March 31, 2014

STATEWIDE PLANNING TECHNICAL PAPER NUMBER: #163

ROAD SALT/SAND APPLICATION IN RHODE ISLAND

RHODE ISLAND DIVISION OF PLANNING

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(2) to coordinate activities of the public and private sectors within this framework of policies and programs

(3) to assist local governments in management, and

(4) to advise the Governor and others concerned on physical, social, and economic topics.

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(2) State Guide Plan*.* The State Guide Plan is comprised of functional elements or plans dealing with land use, physical development and environmental concerns, economic development, housing production, energy supply (including the development of renewable energy resources in Rhode Island), energy access, use, and conservation, human services, and other factors.

ABSTRACT

TITLE: Road Salt/Sand Application in Rhode Island

SUBJECT: Water Quality

DATE: March 31, 2014

AGENCY: Rhode Island Department of Administration
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PROJECT: Work Task # 2040, Fiscal Years 2013-14

SERIES: Technical Report Number 163

NUMBER OF PAGES: 16

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ABSTRACT: This report documents the current state and municipal policies related to salt and sand application to Rhode Island's roads and highways during winter weather events. The effects on water quality are described. Current data, application rates and ratios along with new and proposed policies are explored in this report. The purpose of the report is to help inform goals and policies for a new water quality management state guide plan element.

ACKNOWLEDGEMENTS: This paper contains data and information provided by individuals from several key state agencies. Special thanks to:

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(Plow trucks, DOT)

INTRODUCTION

This paper summarizes the current policies related to the application of salt and salt-related products and chemicals on Rhode Island roads and highways. Application ratios and amounts will be explored. The report will attempt to describe the fiscal and environmental impacts of road salting. It will be conducted through data collection from federal, state, municipal, out-of-state entities. The information on “current policies and usage” is based on information obtained through the Department of Transportation (DOT) and municipal Public Works Departments.

Road Salt Application Policies in Rhode Island

The State of Rhode Island is responsible for the safety of federal and state highways. The DOT’s Highway and Bridge Maintenance Division has the main duties of maintaining the road surfaces during ice and snow events. On average, the State receives about 37 inches of snow each year, but snowfall totals can vary significantly from town to town, even given Rhode Island’s relatively small area. For example, North Foster averages about 57 inches per year while New Shoreham sees about half of that. The number of snow events per year varies widely from year to year. The DOT staff and private contractors, carry out these ice/snow removal activities. Various technologies are used to guide drivers with updates on weather, pavement and traffic conditions. Pavement temperature information is provided by DOT's Roadway Weather Information Systems (RWIS). These systems can help DOT staff make determinations when icy conditions may be present and helps in the selection and application of materials for the Department’s roadway treatment actions. DOT Highway and Bridge Maintenance uses three techniques to inhibit ice formation and improve the roadway surface for plowing including anti-icing, pre-wetting, and de-icing. These three methods will be discussed in more detail later in this report.

State Road Salting/Sanding Practices

As more roads are built and as more vehicles are added to our roads, the need for road, bridge and highway maintenance increases. The history of road maintenance in Rhode Island in regards to snow and icing dates back to the 1930’s-40 when only abrasives like sand were used in addition to plowing. After World War II, the use of salt on roads became more common and it grew substantially in the 50’s and 60’s. As of 2013, the State spends about $10 million per year on road salting on an annual basis, which is about 25% of DOT’s statewide highway and bridge maintenance budget.

Currently, both salt and sand are used on Rhode Island's roads. There are two types of mixes used on Rhode Island roads. The first type is a 1:1 mixture of salt and sand. The sand is used only to provide traction on slick surfaces, while the salt part of the mixture provides the ice and snow melting power. The other formula consists of salt only, but is applied using what is called a "closed loop spreader control system". This new technology will be discussed later in this document. Aside from the mixture types used, there are generally three methods of snow/ice road maintenance practiced and they are:

(Brine (saltwater) being applied to road surface, Jerry McCrea/The Star-Ledger)

1. *Anti-Icing (Brine)*

Anti-icing prevents the formation of frost and bonding between snow and ice and pavement. Anti-icing chemicals are primarily liquids applied before or early in a snowfall. This practice has only been in wide use since February of 2012. A solution of salt brine (23.3% salt-water solution) may be applied to highways before a forecasted snow event. The pavement appears wet temporarily, but as the water evaporates, a layer of salt bonds to the semi-porous road surface, preventing the snow from bonding to the road. The brine can still be effective if applied up to 72 hours before snowfall. The use of brine is effective in reducing the amount of salt used during snow storms.

2. *Pre-wetting*

Pre-wetting adds chemical solutions to the salt and sand mixture, causing the mixture to stick to the road instead of blowing off to the shoulder.

3. *De-icing*

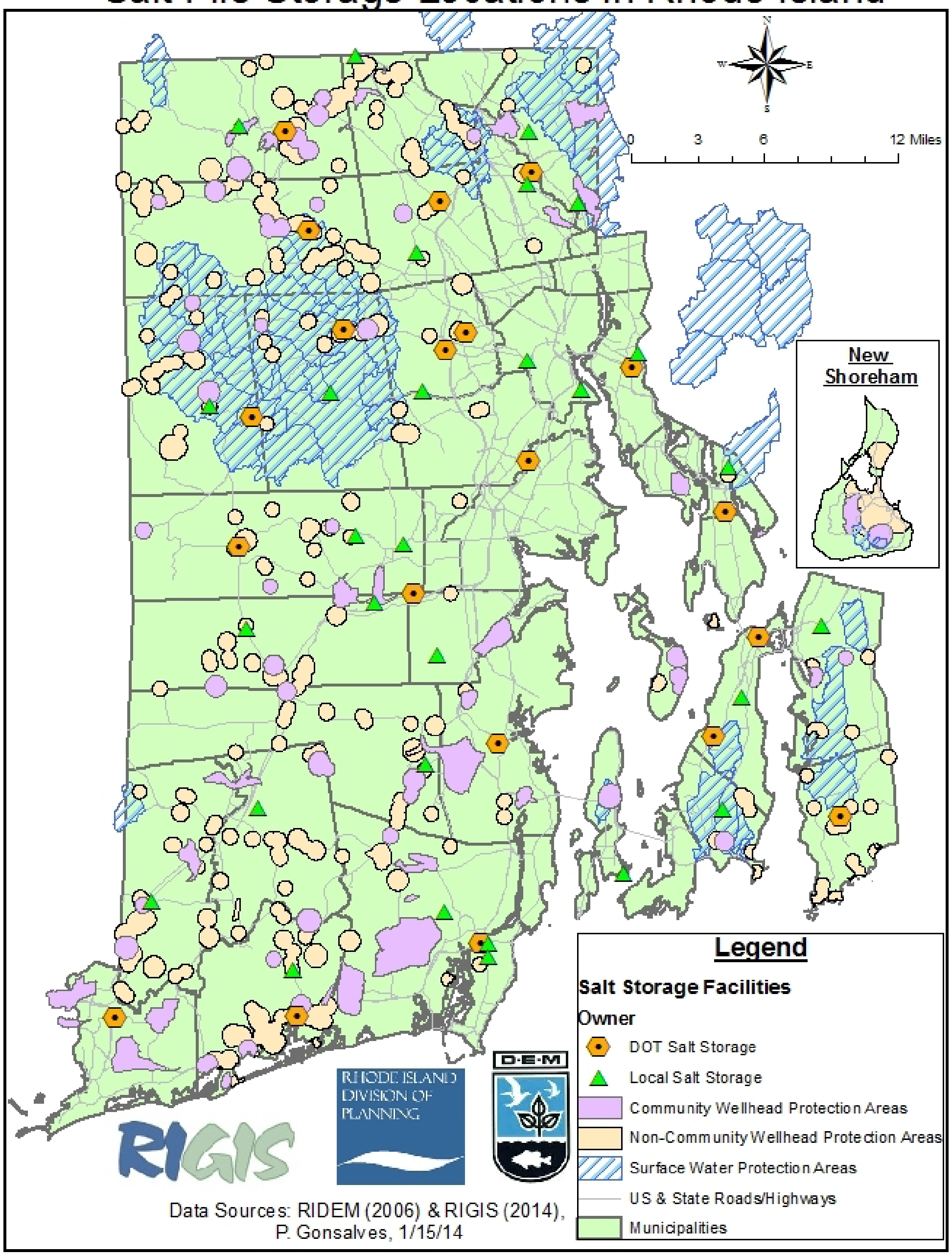
De-icing uses chemical or mechanical means to separate ice and pavement. Plowing is the most common practice of mechanical snow/ice removal.

Salt Storage Facilities

The DOT currently has twenty stock piles of salt and sand throughout the State, covering seven maintenance districts.(see Figure 1, Salt Pile Locations in Rhode Island). Five of these locations are "uncovered", meaning that there is no permanent structure at these locations. The State also operates the facility that makes the salt brine solution. The facility is located off of Exit 7 off Interstate 95. Up to 5,000 gallons of brine per hour can be produced there. As of 2006, there were at least 29 salt piles in the State reserved for local use. Some municipal salt piles are inlcuded in Figure 1 but updated data was not available for this report.

FIGURE 1

Salt Pile Storage Locations in Rhode Island



Vehicles and Equipment

The DOT currently has a fleet of one hundred snow plow/spreader trucks. Sixty-nine trucks are equipped with “closed loop spreader control systems”. The automated equipment allows the operators to accurately administer and monitor the exact amount of salt applied. The equipment also tracks and reports the application rate in pounds per lane mile (lbs/LM). The Department has seen a significant reduction in lbs/LM since the introduction of the closed loop system. Up to three hundred vendor vehicles can be used for winter highway maintenance, depending on severity of the winter. Currently, none of the vendor trucks have the closed loop system.

<u>New Pavement Technologies</u>

DOT currently uses real-time information systems capable of monitoring road temperatures. This technology is especially useful in spots such as the Newport Bridge where air temperatures may significantly vary from road surface temperatures.

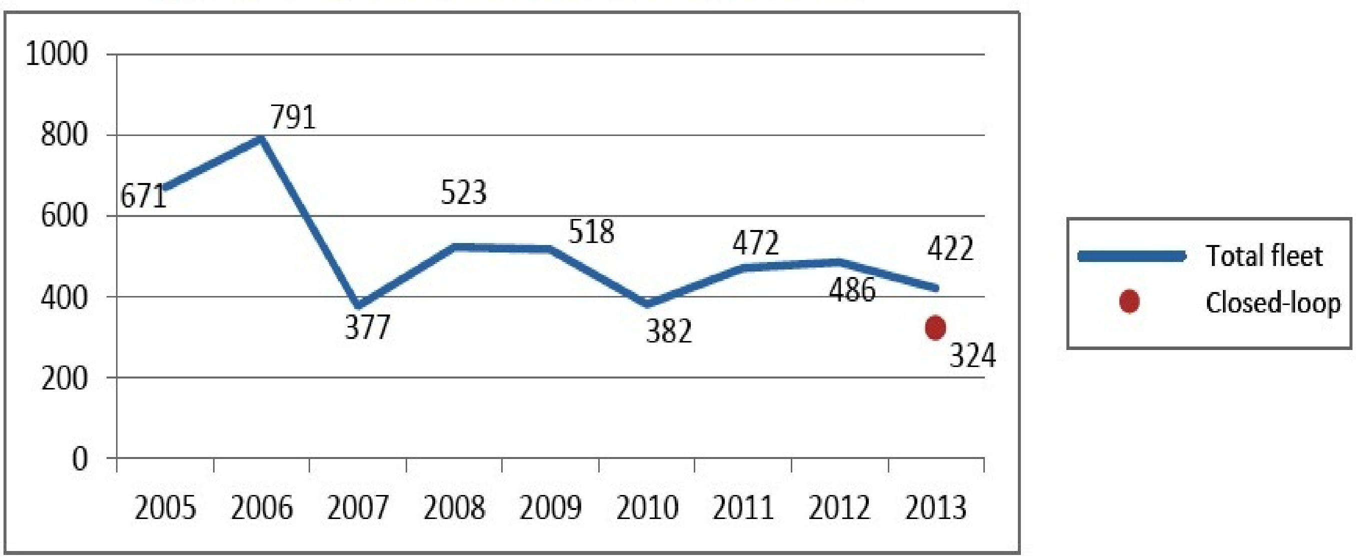
<u>Roads and Highways Covered</u>

The DOT has the primary responsibility to plow and salt/sand all interstate highway surfaces, as well as state Roads. The interstate highways include I-95, I-195 and I-295. Municipalities are generally responsible for their own arterial and collector roads and other side streets.

<u>Historical Salt Use</u>

Annual salt and sand application totals vary due to annual differences in snowfall totals. The best metric of salt application rates to use is the ratio of “pounds per lane mile” (lb. /LM). See Figure 2 below for DOT salt applications rates from 2005-2012.

Figure 2: Average Number of Pounds of Salt per Lane Mile



Average Number of Pounds of Salt per Lane Mile, *DOT Performance Update*, (RI Office of Management and Budget, March 2013)

Current Use of Salt

With annual differences in snowfall totals and storm events, the total amount of salt used fluctuates from year to year. The average lbs. /LM applied by the closed loop equipped trucks is approximately 25% lower than for the trucks without closed loop systems based on recent data from the winter of 2014. Overall, the DOT has reduced salt application by more than 27% over the past seven years. There are several types of salt that are used on RI roadways, highways and bridges.

<u>Sodium Chloride (NaCl)</u>

Commonly known as "salt", is by far the most commonly used deicing chemical substance. Sodium Chloride is the main substance used in highway and road maintenance and it can melt snow and ice down to negative 6 degrees below zero, but is only significantly effective down to about 15 degrees Fahrenheit. Although it is the same chemical composition as basic table salt, the NaCl used on roads is in a "rock salt" form. The granules are much larger than table salt. As is the case with the other chlorides listed below, salt is often viewed as being corrosive, but it is the most cost-effective as it is one of the most abundant minerals on the Earth. Corrosion inhibitors or performance enhancers such as molasses are sometimes used in conjunction with road salt.

<u>Calcium Chloride (CaCl)</u>

Calcium Chloride may have several advantages over sodium chloride. CaCl is effective at much lower temperatures than NaCl. CaCl is most effective at temperatures between 5 and 25 degrees Fahrenheit. The major drawback to CaCl is the cost, which can be up to three times more than NaCl. In 1991, The Providence Water Supply Board started an agreement with DOT to use CaCl in the Scituate Reservoir watershed. Upon further studies in conjunction with USGS, it was found that using CaCl instead of NaCl did not lead to decreased *chloride levels*. CaCl is rarely used for winter road maintenance elsewhere in the State, as it can cause slick road conditions as it draws moisture from the air. It is also known to be problematic as it sticks to truck equipment including truck brakes.

<u>Magnesium Chloride (MgCl)</u>

When compared to calcium chloride, magnesium chloride has similar properties. It is most effective in the temperature range of 0 to 25 degrees. Although about twice the amount per lane mile is needed, MgCl is generally seen as being safer for the environment than both NaCl and CaCl. It is carefully used in Rhode Island as it could lead to slippery road surfaces when used alone, since it does not bond to the road surface as well as NaCl and CaCl. Currently, the most common application of MgCl is seen on bridges as it has a lower freezing point than regular road salt. In the 2013/2014 winter, there was about 60,000 gallons of MgCl pre-treatment used in the State.

<u>Brine/Pre-Mix</u>

The DOT has a brine mixing facility off of Exit 7 of I-95, which is close to the halfway point of I-95 between the Connecticut and Massachusetts borders. The facility has the capability to mix up to 5,000 gallons per hour.

<u>Sand</u>

Sand is commonly used with rock salt in a 1:1 ratio on Rhode Island's highways and roads. The sand does not have any melting properties, as it is only applied to provide increased traction. Most of the sand used in RI comes from within the State. Because sand does not melt, it will remain on the pavement until removed either by manual sweeping, or as runoff into catch basins, sewers, shoulders and adjacent water bodies. An increase in sand usage is common when salt supplies run low. It often is cheaper to obtain than salt.

Municipal Road Salt Practices

For the purposes of acquiring information on local salt and sand application practices, a short survey was sent to all municipal public works departments. About 25% of municipalities replied to the survey. In general, the practices at the municipal level involved applying only sodium chloride rock salt and sand. Only one municipality (Central Falls) reported the use of saltwater brine. The on-board technology used at the State level tends to be more advanced than the municipal counterparts, as there were no reported installations of the "closed-loop" system on municipal trucks. RIDEM is not aware of any municipal trucks with that system. At the local level, the amount of salt/sand applied per lane mile varies from 250 to 450 lb. / lm. Not all municipalities have the equipment to track this info.

ENVIRONMENTAL IMPACTS AND CONCERNS

Even though rock salt and sand are natural substances, the repeated application of tons of these materials is not without environmental consequences. In the winter of 2004/2005, the State set a record high in terms of tons of salt used in a single winter/fiscal year. That year, about 180,000 tons of salt was used by the DOT. The five-year average for salt use is about 85,000 tons, which can fluctuate based on the severity of each winter. As of mid-March 2014, approximately 130,000 tons were used. Although it is spread throughout the State and diluted, the cumulative effects of salt additions at high rates can possibly have environmental consequences.

Sand removal is also a major issue in the State, as only a small fraction (as low as 5% by DOT estimates), is swept up due to staff and budget constraints at all levels. With each spring/rainy season, the salt and sand that was applied during the winter slowly makes its way to adjacent water bodies and catch basins, making localized flooding more likely to occur. Also, excess sand accumulation at the bottom of adjacent streams and ponds can lead to the smothering of aquatic life. Normal traffic can act as a grinding agent turning the sand particles in to a dust which can lead to aggravate certain respiratory problems such as asthma.

Effects on Drinking Water Supplies

As stated in State Guide Plan Element 721: *RI Water 2030*, "...road salt can interrupt natural watershed drainage patterns and degrade water quality." (p.2-9). Sodium Chloride can enter the water supply by either direct contact with surface waters or by infiltration to groundwater which can contaminate public and private wells. Increased sodium levels in drinking water can have negative effects for people sensitive to sodium, such as those who suffer from high-blood pressure. Increased sodium levels may be present in drinking water without a noticeable difference in taste, but chloride levels do affect taste. Anecdotal statements say that some private wells in Rhode Island contain levels of chloride above the EPA secondary standard of 250 mg/l from road salt practices. The authors did not investigate these claims in depth due to a limited timeframe and were unable to either substantiate or disprove the anecdotal statements. Sodium Chloride is also known to be corrosive to metals, especially those related to plumbing.

Potential Impacts on Wildlife

The salt and sand can affect aquatic and non-aquatic plants and animals living in or nearby surface waters. If sand is not recovered in the spring, it can clog catch basins and fill stream beds, which can result in habitat alteration for fish, amphibians and aquatic invertebrates. Since sanding occurs in winter when plants are dormant, it is unlikely that animals will be attracted to plants along roadways. Most grass and some trees along the roadsides that have been affected by salt-sand spray will have died and thus there would be no green leaves to attract animals. Attraction to salt would be more likely in the brine-spray scenario where spray onto low branches of woody vegetation that deer or other larger mammals could lick would seem more likely than grass. A Michigan study found no correlation between road salting and animal attractions. [1]

Potential Freshwater Aquatic Impacts

Salt and sand can affect microorganism growth by clouding the water. Levels of chloride in water bodies have been increasing and road salting is a major contributor, especially in built-up areas and heavy traffic roadways. Not only salt use on major roads, but also salt use on secondary roads and parking lots are contributing to these increased chloride levels. Some researchers such as those from the University of Dayton in Ohio conclude that sand is worse than salt for some aquatic systems. A new study released in December 2013 done though Clear Roads: Research for Highway Maintenance suggests that sodium chloride with a low level of corrosion inhibitor is among the least toxic deicing materials used, contrary to popular believe that magnesium, potassium and calcium based salts are the safest. Clear Roads is a pooled fund project with 28 member states, including Rhode Island. It was started in 2004 in response to a need for real-world testing in the field of winter highway operations and is funding practical, usable winter maintenance research.[2] Rhode Island's participation in the program through DOT is federally funded.

Federal Guidelines Water Quality (Chloride Levels)

The US Environmental Protection Agency in 1988 released a document titled: "*Ambient Aquatic Life Water Quality Criteria for Chloride*". The report addresses water quality by looking at acute and chronic toxicity to animals and toxicity to aquatic plants. The data showed that different species of plants and animals had a wide range of chloride tolerances. The acute sensitivities in freshwater animals ranged from 1,470 milligrams per liter (mg/L) to 11,940 mg/L. Plants had an even wider variation in sensitivities ranging from 71 to 36,400 mg/L. Ultimately, the report concludes that aquatic organisms should not be adversely effected if,

> *"the four-day average concentration of dissolved chloride, when associated with sodium, does not exceed 230 mg/L more than once every three years on the average and if the one-hour average concentration does not exceed 860 mg/L more than once every three years on the average."* [3]

Potential Impacts on Vegetation

Along the shoulders of roadways, salt and sand can degrade vegetation and soil, leading to erosion. In high concentrations, salt can kill certain types of vegetation. It is important for roadside vegetation to be chosen based on several factors including salt tolerance. Healthy roadside vegetation can combat erosion by increasing the integrity of the soil. In 2011, the DOT in conjunction with The University of Rhode Island, conducted a study and submitted a report to the FHWA on salt tolerant vegetation. The report, *Development of Salt Tolerant Grasses for Roadside Use*, aimed to address the issue of dying turf grasses along roadways and what alternatives existed. The report concludes with specific recommendations for grass types, soil ratios and best practices. An underlying assumption of the report is that the recommendations can be achieved on existing maintenance budgets. The inclusion of the grasses and shrubbery identified in the study could lead to more robust roadside vegetation, which will reduce runoff into nearby water bodies. The image below is from the project which found that the inclusion of biosolid materials into roadside vegetation significantly increases the quality and persistence of turf by over 50%, when compared to just soil alone.

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[1] *Deicing Chemical Use on the Michigan State Highway System,* Science and Technology Division, Legislative Service Bureau, Lansing
[2] www.clearroads.org
[3] U.S. EPA (1988), Ambient Water Quality Criteria for Chloride, Office of Water Regulations and Standards, Publication 440588001

Inclusion of Bio solids on Roadside Turf, I-295, (R. Brown, URI, 2011)

Impaired Waterbodies in RI

According to the 2012 *RI Integrated Water Quality and Monitoring Assessment Report* published by DEM, two water bodies in the State have not met water quality standards for their intended uses because of chloride levels. This number may not reflect all water bodies affected as water quality sampling is done in the summer when streams may not be as directly impacted by salting activities in the spring or winter. Those waterbodies showing impairments are Print Works Pond (Cranston) and the Pocasset River and tributaries from the headwaters to the inlet of Printworks Pond (Cranston, Johnston). There were a total of 96 named water bodies at that time which were found to be impaired but most are impaired for reasons other than chloride levels. It is important to reduce chloride levels in areas where salt runoff may already be a problem.

BEST MANAGEMENT PRACTICES AND NEW TECHNOLOGIES

Successful Reduction Policies in New Hampshire

The State of New Hampshire has made strides recently in the reduction of road salt on its roads and highways. In 2008, New Hampshire listed nineteen chloride impaired water bodies under the Clean Water Act. In that same year, Plymouth State University worked with a consultant to produce a report named "*Potential Solutions for Reducing Road Salt Use in New Hampshire: A Report to the I-93 Salt Reduction Workgroup*". The report is part a larger effort called the "New Hampshire Road Salt Reduction Initiative". The report concluded that the only way to prevent chloride from reaching surface and ground water is to reduce the amount applied to roadways and parking lots without compromising safety. The following recommendations were highlighted by the project's focus group:

- Use education initiatives on road salt and its impacts on water quality, directed at the driving public, to change driver habits;
- Educational and informational efforts should be presented by NHDOT and NHDES in multiple ways and designed for different audiences;
- Provide additional enforcement to reduce speed limits during storm events;
- Use technology (cameras, radar, and other devices) to assist with enforcement;
- Create "No Salt" areas;
- Create additional public transportation alternatives;
- Engage employers and delay or cancel work related activities during inclement weather;
- Pass a law requiring all drivers to take a winter weather driving course;
- Eliminate the legal liability for towns and businesses that reduce their application of salt; and
- Require mandatory use of snow tires on New Hampshire roadways.

The report ultimately recommended the following policies:

Training on treatment practices for maintenance professionals (public and private);
Equipment and infrastructure upgrades;
Behavior change programs to assist with voluntary and mandatory approaches;
Lower speed limit during storm events; and
Mandatory use of snow tires for the public

Following the listing of Chloride Impaired Waterbodies along the I-93 Corridor in Southern New Hampshire, NH Department of Environmental Services, NH Department of Transportation, and several municipalities and private contractors are working together to reduce chloride while continuing to provide safe passage for traffic and pedestrians. (2013 NH Road Salt Reduction Initiative).

Bio-degradable, Low Impact Alternative Formulas

Calcium Magnesium Acetate and Potassium Acetate

Calcium Magnesium Acetate (CMA) is combination of acetic acid and limestone. It generally works at temperatures down to 20°F. It is believed to have less of an environmental impact than other salts and chemicals, less corrosive to concrete and steel, less toxic to aquatic organisms, and has limited impact on ground water in comparison to road salt. At about $130 per gallon, CMA is considerably more expensive than rock salt. In the US, it is currently being used in environmentally sensitive areas such-as Yellowstone and Yosemite Parks, and on bridges prone to salt corrosion.

Potassium Acetate (KA) generally works at temperatures down to -15°F and is non-corrosive and biodegradable. It can cause slick road conditions if applied in excess and can lower oxygen levels in surface waters. This is a commonly used at airports. Potassium Acetate though, ranked as the most toxic deicing treatment in the Clear Roads study from December 2013. At the time of this report, there is no indication that CMA or KA are regularly used in Rhode Island.

Carbohydrate-based Solutions

Byproducts from corn or beets can be blended with magnesium chloride for use an anti-icing agent. Also, this mixture can be effective as a deicer. The mixture is less corrosive to metal equipment and is considered safe for the environment. These “natural” solutions are mostly proprietary to the manufacturer and can be derived from sources such as beets, corn, grain, alcohol, or molasses. These are not particularly good at melting snow and ice, but they do slow down the formation of ice lowering the freezing point. They are less corrosive than conventional materials and often help with traction on road surfaces. They are not known to have environmental impacts in aquatic systems due to their composition. Carbohydrate-based solutions in Rhode Island are beginning to gain traction. Recently molasses has been used by DOT with NaCl as a performance enhancer.

RECOMMENDATIONS

Reduction in Road Salt Applications

Based on the best available data over the past five years, the investment in new fleet technologies (closed loop-systems), have significantly reduced the total amount of sand and salt applied to RI roads. Continued/expanded investment in these equipment upgrades will contribute to increased efficiency in winter storm road maintenance procedures, thus reducing application rates and saving the state money in the short and long term. Opportunities for vendors should be invested to incentivize retro-fitting of closed loop systems.

Closed-loop Snowplow Control Module used by DOT, Photo: mto.gov.on.ca

Reductions in Sand Application

When salt is applied to roads in a more efficient manner, the need for sand should decrease, as more of the roads will be clear. Some believe that the application of sand has little to no effect on road conditions. When we weigh the clean-up costs and environmental effects, a reduction in the amount of sand applied to roads makes ecological and economic sense.

Expanded Reduced Salt Areas

In areas adjacent to community wellhead protection areas, and other public drinking water source protection areas, salt use should be reduced in order to protect water quality. Areas needing road salt close to drinking water sources should be defined on a case-by-case basis given hydrology, distance and other factors. The State, Towns and drinking water suppliers should work together to consider all issues. Drinking water sources of State significance have been recommended for reduced road salt usage for decades. For example, *State Guide Plan Element 721: Water 2030* contains recommendations for reduced salt use in the Scituate Reservoir Watershed:

> *"Goal WRM-2, Strategy 1-K: Reduce sodium application rates on roadways to reduce sodium loadings in the watershed"*[4]

> *"Goal WRM-2, Strategy 1-R- Reduce sodium application rates on roadways to reduce sodium loadings in source water areas and sole source aquifers."*

And the same goals and policy applies to the Big River Watershed. In the Scituate Reservoir watershed, the DOT currently uses an alternative mixture of NaCl and CaCl at 170 pounds per lane mile. This practice, or a similar one, is recommended to be expanded to the Big River Watershed and other drinking supply protection areas. It should also be applied to other areas where chloride or sodium levels exceed the recommended EPA water quality limits. In these areas, alternative methods should be considered, such as the carbohydrate-based solutions. Reductions of salt in areas of impaired watersheds and other alternative methods should also be considered.

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[4] *Rhode Island Water 2030,* Department of Administration, Division of Planning, 2012)
http://www.planning.ri.gov/documents/guide_plan/RI%20Water%202030_06.14.12_Final.pdf

Increase Sand Recovery Rates in Drinking Water Areas

If sand application levels do not decrease, and recovery levels do not increase, the gradual build up over time may have devastating effects. While salt easily dissolves and can be carried to and through groundwater and freshwater, sand is less likely to travel and tends to accumulate at roadsides, stormwater drainage basins and in adjacent ponds and streams. Currently, only about five to ten percent of sand applied to roads is recovered each year, priority should be placed on sand recovery in drinking water protection areas. *State Guide Plan Element 721: Water 2030* also contains recommendations for street sweeping in the Scituate Reservoir and Big River Watersheds:

> *"Goal WRM-2, Strategy 1-O: Ensure that annual street sweeping is completed in the watershed"*[5]

This strategy should be implemented in all drinking water protection areas for sources both public and private. With more efficient technology and equipment overall, sand application rates are likely to decrease. Until these technologies are widespread throughout the state, municipal and private fleets, increased sand recovery is a short-term water protection strategy that should be considered.

[5] *Rhode Island Water 2030,* Department of Administration, Division of Planning, 2012) http://www.planning.ri.gov/documents/guide_plan/RI%20Water%202030_06.14.12_Final.pdf

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