25 degrees and falling but may not give an advantage over salt brine or salt brine blends at warmer temperature ranges.
- The industry has seen success at below 0 pavements, but it is more risky.
- Stay within the conservative application rates.
- Wet dry pattern on the pavement is essential for safety.

- Since these products attract moisture from the air to the pavement surface, the safest time to apply them for anti-icing is as the storm starts.
- Acetates
- Each type of acetate works at its own recommended pavement temperature range.
    - Check with your vendor to understand the optimal pavement temperature range and trend for the acetate you intend to use.
    - If you pay a premium for a product, you have every right to expect premium-level customer service, including technical guidance on its application, storage, and handling and have all your questions answered completely.
- Acetates can be spread with a fan or a streamer nozzle for anti-icing.
    - CAUTION: test it on your surface type. For example, marble surfaces may lose friction easier than asphalt from anti-icing.
    - Because they flatten out quickly, they run across pavements causing a blanket coating of acetate with good pavement friction.
    - Because they form a very flat thin layer, losing pavement friction on most surfaces from anti-icing is not a concern.
- To avoid potential solubility problems, don't mix liquid acetates with chloride brines in the same tank.

Deicing application rate guidelines for parking lots and sidewalks

The de-icing application rates in Table 16 are based on road application guidelines (LRRB 2022). Develop specific application rates by adjusting your current rates incrementally downward toward the guidelines. Where temperature categories overlap, select the rate most applicable to the present situation.

Are your products not on this chart?

Work with your vendor. In the absence of that and since very few products are on this chart, we recommend for packaged products that are primarily NaCl use the **Dry Salt** category. For packaged products that are dominated by other products (not NaCl) use **Salt wet with other Blends** category. For acetates, formates and other high performance expensive products, get in the habit of working closely with your vendors.

Deicing application rate chart

These rates are based on road application guidelines (LRRB 2022). Use them as a target to achieve by gradually adjusting your application rates downward.

Table 16: Application rates for deicing

Pavement temp. (°F) and trend (↑↓)	Weather condition	Maintenance actions	Application rate in lbs./per 1,000 square foot area			
			Salt pre-wetted/ pretreated with salt brine **1**	Salt pre-wetted/ pretreated with other blends **2**	Dry salt **3**	Winter sand (abrasives) **4**
>30° ↑ **A**	Snow	Plow, treat intersections only	0.75	0.5	0.75	not recommended
B	Frz. Rain	Apply chemical	1.25	1.0	1.5	not recommended
30° ↓ **C**	Snow	Plow & apply chemical	1.25	1.0	1.5	not recommended
D	Frz. Rain	Apply chemical	1.5	1.25	1.75.	not recommended
25 – 30° ↑ **E**	Snow	Plow & apply chemical	1.25	1.0	1.5	not recommended
F	Frz. Rain	Apply chemical	1.5	1.25	1.75	not recommended
25 – 30° ↓ **G**	Snow	Plow & apply chemical	1.25	1.0	1.5	not recommended
H	Frz. Rain	Apply chemical	1.75	1.5	2.25	3.25
20 – 25° ↑ **I**	Snow or Frz. Rain	Plow & apply chemical	1.75	1.5	2.25	3.25 for frz. rain
20 – 25° ↓ **J**	Snow	Plow & apply chemical	2.0	2.0	2.75	not recommended
K	Frz. Rain	Apply chemical	2.5	2.0	3.0	3.25
15° to 20° ↑ **L**	Snow	Plow & apply chemical	2.0	2.0	2.75	not recommended
M	Frz. Rain	Apply chemical	2.5	2.0	3.0	3.25
15° to 20° ↓ **N**	Snow or Frz. Rain	Plow & apply chemical	2.5	2.0	3.0	3.25 for frz. rain
0 to 15° ↑↓ **O**	Snow	Plow, treat with blends, sand hazardous areas	not recommended	3.0	not recommended	5.0 spot treat as needed
< 0° **P**	Snow	Plow, treat with blends, sand hazardous areas	not recommended	4.5	not recommended	5.0 spot treat as needed

All application rates are based on thoroughly cleared surfaces.

Instructions for using application rate table for calibrated spreaders

1. Use Deicing Application Rate Guidelines for Parking Lots and Sidewalks in Table 16. Select the row with the appropriate pavement temperature, temperature trend, and weather conditions.
2. Select the column (**1-4**) that has the type of material used.
3. Find the box where the row (**A-P**) and columns (**1-4**) intersect to find the application rate.
4. Compare those values to the calibration chart you created for your spreader.
5. Select the correct spreader setting.

Example:

1. Parking lot is 54,000 sq. ft.
2. Temperature: 22°F and falling. It has finished snowing.
3. Using salt pretreated with salt brine. (**1**)
4. Find the 20 – 25° ↓ box (**J**). Follow it to the right to the column labeled "Salt Pre-wetted/pretreated with salt brine (**1**)." Read the rate in the box. The box where the column and row intersect shows a rate of 2.0 /1,000 square feet.
5. Refer to the calibration chart in the vehicle and set the spreader to the setting that most closely matches the 2.0 lbs. /1000 square feet.
6. You are ready to apply.

Instructions for using application rate table for spreaders that are NOT calibrated

Using the example above:

1. Calculate size factor: Divide the parking lot size (54,000 sq. ft.) by 1,000 sq. ft. 54,000/1,000 = 54. The size factor is 54.
2. Find application rate (2.0).
3. Multiply application rate by size factor 2 x 54 = 108.
4. The amount needed for the entire lot is 108 lbs. pre-wetted/pretreated salt brine.
5. Because the spreader is not calibrated, the setting is unknown.
6. Although the calibration setting is not known, this establishes the amount of salt to use.
7. Determine the best method to spread the 108 lbs. across the parking lot.

Once chlorides enter the ground or surface water, they never go away.

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Resources

Training

- MPCA Smart Salting Program:
  - https://www.pca.state.mn.us/business-with-us/smart-salting-training
  - smartsalting.pca@state.mn.us
- The Circuit Training and Assistance Program (CTAP):
  - www.mnltap.umn.edu/ctap
- Snow and Ice Management Association (SIMA):
  - www.sima.org

Manuals

- *Smart Salting for Parking Lots and Sidewalks*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/p-tr1-10.pdf
- *Smart Salting for Property Management*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/p-tr1-11.pdf
- *Minnesota's Stormwater Manual*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/business-with-us/minnesota-stormwater-manual

Technical assistance

- *Anti-Icing Equipment: Recommendations and Modifications*. Iowa Department of Transportation. www.iowadot.gov/maintenance/pdf/manualantiicingequipment.pdf
- *What is anti-icing? The science behind anti-icing*. Cargill. www.cargill.com/what-is-anti-icing
- *Snow and Ice Mailing List*. AASHTO Snow and Ice Pooled Fund Cooperative. www.sicop.transportation.org/resources/snow-and-ice-list-serv/
- *Are You Using the Right Amount of Ice Control Chemical?* Salt Institute. www.bv.transports.gouv.qc.ca/per/0974374/03_2004/02_vol_40_no_2_Summer_2004.pdf
- *Snow and Ice Control: Guidelines for Materials and Methods*. National Cooperative Highway Research Program. https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_526.pdf
- *Completed Research on Snow Removal and De-Icing Methods*. Clear Roads. www.clearroads.org/completed-research/
- *Correlating Lab Testing and Field Performance for Deicing and Anti-Icing Chemicals (Phase I)*. Clear Roads. Prepared for Wisconsin Department of Transportation. www.wisconsindot.gov/documents2/research/10-17deicingcorrelation-f.pdf
- *Highway Deicing: Comparing Salt and Calcium Magnesium Acetate*. The National Academies of Sciences,

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- *Winter Operations Training Series*. Iowa Department of Transportation. www.youtube.com/playlist?list=PLurY2WfsVWKn9ismDC4Uz3IbRivAnf0Ld
- *Managing Street Sweepings*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/w-sw4-54.pdf
- *Manual of Practice for An Effective Anti-Icing Program – A Guide for Highway Winter Maintenance Personnel*. Federal Highway Administration Research & Technology. www.fhwa.dot.gov/publications/research/safety/95202/index.cfm
- *Winter Maintenance for Small Sites*. Mississippi Watershed Management Organization. www.youtube.com/watch?v=-xMt1kyzIcg
- Pacific Northwest Snow fighters Association. www.pnsassociation.org/
- *Snow & Ice Control*. Cornell Local Roads Program, New York Local Technical Assistance Program Center. www.cornell.app.box.com/v/clrp-ws-sic
- *Syntheses of Best Practices-Road Salt Management*. Transportation Association of Canada. https://www.tac-atc.ca/en/publications/bp-rsm1-e

Vegetation

- *Plant Selector Program*. Minnesota Department of Transportation https://plantp.dot.state.mn.us/plant/
- *Plants for Stormwater Design: Species Selection for the Upper Midwest*. Minnesota Pollution Control Agency. www.pca.state.mn.us/sites/default/files/pfsd-section1.pdf
- *Best Management Practices for Establishment of Salt-Tolerant Grasses on Roadsides*. Minnesota Department of Transportation. www.dot.state.mn.us/research/reports/2017/201731.pdf
- *Minimizing De-Icing Salt Damage to Trees*. University of Minnesota. cues.cfans.umn.edu/old/extpubs/1413salt/DD1413.html
- *Interactive Plant Selection Tool*. Minnesota Department of Transportation. www.dot.state.mn.us/roadsides/plantselector/index.html

Policy/Rules/Guidance

- *Model Snow and Ice Management Contract Form*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/p-tr1-52a.pdf
- *Model Snow and Ice Management Policy Form*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/p-tr1-51a.docx
- *Model Chloride Reduction Ordinance Language*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/p-tr1-54.docx

Weather

- National Weather Service. www.noaa.gov
- RWIS – Road Weather and Information System. www.rwis.dot.state.mn.us

Deicers and materials

- *Approved Winter Chemical List*. Minnesota Department of Transportation www.dot.state.mn.us/maintenance/pdf/approved-products-winter-chemicals.pdf
- *The Effectiveness of Non-Chloride Liquid Agricultural By-Products and Solid Complex Chloride/Mineral Products Used in Snow and Ice Control Operations*. Clear Roads. www.clearroads.org/project/13-02/
- *Determining the Toxicity of De-Icing Materials*. Clear Roads. www.clearroads.org/wp-content/uploads/dlm_uploads/11-02_12-30-13-Final-Fact-Sheet.pdf
- *Winter Chemical Catalog*. Minnesota Department of Transportation. www.dot.state.mn.us/maintenance/pdf/research/winterchemcatalog.pdf
- *Break the Ice: Comparison of Ice Melting Chemicals*. Peters Chemical Company. www.peterschemical.com/break-the-ice-comparison-of-ice-melting-chemicals/
- *Evaluation of Selected Deicers Based on a Review of the Literature*. The SeaCrest Group for the Colorado Department of Transportation Research Branch. www.codot.gov/programs/research/pdfs/2001/deicers.pdf
- *Ice Melt: A Scientific Primer on Deicers*. Clean Link. www.cleanlink.com/sm/article/Ice-Melt-A-Scientific-Primer-On-Deicers--4896
- *Practical Guide for Storing and Handling Deicing Salt*. Salt Institute. Prepared for Illinois Department of Transportation. www.idot.illinois.gov/Assets/uploads/files/Transportation-System/Manuals-Guides-&-Handbooks/T2/L016%20The%20Salt%20Storage%20Handbook.pdf
- *Stormwater Best Management Practices Manual*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/business-with-us/minnesota-stormwater-manual.

Appendix A

Material Conversions and Essential Chart

Table 17: Material Conversions

SAND			SALT	
Yards	Tons		Yards	Tons
1	1.4		1	1.1
2	2.8		2	2.2
3	4.2		3	3.2
4	5.6		4	4.3
5	7.0		5	5.4
6	8.4		6	6.5
7	9.8		7	7.6
8	11.2		8	8.6
9	12.6		9	9.7
10	14.0		10	10.8
11	15.4		11	11.9
12	16.8		12	13.0
13	18.2		13	14.0
14	19.6		14	15.1
15	21.0		15	16.2
16	22.4		16	17.3
17	23.8		17	18.4
18	25.2		18	19.4
19	26.6		19	20.5
20	28.0		20	21.6

The following formulas and the above quick reference table will help to convert between tons and cubic yards. Weights will vary depending upon moisture content.

1. To convert tons of clean sand to cubic yards: # tons divided by 1.4 = cubic yards
2. To convert cubic yards of clean sand to tons: # cubic yards multiplied by 1.4 = tons
3. To convert tons of winter sand to cubic yards: # tons divided by 1.37 = cubic yards
4. To convert cubic yards of winter sand to tons: # cubic yards multiplied by 1.37 = tons
5. To convert tons of straight salt to cubic yards: # tons divided by 1.08 = cubic yards
6. To convert cubic yards of straight salt to tons: # cubic yards multiplied by 1.08 = tons

Table 18: Application Rate Conversion Charts: Lane Mile to 1,000 sq.ft.

Use these tables to convert application rates between pounds per lane mile and pounds per 1,000 square feet.

lbs./lane mile*	lbs./1,000 square feet
25	0.4
50	0.8
75	1.2
100	1.6
125	2.0
150	2.4
175	2.8
200	3.2
225	3.5
250	3.9
275	4.3
300	4.7
350	5.5

lbs./1,000 square feet	lbs./lane mile*
0.5	32
0.75	48
1	63
1.25	79
1.5	95
1.75	111
2	127
2.25	143
2.5	159
2.75	174
3	190
3.25	206
5	317

*12 foot lane width

Table 19: Prewet gal/ton conversions for smaller quantities

Gallon/Ton	Ounces/50 Lbs.	Oz./Lb.	Gallon/50 lbs.	Gallon/100 lbs.
5	16	0.32	0.125	0.25
6	19	0.38	0.15	0.3
7	22	0.45	0.175	0.35
8	26	0.51	0.2	0.4
9	29	0.58	0.225	0.45
10	32	0.64	0.25	0.5
11	35	0.70	0.275	0.55
12	38	0.77	0.3	0.6
13	42	0.83	0.325	0.65
14	45	0.90	0.35	0.7
15	48	0.96	0.375	0.75
16	51	1.02	0.4	0.8
17	54	1.09	0.425	0.85
18	58	1.15	0.45	0.9
19	61	1.22	0.475	0.95
20	64	1.28	0.5	1
21	67	1.34	0.525	1.05
22	70	1.41	0.55	1.1
23	74	1.47	0.575	1.15
24	77	1.54	0.6	1.2
25	80	1.60	0.625	1.25
26	83	1.66	0.65	1.3
27	86	1.73	0.675	1.35
28	90	1.79	0.7	1.4
29	93	1.86	0.725	1.45
30	96	1.92	0.75	1.5

Liquid Roadway Treatments Technical Reference Guide

Supplement for Parking Lot & Sidewalk Treatments

Disclaimer: These rates are converted from road rates and have not been tested. Use with caution.

Table 3: Suggested Liquid Parking Lot & Sidewalk Application Rates (adjust based on local experience)
Application rates are in gallons of salt brine per 1000 square feet (ft^2)

Event Type	Pavement Temperature			
	32 – 30° F	29 – 27° F	26 – 24° F	23 – 15° F
For 2-hour (or less) Cycle Times - Gallons per 1000 ft^2				
Light Snow (less than 0.5 inch/hour)	0.3	0.6	0.6	0.9
Medium Snow (0.5 to 1.0 inch/hour) [1]	0.6	0.7	0.9	Not Recommended
For 3-hour Cycle Times [3] - Gallons per 1000 ft^2				
Light Snow (less than 0.5 inch/hour)	0.6	0.8	1	1.3
Medium Snow (0.5 to 1.0 inch/hour) [1]	0.8	1	1.3	Not Recommended

Notes:

1. For medium snow events, only consider using liquid treatments based on your experience, and when other factors are highly favorable, such as pavement temperature and moisture content.

2. It is suggested to generally supplement the liquid application with a light pre-wet granular application (1.1 lb/1000 ft^2) when possible (especially as dilution-refreeze potential increases).

3. For cycle times greater than 2 hours, supplementing liquids with granular application is strongly suggested.

4. For magnesium chloride, calcium chloride, additives, and blends, work with vendors to verify application rates

Appendix B

Common conversions

- 1 lane mile (12' x5280 ft.) = 63,360 square feet
- Average size parking spot: 9 x 20 feet or 10 x 20 feet = 180 – 200 square feet
- Driving aisles (2-way) = About 25 feet wide
- 1 acre = 43,560 square feet
- 1 ton = 2,000 lbs.
- Metric ton (tonne) = 1,000 kg = 2,205 pounds
    - Acetates are often described in terms of kg or metric ton
- 1 cup of salt (NaCl) = 0.6 lbs.
- Salt (NaCl) weighs 72 – 84 lbs./ft3 depending upon moisture and granule size
- 1 gallon = 128 ounces
- Each product has a different bulk density, for example:
    - 1 cubic yard of rock salt = 1.1 ton
    - 1 cubic yard of sand = 1.4 tons
- 1 cubic yard = 27 cubic feet
- 1 square yard = 9 square feet

Appendix C

Definitions

°C – degrees Celsius

°F – degrees Fahrenheit

Anti-icing – liquid only application prior to the storm

BMPs – Best Management Practices

brine – liquid deicer made from water and rock salt (NaCl)

Chloride – a component of deicing salts (sodium chloride, magnesium chloride…)

CMP – Chloride Management Plan

lbs. – pounds

Deicers – any product that melts snow or ice (salt, acetates, urea…)

Deicing – Adding deicers during or after the storm

DLA – Direct Liquid Application (liquid only applications)

LTAP – Local Technical Assistance Program

mg/l – milligrams per liter

Mn/DOT – Minnesota Department of Transportation

MPCA – Minnesota Pollution Control Agency

mph – miles per hour

MS4 – Municipal Separate Storm Sewer System

PPE – Personal Protective Equipment

ppm – parts per million

Pre-treating – adding liquid to rock salt stockpile

Pre-wetting – adding both liquid and granular capabilities to the spreader

psi – pounds per square inch

RH – relative humidity

Salt – chloride-based product used for deicing

SSAt – Smart Salting Assessment tool

sq. ft. – square feet

TCMA – Twin Cities Metropolitan Area

WLA – Waste Load Allocation

Appendix D
Smart Salting Assessment tool (SSAt)

SSAt is a free and easy to use online tool. Follow this link: https://smartsaltingtool.com/

SSAt has several modes that allows users to conduct assessments on their salt use. One of the assessment areas is winter maintenance. Within that area you can conduct the following types of assessments:

- Level of Service
- Best Management Practice assessments for
  - High speed roads
  - Low speed roads
  - Parking lots
  - Sidewalks
- Salt Savings prediction

The tool automatically generates reports for you that will highlight where salt savings can be made based on the information you input about your organization.

If you would like help learning how to use SSAt, attend a Smart Salting Level 2 training class. During this class the various assessment types are explained, and students have a chance to start their assessments while instructors are ready to help if problems or question arise.

If you chose to submit your reports to the MPCA they will know you have assessed your operations and will grant you Smart Salting Level 2 Organization wide certification. The MPCA does not judge the contents of your reports.

The SSAt has been designed for use by winter maintenance leadership. The assessments will test your knowledge on the various parts of your organization's operation. Questions range from storage, spread patterns, use of liquids, calibration and beyond.

If you are also involved in using salt for dust control, fertilizers, water softening or other areas. The future of SSAt will offer you the opportunity to delve into these areas as well. Keep checking the SSAt website as new features are under development now.

Appendix E
Minnesota State Laws and Regulations
Minnesota Laws

Discharges to Waters of the State. Minnesota Rules 7053.0205
Subp. 2. Nuisance conditions prohibited. No sewage, industrial waste, or other wastes may be discharged from either point or nonpoint sources into any waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum, visible oil film, excessive suspended solids, material discoloration, obnoxious odors, gas ebullition, deleterious sludge deposits, undesirable slimes or fungus growths, aquatic habitat degradation, excessive growths of aquatic plants, or other offensive or harmful effects.

Liquid deicer storage regulation. Minnesota Rules, Chapter 7151.1200.
The general requirements for ASTs with less than one million capacity include: registration with the MPCA, properly labeled tanks, secondary containment, a sign at the facility, and tank con-struction using appropriate industry standards. However, liquid de-icing materials are considered Other Regulated Substances and are not subject to the same regulations as hazardous materials because they have limited risk. The MPCA does not require the registration of other regulated substance ASTs. The basic requirements for most liquid de-icer storage therefor includes labeling all tanks, having a posted sign on site, and secondary containment. However, the size and location of ASTs containing de-icer will influence the specific regulations that are required. Here is a summary of requirements that may apply to de-icer storage tanks:

- Labeling ASTs containing de-icer: All tanks must be clearly labeled indicating the type of substance stored and the tank's capacity. If there is more than one tank, each tank must be labeled with a unique tank number.
- Sign posting: If a person is not on site 24 hours a day, a sign must be posted with the name, address, and telephone number of the facility owner or operator, or a local emergency re-sponse contact. The sign must be posted so that it can be seen outside any containment area.
- Secondary containment: Other regulated substance ASTs need 100% containment area vol-ume of the largest tank in the containment area. An additional 10% capacity is required for ASTs exposed to precipitation. Double-walled tanks satisfy the secondary containment re-quirement.

Snow Removal; Salt and Chemicals Restricted. Minnesota Rules 160.215.
In order to:
(1) Minimize harmful or corrosive effects of salt or other chemicals upon vehicles, roadways, and vegetation;
(2) Reduce the pollution of waters; and
(3) Reduce the driving hazards resulting from chemicals on windshields;
road authorities, including road authorities of cities, responsible for the maintenance of highways or streets during periods when snow and ice are prevalent, shall utilize such salt or other chemicals only at such places as upon hills, at intersections, or upon high-speed or arterial roadways where vehicle traction is particularly critical, and only if, in the opinion of the road authorities, removal of snow and ice or reduction of hazardous conditions by blading, plowing, sanding, including chemicals needed for free flow of sand, or natural elements cannot be accomplished within a reasonable time.

Street Sweepings. Minnesota Rules 7035.2855.
Street sweepings that are not screened for trash and debris are considered industrial solid waste and must be disposed of at a permitted solid waste facility that can accept the waste. Unscreened street sweepings must also be stored in accordance with solid waste storage standards. MPCA managing street sweepings fact sheet.

MS4 General Permit. Minnesota Rules chapter 7090.
An MS4 is a conveyance or system of conveyances that is owned by a state, city, town, village, or other public entity that discharges to waters of the U.S., designed or used to collect or convey stormwater (e.g., storm drains, ditches), not a combined sewer, and not part of a sewage treat-ment plant, or publicly owned treatment works. To prevent harmful pollutants from being washed or dumped into MS4s, certain operators are required to obtain NPDES permits and develop stormwater management programs (SWMPs). The SWMP describes the stormwater control prac-tices that will be implemented consistent with permit requirements to minimize the discharge of pollutants from the sewer system.

Industrial Stormwater General Permit. Minnesota Rules 7090.3000.
17.1 Salt storage, use, and management at the facility (If present at the facility).
17.2 The Permittees should implement the following BMPs if salt piles are present at the facility:

a. Cover salt piles or store the salt piles indoors;
b. Minimize the use of salt or other de-icing/anti-icing materials by using the proper equipment, material, and application rates.
c. Implement practices to reduce exposure resulting from adding or removing material from the salt piles (e.g., sweeping, diversions, containment); and
d. Document within the SWPPP the location of any storage piles containing salt stored outside.

17.3 Hired contractors should minimize the use of salt or other de-icing/anti-icing materials by us-ing equipment, material, and application rates, as recommended by the MPCA Winter Parking Lot and Sidewalk Maintenance Manual. In addition, the Permittee may attend and/or encourage their contractor to attend training and/or utilize best practices for winter maintenance activities.

Water Pollution. Minnesota Statute 609.971.

Subd. 8. (a) A person is guilty of a felony who knowingly:

(1) causes the violation of an effluent standard or limitation for a toxic pollutant in a national pollutant discharge elimination system permit or state disposal system permit;
(2) introduces into a sewer system or into a publicly owned treatment works a hazardous substance that the person knew or reasonably should have known is likely to cause personal injury or property damage; or
(3) except in compliance with all applicable federal, state, and local requirements and permits, introduces into a sewer system or into a publicly owned treatment works a hazardous substance that causes the treatment works to violate an effluent limitation or condition of the treatment works' national pollutant discharge elimination system permit.

Chloride related language in the MS4 permit

16.1 MCM 1: Public Education and Outreach. [Minn. R. 7090]

16.5 At least once each calendar year, the permittee must distribute educational materials or equivalent outreach focused on the following:

a. impacts of deicing salt use on receiving waters; and
b. methods to reduce deicing salt use. [Minn. R. 7090]

16.6 For businesses, commercial facilities, and institutions, the permittee must implement an education and outreach program focused on communicating appropriate deicing salt use (e.g., direct mailing, phone calls, and/or meetings). The permittee must maintain a written or mapped inventory of businesses, commercial facilities, and institutions that the permittee will target for education and outreach over the permit term. At a frequency defined by the permittee's education and outreach plan in item 16.8, the permittee must distribute educational materials or equivalent outreach to these audiences, which must include information on the following:

a. environmental impacts of deicing salt use;
b. BMPs that reduce the use of deicing salt;
c. proper storage of salt or other deicing materials; and
d. training opportunities to improve winter maintenance activities. [Minn. R. 7090]

18.1 MCM 3: Illicit Discharge Detection and Elimination (IDDE). [Minn. R. 7090]

18.6 The permittee's regulatory mechanism(s) must require proper salt storage at commercial, institutional, and non-NPDES permitted industrial facilities. At a minimum, the regulatory mechanism(s) must require the following:

a. designated salt storage areas must be covered or indoors;
b. designated salt storage areas must be located on an impervious surface; and
c. implementation of practices to reduce exposure when transferring material in designated salt storage areas (e.g., sweeping, diversions, and/or containment). [Minn. R. 7090]

21.1 MCM 6: Pollution Prevention/Good Housekeeping For Municipal Operations. [Minn. R. 7090]

21.5 The permittee must implement the following BMPs at permittee owned/operated salt storage areas:

a. cover or store the salt indoors;
b. store salt on an impervious surface; and
c. implement practices to reduce exposure when transferring material from salt storage areas (e.g., sweeping, diversions, and/or containment). [Minn. R. 7090]

21.6 The permittee must implement a written snow and ice management policy for staff that perform winter maintenance activities. The policy must establish practices and procedures for snow and ice control operations (e.g., plowing or other snow removal practices, sand use, and application of deicing compounds). [Minn. R. 7090]

21.7 Each calendar year, the permittee must train all staff that perform winter maintenance activities. The permittee may use training materials from the Agency's Smart Salting Training or other organizations to meet this requirement. The employee training program must include: a. the importance of protecting water quality; b. BMPs to minimize the use of deicers (e.g., proper calibration of equipment and benefits of

pretreatment, pre-wetting, and anti-icing); and c. tools and resources to assist in winter maintenance (e.g., deicing application rate guidelines, calibration charts, Smart Salting Assessment Tool). [Minn. R. 7090]

22.1 Discharges to Impaired Waters with a USEPA-Approved TMDL that Includes an Applicable WLA. [Minn. R. 7090]

22.5 If the permittee has an applicable WLA for chloride, the permittee must document the amount of deicer applied each winter maintenance season to all permittee owned/operated surfaces. [Minn. R. 7090]

22.6 If the permittee has an applicable WLA for chloride, each calendar year the permittee must conduct an assessment of the permittee's winter maintenance operations to reduce the amount of deicing salt applied to permittee owned/operated surfaces and determine current and future opportunities to improve BMPs. The permittee may use the Agency's Smart Salting Assessment Tool or other available resources and methods to complete this assessment. The permittee must document the assessment. The assessment may include, but is not limited to: a. operational changes such as pre-wetting, pre-treating the salt stockpile, increasing plowing prior to deicing, monitoring of road surface temperature, etc.; b. implementation of new or modified equipment providing pre-wetting, or other capability for minimizing salt use; c. regular calibration of equipment; d. optimizing mechanical removal to reduce use of deicers; or e. designation of no salt and/or low salt zones. [Minn. R. 7090]

MS4 Permit Overview

MS4 Mapping tool: https://mpca.maps.arcgis.com/apps/webappviewer/index.html?id=8d310e604baa43699b25395834d0c69a

An MS4 is a conveyance or system of conveyances that is:

- Owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.,
- Designed or used to collect or convey stormwater (e.g., storm drains, pipes, ditches),
- Not a combined sewer, and
- Not part of a sewage treatment plant, or publicly owned treatment works (POTW).

To prevent harmful pollutants from being washed or dumped into MS4s, certain operators are required to obtain NPDES permits and develop stormwater management programs (SWMPs). The SWMP describes the stormwater control practices that will be implemented consistent with permit requirements to minimize the discharge of pollutants from the sewer system.

Description of what each Minimum Control Measure (MCM) means:
MCM 1: Public education and outreach
An educated and informed community can not only prevent pollution in stormwater, but also identify and report illicit discharges or construction activities that may negatively affect stormwater. Permittees must create an education and outreach program to inform residents about the impacts of stormwater and foster proper stormwater management behaviors.

MCM 2: Public participation/involvement
Permittees must motivate their communities to act to prevent stormwater pollution. Common activities in Minnesota include storm drain stenciling, storm drain adoption programs, and volunteer monitoring programs.

MCM 3: Illicit discharge detection and elimination
Storm sewers in Minnesota generally discharge directly to lakes, rivers, and wetlands. Ideally, only stormwater should enter a storm sewer system. Permittees must implement a program to detect and eliminate illicit discharges to their systems.

MCM 4: Construction site stormwater control
Stormwater running off construction sites can carry sediment and other pollutants into nearby wetlands, rivers, and lakes. Permittees must enforce construction site stormwater runoff controls to reduce the impacts of land disturbing activities on stormwater.

MCM 5: Post-construction stormwater management
Managing stormwater onsite post-construction can mitigate the impacts of paved surfaces. Permittees must enforce a post-construction stormwater management program that prevents or reduces stormwater pollution in new and redevelopment projects.

MCM 6: Pollution prevention/good housekeeping
It's generally easier and less expensive to prevent pollution than to restore surface waters once they're polluted. Permittees must take steps to prevent stormwater pollution, as the first line of defense for many pollutants entering storm sewer systems.

For questions about Minnesota rules and regulations contact: smartsalting.pca@state.mn.us

Appendix F

Examples of Smart Salting Rate Reduction Worksheet and Practices Survey

Rate Reduction Worksheet

1. Think of a route or site you maintain (please circle): Parking Lot Sidewalk Road

2. Estimate the size of your route/site _____ miles or _____ square feet

On how much of this route/site do you normally use salt/de-icer? _____miles or _____sq ft

3. What type of material do you most often use?

Rock Salt Salt pretreated with other blends Salt Pre-wetted with brine

Sand Sand/Salt mix: _____ (what %) Other_____

4. About how much material do you use for one application? _____ pounds

Take out your charts

5. At 22 degrees and getting colder, what is your current application rate? _____pounds

6. How much material will you need _____ pounds

7. How much material could you save, in one application, if you tried the recommended amount versus your typical rate? _____ pounds

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Smart Salting Practices Survey
Please place an "X" in the column that best identifies your response.

Recommended practice	Will I try the recommended practice?				
	Already do	Yes	Maybe	No	If no … Why not?
Use an application rate chart.					
Calibrate equipment each year.					
Learn about the deicer ingredients and use the appropriate one for the condition.					
Look for reasons why materials are leaking or spilling from vehicles and fix them (e.g. gaps, overfilling, etc).					
Develop a comprehensive winter maintenance policy. Follow your policy.					
Measure and use pavement temperatures.					
Use anti-icing appropriately prior to the storm.					
Plow before applying deicers.					
Use wet materials (pre-wet or pre-treated).					
Don't apply sodium chloride (road salt) for pavement temperatures below 15ºF.					
Don't apply deicers for pavement temps under -10º F. It's too cold.					
Separate salt and sand. Use salt for melting. Use sand for traction.					
Apply deicers in the center of the road or on the high side of the curve.					
Store the salt in a building or under secure cover.					
Store salt out of the path of water flow or direct the water away from storage area.					
Store snow away from lakes, ponds and wetlands.					
Sweep up sand and dispose of properly.					
For each event, document what you did and how well it worked. Use this information to make improvements.					
Talk to others about what you are trying to do to protect lakes and rivers.					

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Advised by the technical expert committee members from: University of MN Extension, MN Department of Agriculture, Wayzata Schools, University of MN Property Services, City of White Bear Lake, TruGreen Corporation, Heidi's Lifestyle Gardens, Organic Bob, Minneapolis Park and Recreation, City of St. Anthony, Tessman Company, CTAP, Quercus Landscapes, MPCA, MWMO and Fortin Consulting.