Development of a Snow and Ice Control Environmental Best Management Practices Manual

Final Report

research for winter highway maintenance

Western Transportation Institute

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Final Report

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Executive Summary

The goal of this research project was to analyze and make comparisons of the impacts of abrasives, chlorides, acetates, formates, glycerols, glycols, and organic by-products; and to compile the current environmental best practices for using chlorides. To accomplish this, a literature review sought information on the impacts of chemical deicers and abrasives and their associated impacts to air, surface and ground water, roadside soils, flora and fauna. The review also documented currently available knowledge of cost-effective equipment, practices, and strategies that allow snow and ice control operators to use the right amount of material in the right place at the right time, in an effort to achieve the "Triple Bottom line" of sustainability (economy, social, and environmental). A survey and interviews were used capture information from winter maintenance practitioners on the current state-of-the-practice, best practices, and lesson learned. The interviews were developed into Case Studies. The information captured in the previous tasks was further analyzed and processed into easy-to-use at-a-glance tables, which have been incorporated in to the manual. All of the information captured in the aforementioned tasks was used to create the *Snow and Ice Control Environmental Best Practices Manual*, the principal deliverable for this project.

Information on commonly used snow and ice control practices and procedures that can be modified or changed to meet the objective of serving as an environmental best practice is presented here. The manual focuses on the following practices and procedures:

- Levels of Service (LOS) guidelines provide realistic expectations for the operators, road managers, and the driving public for road conditions during and after storm events. Prescribed levels of service may need to be modified over time based on equipment, product availability, and staffing as well as the changing needs and expectations of the driving public.
- Environmental Management Tools provide a method to track snow and ice control practices, and link these practices to environmental policies. These tools identify current practices, highlight what is working, and identify areas for improvement, and how and where these improvements can be made.
- **Training** of snow and ice control professional is an area for continual growth and improvement. Transportation agencies use a wide variety of effective training tools, but these tools often lack or provided limited information on environmental best practices. This section identifies best practices used by some transportation agencies where environmental sustainability is incorporated into snow and ice control.
- **Monitoring and Keeping Records** is a key area for continual growth and improvement. Many transportation agencies monitor and keep records for financial purposes. These same agencies are finding that often costs-saving (improved efficiency in programs) equates to reduced environmental impacts – such as better housekeeping, reduced loss of material, proper application rates, etc.
- Snow and ice control materials commonly used are reviewed in section. Information is presented on beneficial characteristics of each product, application rate, working temperature, cost, and potential impacts.
- **Facility Management** is an area for continual growth and improvement. Good housekeeping practices, including cleaning up spilled material, proper labeling, and creating a safe work environment have been shown to reduce loss of snow and ice control material to the environment.
- Operational Strategies, such as plowing, are discussed in the context of plow types and how the various plows can used most effectively for various conditions (ice, snow, slush, road width,

etc.). Effective plowing operations have been shown to reduce the quantity of snow and ice control products needed, and overall improve efficiency in the operations.

- Material Selection of appropriate snow and ice control material can increase efficiency of operations, and reduce the amount of product needed.
- Material Application Equipment is used to apply solid deicers, pre-wet solids or abrasives, or liquid anti-icer. Each application strategy and the equipment needed are reviewed. Investment in modern application equipment and the adoption of anti-icing and pre-wetting strategies have been shown to provide significant cost and material saving, achieve equal or higher LOS, while using less snow and ice material.
- **Equipment Calibration** is an area for continual growth and improvement. Calibration of equipment used to apply snow and ice control products is often done once a season, which if often not frequently enough. Recommendations on when to calibrate equipment, and information sources on how to calibrate equipment are provided in this section. Equipment calibration allows for the appropriate and intended amount of snow and ice control material to be applied.
- Vehicle Washing is used to reduce impacts of snow and ice control on vehicles. Corrosion related to these operations can damage vehicles and reduce the effectiveness and lifespan of the vehicles. Vehicle washing options are reviewed, as well as options for recycling wash water for use in other snow and ice control operations.
- Corrosion Prevention is discussed in the context of impacts from snow and ice control operations and provides information on tools, equipment design, and practices that can be used to preserve equipment and improve asset management.
- Weather and Pavement Equipment and Technology are used dynamically in snow and ice control operations to determine when, where, and how to treat roads. This section provides information on effective tools like RWIS, MDSS, and FAST systems that aid in snow and ice control operations. Specifically the use of RWIS has been shown to be a cost-effective tool that has improved efficiency and operations for snow and ice control programs.
- Sensors to Improve Snow and Ice Control Operations include friction, salinity, pavement temperature, and others. These sensors can be pavement-invasive or non-invasive and provide additional information to aid in decision making. Use of additional sensors has been shown to improve operations and aid in better decision making.
- Smart Snowplows are snow plow trucks that are integrated with technology to provide real time information to the operator to make best possible decision in the field.
- Mid-Storm Adjustments is a section that discusses best practices that can be used as conditions change during storm events.
- Post-Storm Operations, such as sweeping, are critical operations to reduce the impacts of snow and ice control operations. If abrasives are being used, post-storm or melt-off cleaning is necessary to prevent clogging and reduced efficiency of constructed water conveyances, or natural features, and reduces impacts to air quality.

There are a few key areas where improved practices can provide the greatest benefit; this includes proper material storage, effective training of staff, calibration of equipment, and use of effective application strategies. By implementing these strategies transportation agencies can reduce or eliminate the loss of material from storage sites, provide staff with proper training to only use the amount of product needed, reduce over-application of material through effective calibration, and apply the right amount of material, in the right place, at the right time by using the proper application techniques and equipment.

This document highlights commons practices that can be used to reduce the environmental footprint of snow and ice control operations. Modifying or improving upon existing snow and ice control practices has been shown to lead to significant reduction in environmental impacts associated with snow and ice control operations – mostly through source control (limiting the amount of product applied and or lost to the environment) of snow and ice control products. Adopting one or many of the environmental best practices presented here can lead to significant material saving, therefore putting less product into the environment. Historically, environmental improvements in snow and ice control operations have been driven by a need to reduce costs and improve efficiency, or by regulation. By implementing cost saving and material saving practices, environment regulation issues can be avoided or minimized.

Chapter 1
Introduction

Report Purpose

This document is the final report for the Clear Roads project entitled *Development of a Snow and Ice Control Environmental Best Management Practices Manual*. The project team was led by researchers at the Western Transportation Institute at Montana State University (WTI) on behalf of Clear Roads, an ongoing pooled fund research effort focused on winter maintenance materials, equipment and methods. Clear Roads research projects are managed and administered by the Minnesota Department of Transportation (MnDOT). This report summarizes all tasks and research conducted over the course of the project.

Research Problem and Background

There is a need for the identification of environmental best management practices (BMPs) to aid in responsible and cost-effective operation of winter maintenance programs. State Departments of Transportation (DOTs) are continually challenged to provide a high level of service on winter roadways and improve safety and mobility in a cost-effective manner, while at the same time minimizing adverse effects to the environment, vehicles, and transportation infrastructure. Understanding and minimizing the negative impacts of deicers is critical to effective and responsible winter maintenance operations. Increasing contamination from the continued use of snow and ice control products has become a significant environmental concern because of the detrimental effects on air, water, soil, vegetation, humans, and wildlife.

Snow and ice control BMPs have been developed in all aspects of winter maintenance operations, and there is a need to integrate this information with the impacts of different snow and ice control products as well as the current environmental best practices for using chlorides in a responsible and affordable snow and ice control program. Such a best practices manual will benefit the entire winter maintenance community and could aid in inter-agency understanding and communication, as well as improved understanding and communication with elected officials and the public.

In the final report for this project (*Development of a Snow and Ice Control Environmental Best Management Practices Manual)*; the researchers identified the need for additional study to bridge some existing knowledge gaps relevant to this subject. These include research on the long-term effectiveness of best management practices; assessing level of service and policies related to providing reasonable and feasible snow and ice control defined by priorities, classifications, and road user expectations; improvement upon general snow and ice strategies and tactics; material selection, timing, and application rates, improvement to equipment for application, plowing, and post-storm clean-up; providing appropriate training and quality control for personnel; and investigating method to capture, remove, or recycle applied snow and ice control materials.

Research Goals and Approach

The overall goal of this project was to assess and communicate the impacts of different snow and ice control products as well as the current environmental best practices for using chlorides in a responsible and affordable snow and ice control program.

To create the manual, the basic approach consisted of information gathering using a literature search, survey and interviews, and development of the best practices manual.

Research Scope

The research scope comprised six primary tasks:

- Task 1 – Literature Search
- Task 2 – Survey and Interviews
- Task 3 – Analysis of Tasks 1 & 2
- Task 4 – Development of a Best Management Practices Manual
- Task 5 – Final Report and Presentation
- Task 6 – Convert the Final Report to a Web Document

These tasks are described in greater detail in Chapter 2 (Methodology).

The primary deliverable for this project is the completed Snow and Ice Control Environmental Best Management Practices Manual. Additional deliverables include this final report, and a PowerPoint presentation summarizing recommendations in the manual, for the use of Clear Roads members at conferences and other meetings.

Project research was conducted from January 2014 – June 2015.

Report Organization

Chapter 2 describes the project methodology, while Chapter 3 summarizes the results of each task. Chapter 4 presents conclusions and recommendations based on project research and development of the manual. The Snow and Ice Control Environmental Best Management Practices Manual has been provided as a stand-alone document.

Chapter 2
Methodology

This chapter describes the research approach for each of the six primary tasks.

Task 1 Approach: Literature Search

The research team's approach to the Task 1 literature search sought information on the impacts of chemical deicers and abrasives and their associated impacts to air, surface and ground water, roadside soils, flora and fauna. The review also documented currently available knowledge of cost-effective equipment, practices and strategies that allow snow and ice control operators to use the right amount of material in the right place at the right time, in an effort to achieve the "Triple Bottom line" of sustainability (economy, social, and environmental). Task 1 focused on recent literature and literature useful for developing the best practices manual, specifically the identification of environmental best practices that can be applied to snow and ice control operations.

Task 2 Approach: Survey and Interviews

For this task, the research team's approach was to survey snow and ice control professionals and operators capture information on the current state-of-the-practice, best practices, and lesson learned in areas of environmental management and best practices used in snow and ice operations. The survey targeted Clear Roads member states, as well as U.S. and international snow and ice control operators. The survey remained open for two weeks and received 40 responses. Survey results were incorporated into the best practices manual and used to identify additional topics for discussion in the manual. Survey results can be found in the Appendices of the Snow and Ice Control Environmental Best Management Practices Manual.

Individuals identified in the survey based on their responses were then interviewed. Six interviews were conducted with practitioners from the City of Grandview, Missouri, Kansas DOT, Maine DOT, Pennsylvania Turnpike, Rhode Island DOT, and Virginia DOT. The interviews were developed into Case Studies that were incorporated into the manual and can be found in the Appendices of the Snow and Ice Control Environmental Best Management Practices Manual.

Task 3 Approach: Analysis of Tasks 1 & 2

For this task, the research team's approach was to analyze the information gathered in Tasks 1 and 2. The information was organized by the identified impacts and environmental best practices presented in each document found in the literature search, using information gained from the survey and interview responses, as well as input from the Project Panel. The information was organized into tables that presented the specific impacts, performance characteristics, and environmental best practices for each snow and ice control product. The results of this task were incorporated into the best practices manual.

Task 4 Approach: Development of a Best Management Practices Manual

For this task, the research team's approach was to develop a user-friendly manual that assesses and communicates the impacts of different snow and ice control products as well as the current environmental best practices for using chlorides in a responsible and affordable snow and ice control program. This manual was designed to serve as a “living document” that can be readily implemented and updated after the completion of this project. The audience for this manual will be winter maintenance field supervisors or managers, with a focus on modifying or improving upon existing practices. The content was designed to address proactive strategies and highlight their effectiveness, limitations, and other considerations, and specific recommendations for implementation; but also addresses some key reactive strategies. The intent of the manual is to facilitate the adoption of the identified best practices into mainstream use by the intended audience.

Task 5 Approach: Final Report and Presentation

For this task, the research team’s approach was to prepare a final report of the work completed, including an executive summary, introduction, methodology, results for each task, the user’s manual, and concluding remarks. The review procedures called for the Clear Roads Technical Advisory Committee to review and provide feedback on a draft report, prior to preparation of a final report according to Minnesota DOT template guidelines.

The research team’s approach also included coordinating a meeting with the TAC to present the draft final report findings, and preparing a PowerPoint™ to support presentations at conferences or national and regional meetings by Clear Roads members.

Task 6 Approach: Convert the Final Report to a Web Document

For this task, the research team’s approach was to convert the Final Report and/or best practices manual to a web document. The review procedures called for the Clear Roads Technical Advisory Committee to review and provide feedback on a draft report, so than any requested changes can be incorporated into the final draft document. The final draft document will be provided to the Clear Roads Technical Advisory Committee and Minnesota DOT as a pdf based document for posting on the web.

Chapter 3
Task Results

This chapter describes the results of each of the six primary tasks.

Task 1 Results: Analyze and Review Research

The research team compiled, reviewed, and analyzed available literature on the impacts of chemical deicers and abrasives and their associated impacts to air, surface and ground water, roadside soils, flora and fauna, cost-effective equipment, practices and strategies that allow snow and ice control operators to use the right amount of material in the right place at the right time, in an effort to achieve the "Triple Bottom line" of sustainability (economy, social, and environmental). The literature search was conducted to document the state of the practice and the state of the art related to this project, with a focus on recent literature and literature useful for developing the best practices manual, specifically the identification of environmental best practices that can be applied to snow and ice control operations.

Recent research conducted by international sources was reviewed wherever available, along with the ongoing research and existing documents published by the Clear Roads, Aurora, and Pacific Northwest Snowfighters (PNS), the Transportation Association of Canada (TAC), university transportation centers (UTCs), the Strategic Highway Research Program (SHRP), Federal Highway Administration (FHWA), National Cooperative Highway Research Program (NCHRP) and Airport Cooperative Research Program (ACRP), the American Public Works Association (APWA), (AASHTO), relevant state and local transportation agencies (city and county), the Environmental Protection Agency (US EPA), state Departments of Environmental Quality (DEQ), National Association of County Engineers (NACE), automotive/trucking industry, DOTs, and other key agencies and organizations.

The research team conducted keyword searchers of several databases to gather relevant information including:

- Google (https://www.google.com)
- Google Scholar (http://www.scholar.google.com)
- ScienceDirect (http://www.sciencedirect.com/)
- Engineering Village (http://www.engineeringvillage.com/search/quick.url)
- TRID (http://trid.trb.org/)
- NACE (http://www.countyengineers.org/Pages/default.aspx)
- SCIFinder Scholar (http://www.cas.org/SCIFINDER/SCHOLAR/)
- Patent Office (http://patft.uspto.gov/netahtml/PTO/search-adv.htm) or Google Patents
- Montana State University Library (http://www.lib.montana.edu/)

Through the review and analysis, the team identified extensive and up-to-date information for inclusion in the manual, and identified information gaps to be addressed in the survey. The literature review was submitted to the Clear Roads Technical Advisory Committee for review and comment, and a revised literature review submitted that addressed these comments. The results of the literature were used to develop the content of the Snow and Ice Control Environmental Best Management Practices Manual.

Task 2 Results: Survey and Interviews

The research team developed a survey questionnaire that targeted identified experts at state and local agencies to gather their experience with various materials, equipment and technology, and strategies and techniques used for cost-effective and environmentally responsible snow and ice control operations. The survey targeted snow and ice control professionals and operators with a goal of capturing information on the current state-of-the-practice, best practices, and lesson learned in areas of environmental management and best practices used in snow and ice operations. The survey targeted Clear Roads member states, as well as U.S. and international snow and ice control programs. The survey was designed and distributed to gather input from various winter highway maintenance agencies and professionals in an effort to capture the experience of these practitioners in the cost-effective and environmentally responsible management of snow and ice control operations.

The survey questionnaire was reviewed by the Clear Roads Technical Advisory Committee, and then placed in an online survey tool and tested. Following testing, the survey was distributed to Clear Roads member states, posted on the AASHTO Snow and Ice Listserv, and the Winter Maintenance & Effects LinkedIn group, as well as to individuals and organization identified in the literature search. The survey was open for two weeks and received 40 responses. Survey results were incorporated into the best practices manual and were used to identify additional topics for discussion in the manual. The survey questionnaire and results can be found in the Appendices of the Snow and Ice Control Environmental Best Management Practices Manual.

Following analysis of the survey results, individuals were identified for participation in follow-up interviews. Interviews were conducted over the phone. The interviews were incorporated into the manual and developed into stand-alone case studies. Six interviews were conducted with practitioners from the City of Grandview, Missouri, Kansas DOT, Maine DOT, Pennsylvania Turnpike, Rhode Island DOT, and Virginia DOT. The interviews were developed into the following Case Studies:

- Establishing LOS Standards and Prioritizing Routes
- Adjusting the Time of Attach using Pre-wetting
- Material Storage and Good Housekeeping
- Brine Storage
- Closed Loop Spreaders
- Retention Pond Use and Maintenance
- Stockpile Academy

The information presented in the Case Studies has been incorporated into the manual and can be found in the Appendices of the Snow and Ice Control Environmental Best Management Practices Manual.

Task 3 Results: Analysis of Task 1 & 2

For this task the research team processed the information gain from the literature review and survey into easy to use at a glance tables used in the manual. The information was organized by the identified impacts and environmental best practices presented in each document found in the literature search, using information gained from the survey and interview responses, as well as input from the Project Panel. The information was organized into tables that presented information by product type – chlorides, acetates, formats, glycols, glycerins, and ag- or organically derived additives; the quantifiable impacts, performance characteristics, application strategies, functional temperature range, costs, performance, and environmental impacts.

The developed tables were submitted to the Clear Roads Technical Advisory Committee for review and comment. The tables were then revised based on TAC feedback and resubmitted. The information tables have been incorporated into the Snow and Ice Control Environmental Best Management Practices Manual.

Task 4 Results: Develop a Manual

Utilizing the information and research compiled from the previous three tasks, the research team produced the best practices manual, entitled *Snow and Ice Control Environmental Best Management Practices Manual*.

The format of the final manual includes the following components:

- Introduction and Summary of Survey Results
- Level of Service and Measuring and Quantifying LOS
- Environmental Management Tools including a review of environmental management systems and environmental performance management
- Training and specifically snow and ice control training programs
- Monitoring and Keeping Records
- Snow and Ice Control Materials including abrasives, chlorides, acetate and formats, glycol and glycerin, and organically and ag-based
- Facility Management including material storage, loading, and handling, securing stockpiles, and yard and drainage clean-up
- Operations Strategies including snow removal, and loading, hauling, and dumping snow
- The When, Why, and How of Material Selection presenting information on solids and pre-wetting solids, liquid chemicals, and abrasives
- Material application equipment including solid material spreaders, liquid application equipment, spreader controls, and fully automated spreading systems.
- Equipment Calibration
- Vehicle Washing
- Corrosion Prevention
- Weather and Pavement Equipment and Technology including RWIS, MDSS, and FAST
- Sensors to Improve Snow and Ice Control Operations including friction, salinity, pavement temperature and thermal mapping, freezing point and ice-presence sensors, and MWRS, LIDAR, and LRSS
- Smart Snowplows
- Mid-Storm Adjustments
- Post-Storm Operations including sweeping operations
- Summary of Winter Maintenance Environmental BMPs

- Conclusions and Recommendations

The manual has been provided as a stand-alone document.

Task 5 Results: Final Report and Presentation

This document has been prepared and submitted as the final report for this project. The contents include all the components called for in the approach.

The information presented in the manual and final report has been developed into a PowerPoint™ presentation for use by Clear Roads. The PowerPoint™ presentation has been submitted to the Clear Roads TAC, and is included in this report Appendices.

The meeting with the TAC will be scheduled upon approval of this report.

Task 6 Results: Convert the Final Report to a Web Document

Pending final approval of the manual and final report, the documents will be converted into pdf files and submitted to the Clear Roads TAC and Minnesota DOT for posting on the web.

Chapter 4
Conclusion and Recommendations

Agencies responsible for snow and ice control on public highways, roads and streets have a clear mandate to keep the surface transportation system functionally safe and mobile. Plowing alone cannot meet that charge; de-icing materials and abrasives for enhanced traction are needed as well and usually in large quantities. Rock salt has been the most commonly used de-icer and that will continue for the foreseeable future. However, growing concerns about the potential adverse effects of salt, calcium chloride and other chemicals on the natural and built environment - soil, vegetation, wildlife, surface and ground water, air, pavement, metal infrastructure components, and vehicles- must be addressed. This topic has been extensively researched and will continue to be in the future. Studies substantiate that deicing materials can and do cause problems. Some effects are readily evident such as roadside vegetation "burned' by chlorides and rusting and corrosion of metal bridge components and sign, signal and light poles next to the roadways. Determining the negative impacts on wildlife, water and air requires more empirical measurement, particularly as to the long-term residual effects. Corroborating those findings with actual usage of specific de-icers and abrasives may be problematic in "real-world" situations and subject to challenge and dispute by the industry. Nonetheless, there is sufficient body of knowledge based on research and practical experience to unequivocally state that such materials must be better selected and used not only for environmental reasons but for economy, efficiency and effectiveness. The old days and old ways of literally dumping salt on a road through an open tailgate are over.

Winter roadway maintenance operations is viewed through an entirely different paradigm now; managers must meet the higher expectations of the public as there are more vehicles and more miles traveled per motorist than before as our nation continues to be increasingly dependent on the automobile. Concurrently, managers must contend with constrained funding, both in operational and capital budgets; unit costs for materials, fuel, personnel and equipment maintenance increase annually but funding often does not keep the same pace. Additionally, they must comply with more environmental and workplace regulations and mandates. Considering all of the above, managers must find improved ways to provide snow and ice control.

The following recommendations for consideration and future research were developed based on identified research gaps and needs from the literature, survey and follow-up interivews.

- Levels of Service and related policies: providing reasonable and feasible snow and ice control based upon defined priorities and classifications, and road user expectations.
- General strategies and tactics: route optimization; weather forecasting; activation; anti-icing (pre-treatment of roads); timing of treatment;
- Materials (selection): determining what is best for specific conditions; affordability and availability; adverse properties;
- Application rates: minimal but most effective;
- Equipment: plows and spreaders; calibration; techniques; clean-up after a storm;
- Personnel (including contractors): training ,quality control;
- Facilities: proper storage, handling and containment;
- External mitigation methods: street sweeping, detention basins, roadway design

Appendix A: Power Point Presentation

Snow and Ice Control Environmental Best Management Practices Manual

Laura Fay, Dave Bergner, and Marie Venner

Outline

- Introduction
- Environmental Practices to incorporate into Snow and Ice Control Operations
- Summary of Snow and Ice Control Environmental BMPs
- Conclusions

Introduction

- The objective of this project was to analyze and make comparisons of the impacts of abrasives, chlorides, acetates, formates, glycerols, glycols, and organic by-products; and to compile the current environmental best practices for using chlorides in snow and ice control operations.

Introduction

- This report documented currently available knowledge of cost-effective equipment, practices and strategies that allow winter maintenance professionals to use the right amount of material in the right place at the right time, in an effort to achieve the "Triple Bottom line" of sustainability (economy, social, and environmental).

Level of Service (LOS) - The type of metric used to determine how a road is maintained using winter maintenance practices.

- Commonly used LOS in winter maintenance operations:
  - When snow and ice control begins,
  - Cycle-time to complete one pass on a route,
  - Pavement condition achieved (e.g., bare pavement, clear wheel paths, etc.)
  - A road condition achieved within a specified time after the storm ends.
  - A specified travel speed is achieved,
  - Measured friction values are within an acceptable range.

LOS Continued

- There is no universally accepted or established standard for winter maintenance LOS; but there are suggested guidelines.
- *Bare pavement*, and *bare pavement in the center of the roadway only are* the most commonly used LOS metrics for highways, primary and secondary arterials roads, based on survey responses.




Environmental Management Tools

- Tools used to systematically assess which environmental aspects of an operation are most significant, how well controlled they are, and how any adverse environmental impacts should be handled.
- Commonly used EMS:
  - Eco-Management and Audit Scheme (EMAS)
  - ISO 14001
  - Environmental Performance Management
    - Context Sensitive Design or Solutions, Triple Bottom Line

EMS continued

- Identified Benefits of using an EMS:
  - Reduction in number, type, and severity of compliance incidents.
  - Pollutions and waste reduction
  - Recovered resources
  - Streamlined permit and documentation review and approval
  - More efficient management at all levels
  - Increased environmental awareness
  - Facilitation of “good housekeeping” practices
  - Employee training
  - Corrective action tool
  - Cost savings
  - Positive public relations

Triple Bottom Line

Training

- The importance of training cannot be overstated as the success of any best practice (management system, strategy, technology, or product) hinges on the appropriate implementation by knowledgeable personnel.

Training Continued

- Benefits of improved or target training of winter maintenance personnel:
  - Reduction in the amount of snow and ice control products used while maintaining or increase LOS provided through:
    - Calibration training
    - Salt Smart Principles
    - Application rate
    - Impacts of over applications

Monitoring and Keeping Records

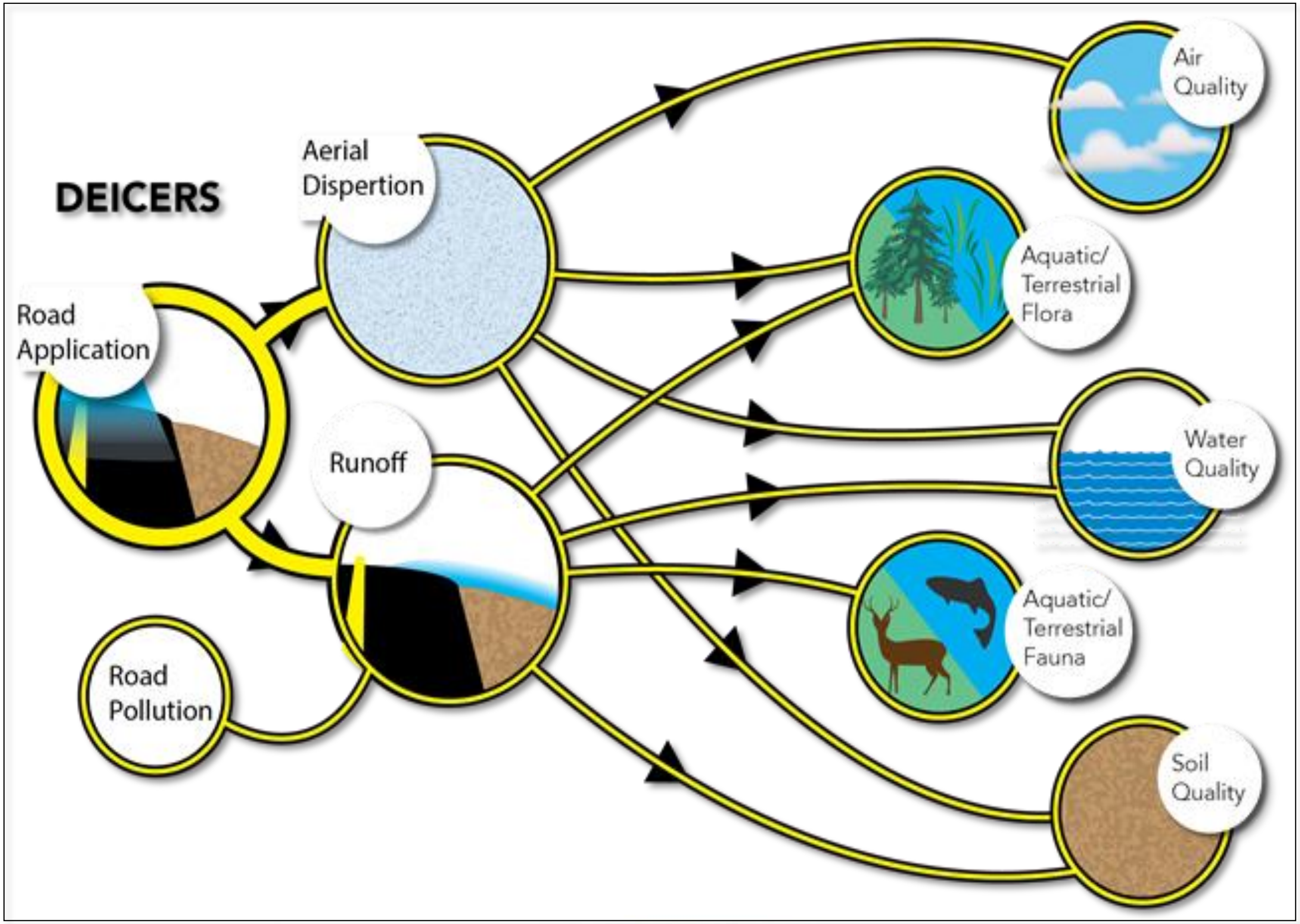
- Monitoring environmental parameters and practicing effective record management of snow and ice control products and related procedures can aid in:
  – materials savings,
  – create a more effective working environment,
  – increase efficiency,
  – reduce person and equipment hours,
  – and enable cost savings.

Snow and Ice Control Materials

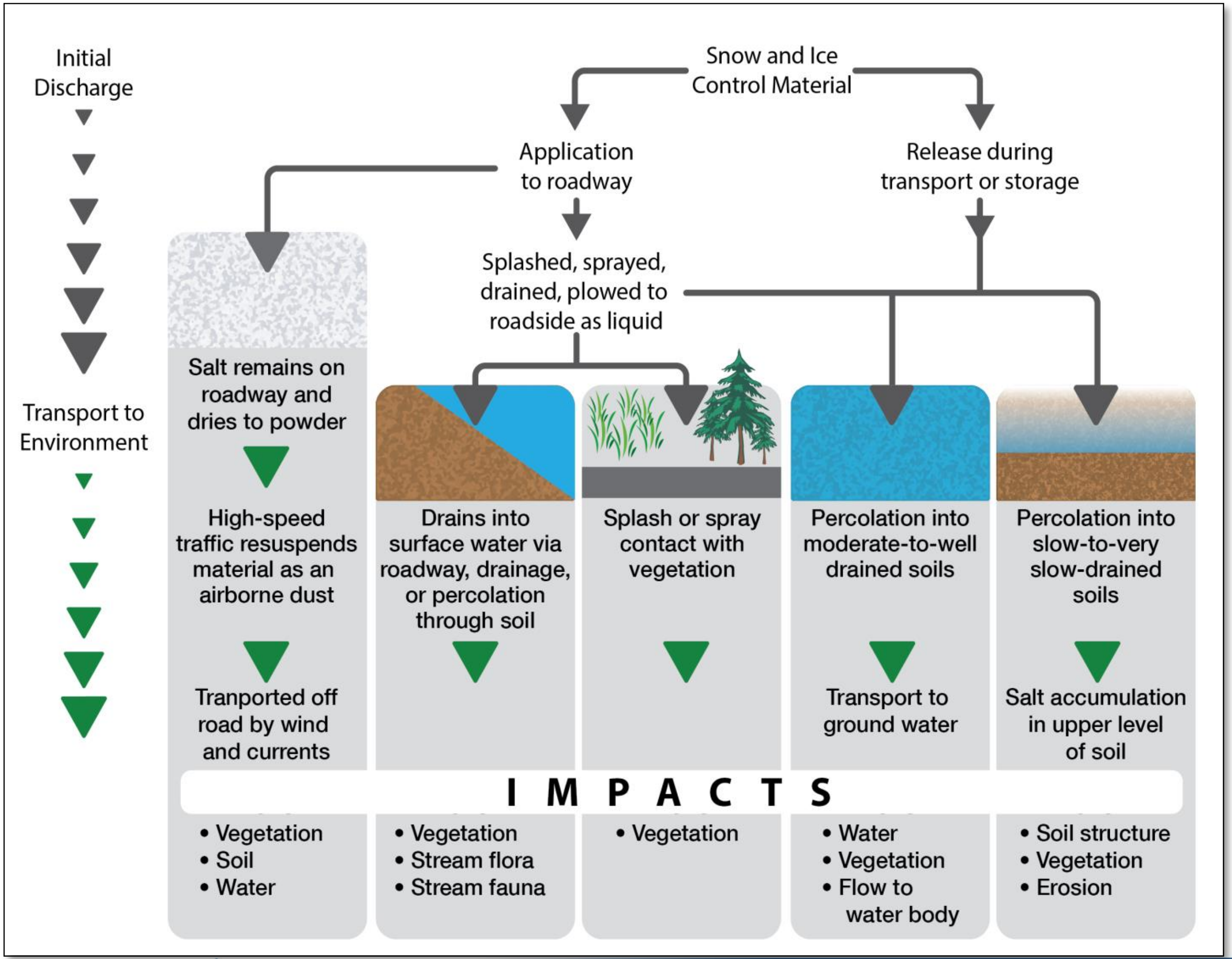
- Sand
- Treated sand (sand + 10% salt (s,l))
- Chlorides – $NaCl$, $MgCl_2$, $CaCl_2$ (s,l)
- Ag-based – beet, corn (l)
- Acetates & formates (s,l), glycols (l) & glycerin (l)



Pathway of deicer migration into and movement within the environment



Environmental pathway model of Snow and Ice Control Products



Facility Management

- The design and operation of maintenance facilities can have a direct influence on potential contamination issues and loss of materials.
- “Good housekeeping” – clean, organized, and well maintained.




Facility Management – Material Storage

- Snow and ice control product storage facilities have the greatest potential to impact the environment, because they are a single source that can release high concentration runoff into the environment.

- Solids – Covered, impermeable surface.
- Liquids – Secondary containment, impermeable surface.

Facility Management – Loading and Handling

- Handle product as few times as possible.
- Load and unload in buildings as much as is possible, or on an impermeable pad.
- Loaders, conveyers
- Clean-up any spills as soon as is possible.
- Capture runoff from loading areas when snow and ice control products are being used.
- Dispose of runoff properly or recycle it!

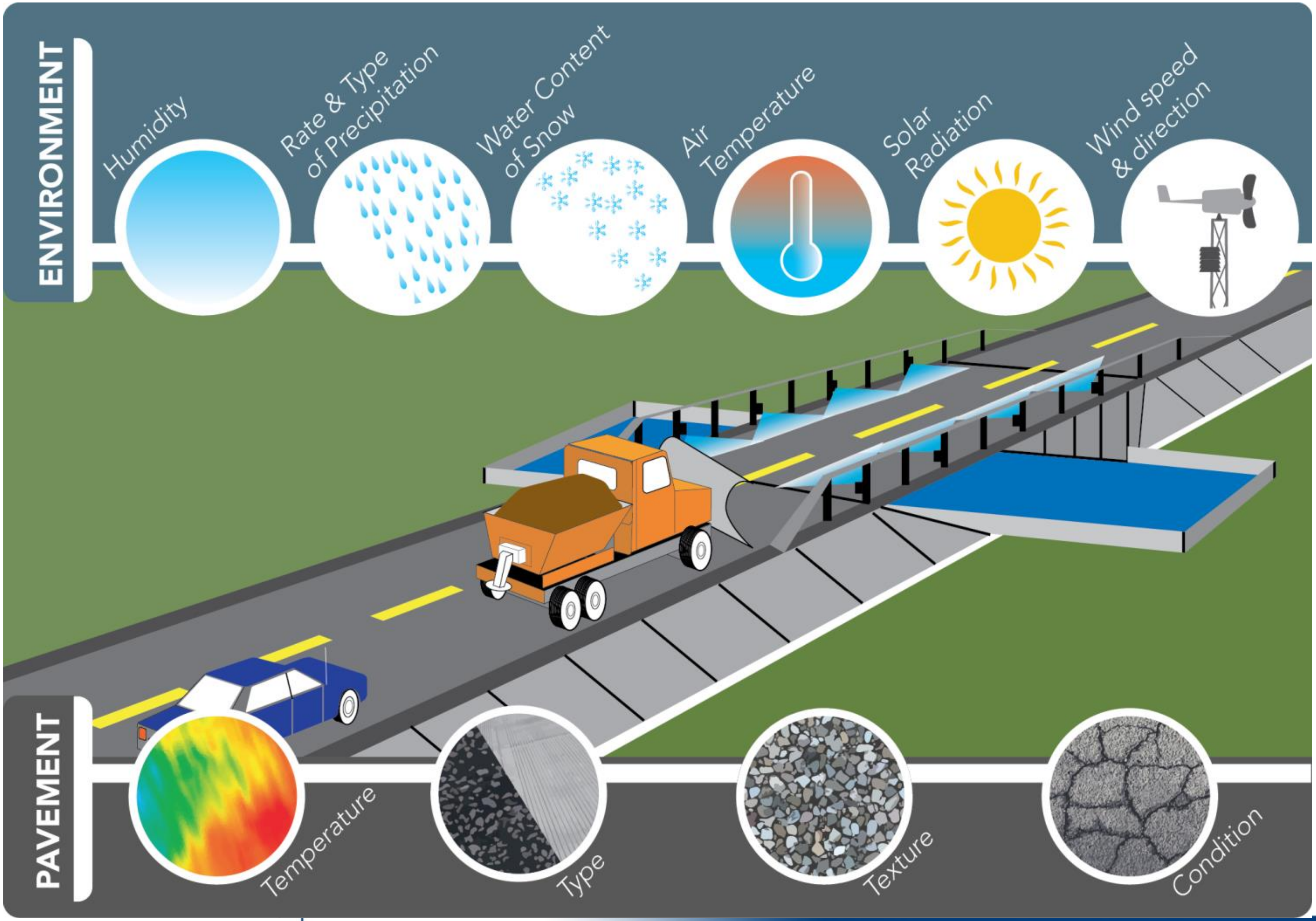
Operational Strategies

- Snow Removal – Plowing
  - the mechanical removal of snow and ice from roadways.
- The use of efficient snow removal can lead to cost saving, a reduction in the use of deicing materials, and improved pavement conditions.

Material Selection

- Selecting the most effective snow and ice control material:
  - for a given road weather scenario,
  - the most efficient application method to minimize loss of material, costs, application rates, and frequency of applications.

Relevant parameters for material selection



Pre-Wetting Solid Material

Adding liquid to products or abrasives at the stockpile or at the spreader.

- Benefits
  - Eases product management and distribution
  - Accelerates breakup of snow/ice and enhances melting
  - Minimizes bounce and scatter, improves performance
  - Increases longevity on road = less frequent applications

Anti-icing

"the snow and ice control practice of prevent the formation or development of bonded snow and ice by timely applications of a chemical freezing-point depressant"

- ↑ LOS, ↓ product, abrasives & plowing
- 10 – 40 gal/l-m
- Cost savings, ↑ mobility & safety
- Side benefit of reducing impacts to the environment, infrastructure, and vehicles.
- Limitations:
  - Cold temps, rain/sleet, blowing snow, air temp above freezing and rising, high humidity

Product Application Rates

- Sand – 100 to 1000 lbs/l-m (32°F and colder)
- Salt/sand – 400 to 1000 lbs/l-m (32 to 0°F)
- NaCl (32 to 15°F)
  - solid – 100 to 800 lbs/l-m
  - liquid – 10 to 40 gal/l-m
  - pre-wet – 8 to 20 gal/l-m
- $MgCl_2$ (32 to -5°F) and $CaCl_2$ (32 to -15°F)
  - solid – 100 to 500 lbs/l-m
  - liquid – 10 to 40 gal/l-m
  - pre-wet – 8 to 20 gal/l-m

Material Application Equipment

- Material distribution systems allow for application of the right amount of materials, in the right location, at the right time.
- Newly purchased vehicles have enhanced capabilities to improve treatment efficiency and or reduce material usage



Material Application Equipment

- Tailgate Spreaders & Reverse dumping
- Multipurpose spreaders
- Rear Discharge Spreaders
- Zero velocity spreaders
- Dual spinners
- Spinner
- Modified spinners
- Homemade chutes

<u>Challenges</u>

- Mechanical failure
- Clogging & freezing
- Corrosion
- Frequently calibration

Tailgate Spreaders and Reverse Dumping of Dual Dump Spreaders

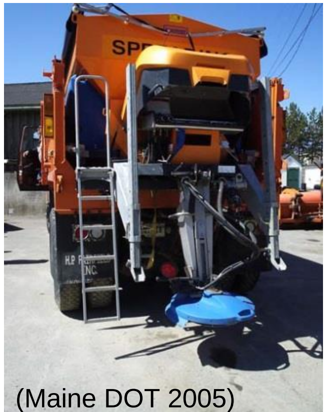
- Benefit
  - Multipurpose spreader that can be used year round
- Challenge
  - Heavy
  - Need to raise body, reduced stability

Rear-Discharge Spreaders

- Designed to pre-wet, fine grained salt
- Pre-wet at: spinner, hopper using auger, or both.
- Allow for “high-ratio” or “slurry” salt application
  – 30:70 liquid-to-solid by weight
- Requires large capacity liquid tanks and adequate pumping

Slurry Technology

- High volume liquid anti-icer to dry salt (30%:70%) ~ 60-90 gal/ton
- 200 lb/l-m = ~ 9 gal
- Oatmeal consistency, salt grains fully saturated
- Slurry auger and at spinner


(Maine DOT 2005)

Slurry Technology Contd.

- Lesson Learned
  - ¾ in salt allowed but smaller grains work better.
  - Start with a heavier application, followed by smaller
  - Some equipment has worked better than others
    - Pumps, on board crushers, overall equipment design/functionality
- Material and cost savings (Maine DOT 2005)
- Anecdotal comments:
  - Goes into action quicker, acts immediately, lasts longer on road, out-perform traditional pre-wetting methods, minimizes bounce and scatter.

Rearward Casting Spreaders (Ground-Speed and Zero-Velocity Spreaders)

- Material is discharged rearward at the same speed as the spreading vehicle is traveling forward.
- Keeps more material on the road where it was placed.
- Application speeds should not exceed 35 mph, higher speeds reduce application accuracy.

Electronic Spreader Controls

- Pre-set or on-demand application rates
- Use electronic ground speed controls to provide consistent application rates.
- Can be linked with sensors (e.g. friction, AVL, GPS)
- Modern units can record information about
  - Application rate, gate position, run time, blast information, avg. spread width/symmetry.

Equipment Calibration

- Is a must
- Why: to realize savings gained from investment in new technology
- Train how to calibrate & keep records
- When to calibrate:
  - When first acquired, points throughout a season, whenever a new material is used, after repairs, if there appears to be discrepancy in material usage

Vehicle Washing

- Low pressure, high volume wash to remove salt and abrasives.
- Wash vehicles indoors or where water can be contained.
- Properly dispose of wash water or reuse for brine production.

Corrosion Prevention

- Corrosion prevention programs may involve:
  - use of salt removers (neutralizers) together with routine washing;
  - Protecting of electrical components by sealing or moving them to inside the cab;
  - reapplication of post-assembly coatings;
  - spray-on corrosion inhibitors
  - operational changes supplemented by corrective maintenance practices to minimize the negative impact of deicer corrosion to equipment asset.
- Track data relevant to direct costs of deicer corrosion to equipment and direct benefits of countermeasures.
- Ensure compliance with procedures and practices for vehicle inspection and operation, and staff and contractor training.

Weather and Pavement Equipment and Technology

RWIS – Road Weather Information Systems

MDSS – Maintenance Decision Support Systems

FAST – Fixed Automated Spray Technology

RWIS

Real-time road condition information

- Used to time treatments and determine which treatments to use
- Benefits:
  - ↑LOS
  - Cost savings
  - Aid in maintenance response
  - ↑Efficiency
- Cost-benefit ratio : 1.4 to 11

Road Weather Management Decision Support (MDSS)

Tools that integrate road weather forecasts, coded maintenance rules of practice, resource data to provide recommended treatment strategies (FHWA 2011)

- Software application, weather forecast and predictions, road weather reports, training tools.
- Benefits:
  - Cost and material savings, benefit-cost: 1.33 to 8.67, less use of vehicles
- Lessons learned:
  - Time needed to refine forecast & get management on board, continued training and exposure

FAST

- Benefits
  - Reduced mobile operations
  - Reduced crash frequency & delay
  - Less material required
- Challenges
  - Activation frequency
  - System maintenance & training

**Installation should be site specific.*

Friction Measurements

- Indicator of road condition
- Monitoring, planning, treatment strategy, prevent over application
- Friction to assess Performance Measures (CDOT)
  - Non-contract friction measurements
  - Noticed difference in products performance
  - Provide good short/long term assessment of product performance

Residual Chemical Measurement

Salinity sensors have been used to make educated decisions about reapplication (Ye et al., 2012).

- Monitor road surface product concentration
- On-vehicle, embedded, or non-contact
- Accurate/recalibrated application rates
- Link measurements with automatic spreader controls
- Benefits:
  - Prevents over application, saves material and $$$

Pavement Sensors & Thermal Mapping

www.vaisala.com

Maine DOT

- Monitoring, planning, treatment strategies, forecasting
- Invasive and non-invasive

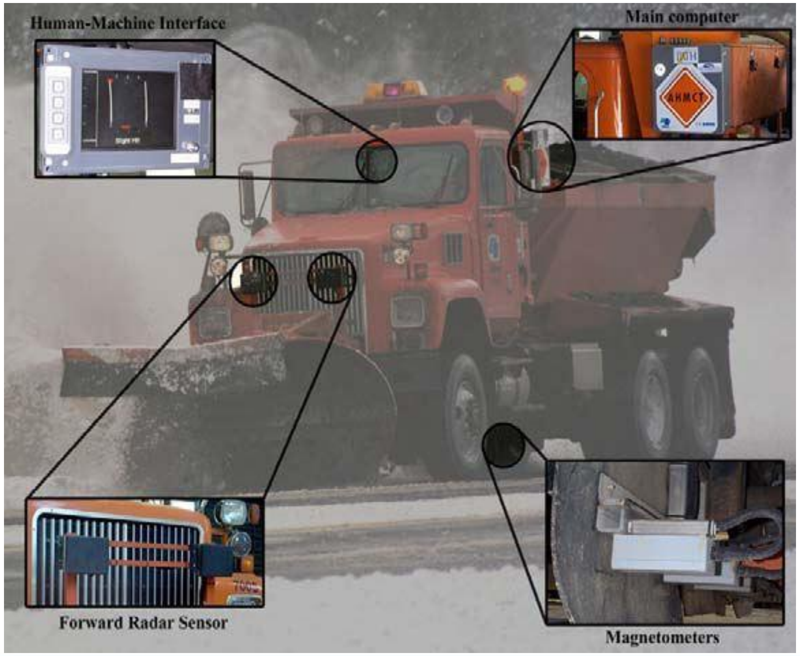
www.enterpriseflasher.com

www.cbc.ca

www.bangordailynew.com

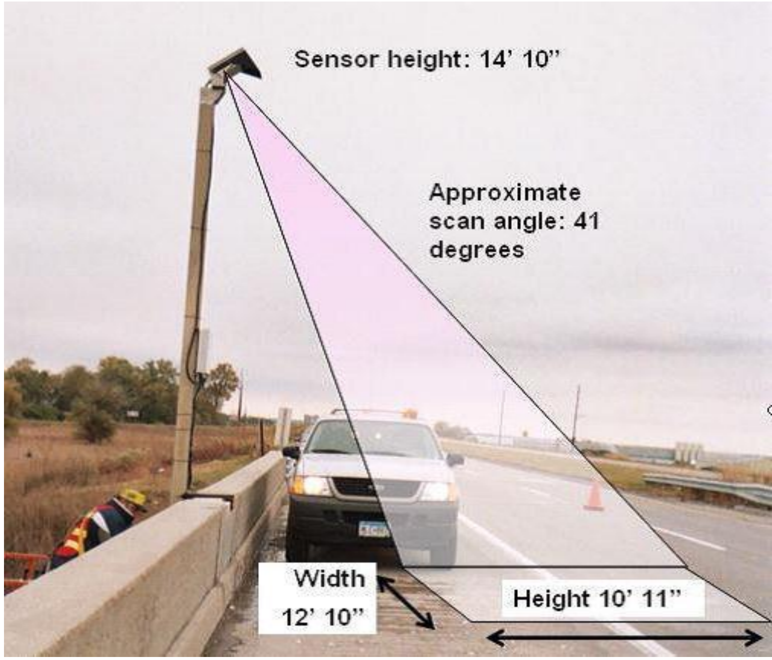
Millimeter Wave Radar Sensor (MWRS)

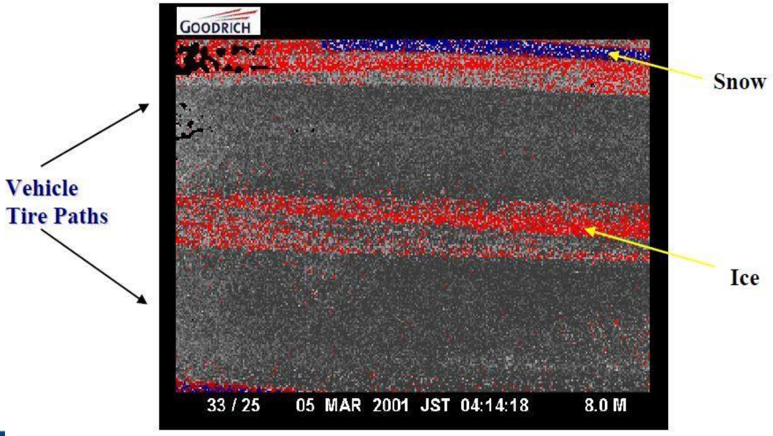
- MWRS technology is used to assist snowplow and vehicle operators in their ability to detect objects, located in front, to the side, or behind the vehicle.
- MWRS is the most promising Collision Warning System (CWS) in use.



Laser-Wavelength Road Condition Sensor (LRSS)

- A non-invasive sensor that detects road surface conditions:
  - dry, snowy, icy, or wet areas
  - Reports percent areas for each condition.





Smart Snowplows

- The integration of available technology for snow plows with winter maintenance operations to create a trackable, automated system.

Post-Storm Operations

- Continue maintenance to achieve LOS.
- Asses current conditions and prepare for forecasted conditions.
- Pavement sweeping, clean out ditches, catchments, and culverts.

Summary of Environmental BMPs for Snow and Ice Control

- Cover and store snow and ice control materials on an impermeable surface, secondary containment for liquids.
- Regulate the application of snow and ice control materials to prevent over application.
- Use specialized equipment to apply the right amount, in the right place, at the right time.

Summary of Environmental BMPs for Snow and Ice Control

- Use the appropriate snow and ice control materials for the given conditions.
- Calibrate equipment.
- Train operators in proper application, calibration, and cleaning procedures.
- “Good housekeeping” – clean, organized and well maintained.

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Questions?

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research for winter highway maintenance

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