



# Source Water Protection Practices Bulletin

## Managing Highway Deicing to Prevent Contamination of Drinking Water

We depend on clear roads and highways for safe travel and the continual flow of goods and services. Deicing chemicals are used to clear roads covered by snow and ice during winter weather. The runoff associated with highway deicing may contain various chemicals and sediment which have the potential to enter surface and ground water sources. This bulletin focuses on the management of highway deicing chemicals. See the bulletin on storm water runoff for additional management measures.



### USE OF HIGHWAY DEICING CHEMICALS

Each winter, state, county, and local transportation departments stock their arsenal with the tools necessary to face whatever winter storms may bring. This arsenal includes a variety of chemicals to melt snow and ice. This preparedness has a high price tag; in the U.S., an estimated \$2 billion is spent each year on chemicals, materials, labor, and equipment for winter road maintenance.

The most commonly used and economical deicer is sodium chloride, better known as salt; 15 million tons of deicing salt are used in the U.S. each year. Salt is effective because it lowers the freezing point of water, preventing ice and snow from bonding to the pavement and allowing easy removal by plows. However, the use of salt is not without problems. Salt contributes to the corrosion of vehicles and infrastructure, and can damage water bodies, ground water, and roadside vegetation. These issues have led to the investigation and use of other chemicals as substitutes for and supplements to salt. Other deicing chemicals include magnesium chloride, potassium acetate, calcium chloride, calcium magnesium acetate, and potassium chloride (these are described below).

Abrasives such as sand are often used in conjunction with deicing chemicals to provide traction for vehicles, particularly on corners, intersections, and steep grades. However, when sand is overused, it often ends up in the environment, either as dust particles that contribute to air pollution or in runoff to streams and rivers.

## **WHY IS IT IMPORTANT TO MANAGE HIGHWAY DEICING NEAR THE SOURCES OF YOUR DRINKING WATER?**

Salt and other deicing chemicals can concentrate in runoff, which enters surface water or percolates through soil to reach ground water sources. It is difficult to generalize and quantify a deicer's effect on water bodies on a national level due to the complexity of stream environments and lack of detailed data. Furthermore, runoff is often diluted once it enters larger bodies of water, though it may affect smaller streams and creeks along highways. Generally, reservoirs and other drinking water supplies near treated highways and salt storage sites are susceptible to contamination, therefore special consideration and best management practices (BMPs) are needed to protect them.

Sodium is associated with general human health concerns. It can contribute to or affect cardiovascular, kidney, and liver diseases, and has a direct link to high blood pressure. Elevated sodium levels in sources of drinking water could prove dangerous, and dietary intake of sodium should be restricted. There is no MCL or health advisory level for sodium; however, there is a Drinking Water Equivalent Level of 20 mg/L, a non-enforceable guidance level considered protective against non-carcinogenic adverse health effects. Sodium is one of the contaminants EPA is considering for a regulatory determination.

Chloride, for which EPA has established a national secondary drinking water standard of 250 mg/L, adds a salty taste to water and corrodes pipes. The water quality standard for chloride is 230 mg/L, based on toxicity to aquatic life.

Anti-caking agents are often added to salt, the most common of which is sodium ferrocyanide. There is no evidence of toxicity in humans from sodium ferrocyanide, even at levels higher than those employed for deicing. However, some studies have found that the resulting release of cyanide ions is toxic to fish.

## **AVAILABLE PREVENTION MEASURES TO ADDRESS HIGHWAY DEICING**

This section provides an overview of several management measures. The reference materials below can provide additional resources and information. Please keep in mind that individual prevention measures may or may not be adequate to prevent contamination of source waters. Most likely, individual measures should be combined in an overall prevention approach that considers the nature of the potential source of contamination, the purpose, cost, operational, and maintenance requirements of the measures, the vulnerability of the source water, the public's acceptance of the measures, and the community's desired degree of risk reduction.

The goal of these prevention measures is to minimize the loss of deicing chemicals due to overuse and mishandling. Management of deicing chemicals focuses on reducing waste through training and access to information on road conditions through the use of technology. Generally, optimal strategies for keeping roads clear of ice and snow will depend on local climatic, site, and traffic conditions, and should be tailored as such. Road maintenance workers should be trained on these measures prior to the winter season. Personnel should also be made aware of areas where careful management of deicing chemicals is particularly important, e.g., sensitive water areas such as lakes, ponds, and rivers. Similarly, personnel should be aware of runoff concerns from roadways that are near surface water bodies or that drain to either surface water or the subsurface (e.g., through a dry well).

**Alternative deicing chemicals** include calcium chloride and calcium magnesium acetate (CMA). Another alternative, sodium ferrocyanate, should be avoided due to its toxicity to fish. Although alternatives are usually more expensive than salt, their use may be warranted in some circumstances, such as near habitats of endangered or threatened species or in areas with elevated levels of sodium in the drinking water. Sensitive areas and ecosystems along highways should be mapped, and the use of deicing alternatives should be targeted to those spots. Other considerations for using alternatives to salt include traffic volume and extreme weather conditions.



Anti-icing chemical application.

Each deicer works differently in various climatic and regional circumstances. For example, salt is most effective at temperatures above 20° F. As an alternative, calcium chloride is effective for temperatures that dip below 0° F and is fast acting, making it ideal for several areas of the country. In New England, it is used as an alternative on roadways in areas with high sodium concentrations in water. However, its high cost limits its use to these severe conditions. CMA has had limited use on roadways because of its high cost and the fact that it is only effective above 23° F; however, research shows few negative impacts on human health and the environment. Combining deicers, such as mixing calcium chloride and salt, can be cost-effective and safe if good information on weather conditions and road usage are available.

**Road Weather Information Systems (RWIS)** help maintenance centers determine current weather conditions in a given location. Since the mid-1980's, increasing numbers of states are using this technology. Sensors collect data on air and pavement temperatures, levels of precipitation, and the amount of deicing chemicals on the pavement. The data are paired with weather forecast information to predict pavement temperatures for a specific area and determine the amount of chemicals needed in the changing conditions. The strategically placed stations are 90 to 95 percent accurate. This information is also used for anti-icing treatment (described below) to allow for chemicals to be applied before the pavement freezes, reducing the amount of deicing chemicals used. Several states are developing satellite delivery of this information to maintenance workers.



RWIS Unit.

**Anti-icing or pretreatment** methods are increasingly being used as a preventative tool. Anti-icing may require up to 90 percent less product than is needed for deicing after snow and ice have settled on road surfaces. Deicing chemicals, often liquid magnesium chloride, are applied to the pavement before precipitation or at the start of a storm to lower the freezing point of water. Magnesium chloride is effective in extreme cold temperatures (as low as -13° F) and is cost effective as well. Timing is everything in the process, and weather reports or RWIS data can assist highway departments in determining the best time and place to apply chemicals. Anti-icing programs can avoid over-application of deicing chemicals after a storm event because less ice and snow bonds to the road. Several states reported improvements in traffic mobility and traction after using anti-icing treatment techniques. The Pacific Northwest Snowfighters (PNS) Association evaluates the safety, environmental preservation, and performance of winter road maintenance

products, including road deicers and anti-icers. PNS maintains, monitors, and updates a list of approved products on its web site (see the section on additional information below).

Some states have installed fixed chemical spraying systems in highway trouble spots, such as on curves and bridges, to prevent slippery roads. Chemicals are dispensed through spray nozzles embedded in the pavement, curbs, barriers, or bridge decks. Using pavement temperature and precipitation sensors, maintenance workers can monitor conditions and activate these fixed maintenance systems. This technique saves materials and manpower and reduces deicing operations during a storm. Though expensive to implement, these systems can be beneficial for areas such as bridges that cross sensitive water bodies, because the risk of over-application is reduced through the systems' efficiency.

**Spreading rates and the amount** of deicer used are important considerations. Some studies have shown that snow melts faster when salt is applied in narrow strips. In a technique known as windrowing, spreading is concentrated in a four to eight foot strip along the centerline to melt snow to expose the pavement, which in turn warms a greater portion of the road surface, and causes more melting. This technique can be used on lesser traveled roads. The amount used is important, since too much deicer can be ineffective, as chemicals will be dispersed (i.e., to the side of the road) where they cannot melt snow and ice. If not enough deicer is used, the chemical interaction with ice needed for melting will not occur, wasting the application. Here is where knowledge of the specific conditions of precipitation and the pavement is needed. For example, shaded areas have lower



pavement temperatures and ice forms easier; therefore, more chemicals may be needed in these spots. As a general rule, less chemicals should be used when the temperatures are rising, and more should be used when they are falling.

**Timing of application** is an important consideration, as the strategy of anti-icing indicates. It takes time for the chemical reactions of salt and other deicers to become effective, after which a plow can more easily remove the snow. Sand should not be applied to roadways if more snow or ice is expected, as it will no longer be effective once covered. Traffic volume should also be taken into consideration, as vehicles can disperse deicers and sand to the side of the road. The timing of a second application is dictated by the road conditions. For example, while the snow is slushy on the pavement, the salt or deicer is still effective. Once it stiffens, however, plowing should be done to remove excess snow.

**Application equipment** aids in the proper distribution of deicer chemicals. Many trucks are equipped with a spinning circular plate that throws the chemicals in a semi-circle onto the road. A chute is used to distribute in a windrow, typically near the centerline of the road. Modified spreaders prevent the over-application of materials by calibration or by the speed of the truck and should be used. Spreader calibration controls the amount of chemicals applied and allows different chemicals to be distributed at different rates. Equipment can also be used to vary the width of the deiced area. General equipment maintenance and checks should be conducted at least once a year to ensure proper and accurate operation.

**Plowing and snow removal** are chemical-free options to keep roads clear of snow and ice. With plowing, less chemicals are needed to melt the remaining snow and ice pack. For specific weather conditions, specialized snow plows may be used. For example, various materials, such as polymers and rubber, can be used on the blade.

**Pre-wetting** of sand or deicing chemicals such as salt is a widespread practice. The resulting brine mixture can provide faster melting. Salt can be pre-wetted through a spray as it leaves the spreader. Sand is often pre-wet with liquid deicing chemicals just prior to spreading. This is an

effective method for embedding the sand into the ice and snow on the pavement. This technique can pay for itself through the savings in materials because less sand or salt bounces off the pavement and is lost.

**Street sweeping** during or soon after the spring snow melt can prevent excess sand and deicing residue from entering surface and ground waters. Many road departments sweep streets at least once in the spring, with either a broom sweeping or vacuuming vehicle. The sweepings can be added to sand piles for future reuse.

**Proper salt storage** is a key measure to prevent the introduction of potentially harmful contaminant loads to nearby surface and ground waters. It is important to shelter salt piles from moisture and wind, as unprotected piles can contribute large doses of sodium chloride to runoff. Salt should be stored inside a covered, waterproof structure, such as a dome or shed. Soil type, hydrology, and topography must also be appropriate for the storage area. Any runoff should be cleaned up immediately and the collected brine reused. Spills during loading and unloading should be cleaned as soon as possible. Salt storage sites should also be located outside of wellhead and source water protection areas, away from private wells, sole source aquifers (where feasible), and public water supply intakes. These areas should be identified so application in these areas can be controlled and storage precautions enforced.

**Ground water quality monitoring** near salt storage and application sites should be performed, at minimum, annually. Site-specific water table maps that show the direction of groundwater flow should be reviewed, and monitoring performed up gradient and down gradient of storage and application sites to detect contamination.

#### **FOR ADDITIONAL INFORMATION**

These resources contain information on deicing chemicals, related studies, or BMPs. All of the documents listed are available for free on the Internet. State departments of transportation, whose contact information can be found on the Internet or in the phone book, are also good sources of information.

Caraco D. and R. Claytor. (1997) *Storm Water BMP Design Supplement for Cold Climates*. Center for Watershed Protection. Ellicott City, MD. <http://www.cwp.org/cold-climates.htm>

Center for Watershed Protection, 8391 Main Street, Ellicott City, MD, 21043  
<http://www.cwp.org>. CWP also maintains the Stormwater Manager's Resource Center, <http://www.stormwatercenter.net>

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<http://www.sicop.net/Abrasives%20report.pdf>

Michigan Department of Transportation. (1993) *The Use of Selected Deicing Materials on Michigan Roads: Environmental and Economic Impacts*. December.  
<http://www.mdot.state.mi.us/mappub/deicing/>

New England Interstate Water Pollution Control Commission. (1996) *Source Protection: a Guidance Manual for Small Surface Water Supplies in New England*. March.

New Hampshire Department of Environmental Services. *Road Salt and Water Quality*. Environmental Fact Sheet WMB-4. 1996.  
<http://www.des.state.nh.us/factsheets/wmb/wmb-4.htm>

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Ohrel, R. (1995) *Rating Deicing Agents: Road Salt Stands Firm*. *Watershed Protection Techniques*. 1(4): 217-220.  
[http://www.stormwatercenter.net/Database\\_Files/Publications\\_Database\\_1Page423.html](http://www.stormwatercenter.net/Database_Files/Publications_Database_1Page423.html)

Pacific Northwest Snowfighters Association. Website includes a monitored and updated list of approved deicing products. <http://www.wsdot.wa.gov/fossc/maint/pns/htm/resources.htm>

Road Management Journal. (1997) *Using Salt and Sand for Winter Road Maintenance*. [Information reproduced with permission from the Wisconsin Transportation Bulletin No. 6, March 1996.] December. <http://www.usroads.com/journals/p/rmj/9712/rm971202.htm>

The Salt Institute, 700 N. Fairfax Street, Suite 600, Fairfax Plaza, Alexandria, VA 22314-2026 703.549.4648. Website contains useful information on salt storage and its Sensible Salting Program. <http://www.saltinstitute.org>

Seawell, Charles and Newland Agbenowosi. (1998) *Effects of Road Deicing Salts on Groundwater Systems*.  
[www.ce.vt.edu/program\\_areas/environmental/teach/gwprimer/roadsalt/roadsalt.html](http://www.ce.vt.edu/program_areas/environmental/teach/gwprimer/roadsalt/roadsalt.html)

Transportation Research Board, National Research Council. (1991) *Highway Deicing: Comparing Salt and Calcium Magnesium Acetate*. Special Report 235.  
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<http://www.epa.gov/safewater/uic/classv.html>

USEPA links to sites on Roads, Highways, and Bridges:  
<http://www.epa.gov/owow/nps/roadshwys.html>

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Winter Maintenance Virtual Clearinghouse, Federal Highway Administration. U.S. Department of Transportation. <http://www.fhwa.dot.gov/winter>