

1 **DEVELOPING A “TOP TEN LIST” FOR WINTER HIGHWAY MAINTENANCE**

2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Wilfrid A. Nixon, Corresponding Author

IIHR Hydroscience and Engineering

Department of Civil and Environmental Engineering

University of Iowa

Iowa City, IA 52242

Tel: 319-335-5166; Fax: 319-335-5660; Email: Wilfrid-nixon@uiowa.edu

Richard Nelson

AASHTO SICOP Coordinator

2540 Henning Lane

Minden, NV 89423

Tel: 775-230-6928; Email: ricknelson.engr@gmail.com

Word Count: 2,613 words text + 14 Tables/Figures x 250 words (each) = 6,113 words

26 **ABSTRACT**

27 The winter maintenance community has used many methods in the past decade to determine
28 research needs, including peer exchange meetings, an email list serve, and an NCHRP 20-7
29 project that identified Grand Challenges. This is in addition to annual, biannual, and quadrennial
30 scientific meetings at which new research results are presented and discussed. However, at the
31 most recent peer exchange meeting, held in September 2013, the question was raised as to
32 whether there might be research issues that had not been discussed, as well as how such issues
33 might be identified and how those who had not been involved in the research needs discussion
34 might be included.

35 A two part approach was taken to address this potential shortcoming in the winter
36 maintenance research needs identification process. First, the list serve was used to poll ideas for
37 a top ten list of research needs. The same message used for the list serve was also sent to others
38 in the International winter maintenance community, including members of the PIARC
39 (Permanent International Association of Road Congresses) 2.4 working group. This generated a
40 list of 181 ideas which were reviewed by the AASHTO Winter Maintenance Technical Services
41 Program (WMTSP) Steering Committee. Committee members selected their top choices, and in
42 addition, 74 of the ideas were used in an online survey to gather input from a broader audience.
43 The online survey generated a top ten list of 11 ideas (two of them got identical scores) which
44 are presented herein.

45

46 *Keywords: Winter Maintenance; Research Needs; Sustainability*

47

48 **INTRODUCTION**

49 There are many ways that a community of practice can determine future directions. In the area of
50 winter maintenance, a variety of methods have been tried over the past two decades, with
51 significant success. In fall 2013, a new approach was undertaken to determine the major issues
52 that need to be addressed for the winter highway maintenance community to have the most
53 effective and efficient tool kit available to provide safe and efficient transportation to the
54 traveling public during winter weather events.

55 Winter weather impacts most of the United States, although in any given year the impacts
56 in some states will vary significantly. The 2013-14 winter was particularly severe for the Eastern
57 and parts of the Midwest United States. The length and severity of the winter made it clear that
58 there is an ongoing need for new approaches in winter maintenance, and thus there is a need for
59 the community of practice in winter maintenance to determine which areas should be key focus
60 points in developing new knowledge. This raises a challenge: what is the best way to determine
61 what those key focus points should be?

62 This issue of how to determine key focus areas for winter maintenance has been much
63 discussed [see e.g. 1]. A major part of the discussion was the establishment of a forum through
64 which the community could hold meaningful conversations about pertinent issues, which was
65 done through the establishment of a list-serve (the snow and ice list-serve: address here) in 1997
66 [2]. The list-serve remains active today and has more than 600 subscribers at this time.

67
68 **TABLE 1 Winter Maintenance Related Scientific Meetings**
69

Meeting	Frequency
TRB International Symposium on Snow Removal and Ice Control Technology	Every 4 Years
PIARC (Permanent International Association of Road Congresses) Winter Road Congress	Every 4 Years
SIRWEC (Standing International Road Weather Conference)	Every 2 Years
TRB Equipment Management Conference	Every 2 Years
TRB Annual Meeting	Every Year

70
71 The list-serve was in addition to more traditional means of discussion which included a
72 variety of scientific meetings as indicated in Table 1. More recent events that have allowed the
73 discussion to develop and focus included biannual peer exchange meetings and a workshop that
74 produced a “Grand Challenges” document [3]. The peer exchange is facilitated with funding
75 from pooled fund studies, and the outcomes are made available to the whole community [4].
76 Further, the research needs identified at the peer exchange are handed off to one of four entities
77 that have been identified as being able to move a given research need forward. These four areas
78 include three pooled fund efforts (the Winter Maintenance Technical Services Program -
79 WMTSP [5], the Clear Roads pooled fund [6], and the Aurora pooled fund [7]). The fourth entity
80 is the Transportation Research Board Committee on Winter Highway Maintenance, AHD65 [8].
81 Progress on the research needs identified at any given peer exchange meeting gets reported upon
82 at the next meeting.

83 In addition to the peer exchange program, in 2010 an NCHRP 20-7 project was approved
84 to identify major challenges for the winter highway maintenance community, as indicated above
85 [3]. The report from this workshop identified six Grand Challenges for winter maintenance:

86 recruiting, development and retention of the winter maintenance workforce; developing
 87 comprehensive communications capabilities; increasing the recognition of the value of winter
 88 maintenance; systems management for a consistent and reliable network; balancing social,
 89 environmental, and economic factors; and new technology for winter maintenance. This report
 90 and these challenges have been used to inform the peer exchange meetings since 2010 and have
 91 provided valuable focus for the peer exchange efforts.

92 Given all these various activities, it would seem that the issue of determining future
 93 directions was well handled in the winter maintenance field. However, one identified
 94 shortcoming of all these approaches was that the number of people involved in the discussions
 95 was relatively small and the breadth of experience, as opposed to the depth which was
 96 significant, was not as large as it could have been. This issue was raised at the most recent peer
 97 exchange meeting (September 2013) and as a result, steps were taken to try and reach out to a
 98 broader community and determine any unmet or unidentified needs. The purpose of this paper is
 99 to describe the process whereby this reaching out was conducted and to present the results of this
 100 process.

101 **PROCESS**

102 As indicated above, a discussion on the Steering Committee of the WMTSP at the winter
 103 maintenance peer exchange meeting in September 2013 raised the concern that perhaps a broader
 104 field of winter maintenance professionals should be polled about the needs of the winter
 105 maintenance community. In response to this concern, a multi-part process was initiated.

107 **TABLE 2 Top Ten Issues Presented in Initiating Snow and Ice List-Serve Email**

Issues
Pre-wetting
Anti-icing
Calibration
Performance measurement
Levels of service
Pavement temperature
Media relations
Workforce development and training
Sustainable practices
Equipment selection

109

110 The first step in this process was to send out an email to the snow and ice list-serve,
 111 asking the subscribers to the list-serve to share their top ten list of winter maintenance needs. To
 112 start the ball rolling, the initiating email included a top ten list of its own, shown in Table 2.
 113 Thirty responses were received in the first twenty four hours after posting, one of the highest
 114 response rates on the snow and ice list-serve ever, indicating that this was an issue that “touched
 115 a nerve.” Nearly 50 responses in total were received from the list-serve. The request was also
 116 sent to members on the PIARC (Permanent International Association of Road Congresses) 2.4
 117 Working Group and there were an additional 15 responses from there.

118 From these responses an initial listing of 181 different ideas was compiled. Clearly, such
 119 a list was overly long for use on a survey, so it was decided that possible duplicates would be
 120 removed by asking the members of the WMTSP Steering Committee to select between 30 and 50
 121 of the 181 different ideas as being their most important. Eight members of the steering
 122 committee responded (the authors of this paper did not do so, since they felt they had significant
 123 input to the process already). Those topics garnering the most support (selected by four or more
 124 of the eight committee members) are shown in Table 3. Most of the ideas selected were close to
 125 areas that had been the focus of research efforts over the past decade in winter maintenance. The
 126 exception (and one of only two topics to get six votes) was maintenance facility design. It could
 127 be said that at this point the exercise had already shown positive results, since an issue that had
 128 not previously been considered of importance was shown to be of great significance and concern
 129 to the winter maintenance community.

130
 131
 132
 133

TABLE 3 Most Frequently Selected Ideas from the WMTSP Steering Committee Members

Category	Topic	Votes
Chemicals	Liquid blends	5
Decision Support	RWIS data (the standard suite of instruments, plus, camera image and pavement grip)	4
Equipment	Plough & blade technology	5
Innovation	Technology transfer	4
Management	Adequate funding for operations and sustainability	5
Management	Performance measurement (measuring the ability to achieve prescribed levels of service)	4
Media Relations	Media relations (public and political relations)	5
Policy	-Defined levels of service (necessary for performance measurement)	4
Strategy	Maintenance facility design, operation and maintenance (safe and efficient traffic flow, proper storage facilities, indoor operations where possible, good housekeeping practices, drainage management, vehicle washing and wash water runoff management)	6
Tactics	Anti-icing and cold region	4
Tactics	Drift control and snow fence.	5
Tactics	Effective use of liquid de-icers (pre-wetting and anti-icing together)	4
Technology	AVL and automatic data collection from maintenance vehicles about ongoing activities	6
Technology	Measurements of residual road salt	4
Workforce	Staff training	4
Workforce	Trained and experienced decision makers	4
Workforce	Trained and experienced operatives/drivers	4

134
 135

136 **IDENTIFIED ISSUES**

137 Using the results from the review of topics by the steering committee of the WMTSP the list of
 138 topics was reduced to 74 topics in five areas. These are shown in Tables 4 through 8. Using these
 139 five areas, a survey was created [9] using the web tool Survey Monkey. The survey was
 140 constructed to allow users to select a first and second choice in each of five topic areas (the five
 141 areas shown in Table 4 through 8). In this way, each survey taker could select their top ten
 142 topics, although of course the selection was constrained by use of the five topic areas.

143
 144 **TABLE 4 Topics in the Area of Materials, Sustainability, and the Environment (Group A)**
 145

ID #	Topic	Explanation
A01	Corrosion Inhibition	All the chloride deicers have the potential to corrode any steel materials and may also cause corrosion in other materials too (e.g. wiring). The addition of inhibitors can reduce this corrosion, but there are concerns about the extent to which these inhibitors remain with the chlorides in the environment. This item suggests that such inhibitors are very important.
A02	Liquid blends	Some agencies that use liquids (either for direct liquid application or for pre-wetting) use blends of liquids rather than just a straight (primarily single component) brine. An example would be a brine with 85% salt brine, 10% calcium chloride brine and 5% agricultural by-products. These blends may be more persistent on roads and may be more effective at lower temperatures.
A03	Treated salt	Rather than using straight rock salt for their solid application, some agencies treat their salt (typically in the stockpile) by adding a liquid to it, typically at rates of from 2 to 10 gallons per ton. This provides some of the benefits of pre-wetting without the need for pre-wetting equipment and liquid on the truck.
A04	Winter liquid utilization (pre-wetting and anti-icing)	Using liquids for pre-treatment (direct liquid application prior to a storm starting) or for pre-wetting (applying it to solid material as it is being dispensed from the truck) allows levels of service to be attained using much less material than would be needed in a reactive mode.
A05	Strictly controlled use of salt	The purpose of salt in winter maintenance is preventing the bond between the pavement and the snow or ice. Making sure that we get the right amount of salt to the right place at the right time is a critical part of a good winter maintenance program.
A06	Adequate funding for operations and sustainability	No money, no workee! Or, more seriously, a sustainable winter maintenance program requires appropriate long term funding levels.
A07	Proper liquid applications	Liquids (ice control chemicals in liquid form) are extremely effective in some circumstances (e.g. in frost prevention) and ineffective in others (e.g. freezing rain). Knowing when they work and when they don't is critical to getting best results.
A08	Using sustainable winter maintenances practices	Sustainability requires balancing three factors – economics, the environment, and the public need. Building a winter service program around these three legs creates a system that can provide optimal benefits to all.
A09	Environmental Impacts of sodium chloride and regulations	Salt can, if used to excess, create contamination issues in surface water and ground water. Best practices avoid this, and there are also environmental regulations at both State and Federal levels that limit the amount of salt permitted in various natural water systems.

A10	Salt storage	Proper storage of salt minimizes losses, eliminates the possibility of environmental contamination, and allows for easy and efficient loading of trucks during winter storms.
A11	Strategies to avoid environmental damage during extreme winters with extreme use of salt.	Severe winter weather, which may include very heavy snow fall and very cold temperatures, sounds at first like a case for using more salt, but often salting can be reduced under such circumstances without loss in the service provided.
A12	Anti-icing (early treatment or proactive snow and ice control, including direct liquid application)	Studies indicate that it is about four times more efficient to be pro-active with our chemical application (i.e. to anti ice) than to be reactive.
A13	Pre-wetting and use of brine/preventive salting	Pre-wetting salt keeps more of the salt on the road, allows less of it to bounce and scatter into the ditch, and gets the salt working more rapidly when compared to dry salt application.
A14	Application rates	Different pavement temperatures, different storm types, and different cycle times all impact how much salt we need to apply to the road to maintain levels of service.
A15	Strategies for snowfall at temperatures below -10°C (14°F)	When the pavement temperature gets really cold, salt becomes ineffective. Having a plan for what to do then is important.

146

147

TABLE 5 Topics in the Area of Weather and Information (Group B)

ID #	Topic	Explanation
B01	Accurate and timely weather forecast	Especially when anti-icing is being used by an agency, accurate forecasts are critically important and they must be delivered in a timeframe that is appropriate for the agency with regard to staffing decisions.
B02	Effective use of data for decision making	The multiplicity and relatively low costs of sensors mean that we have a lot more data available to us than previously. Having the data is great but only if we can make good use of it in decision making.
B03	Optimal route planning	With limited resources, getting the most out of our trucks is critical. Optimizing routes is one way of doing this.
B04	Good site specific weather forecast.	A weather forecast for a region is OK, but often agencies deal with microclimates and significant variations in weather across their region of responsibility. Site-specific weather forecasts are intended to address this challenge.
B05	Improve winter maintenance support systems (better and more accurate weather data, improving our ability to act before hazardous conditions arise)	Defining and refining the critical information needed to make the optimal winter maintenance decisions.
B06	Improved use of historic weather data in order to identify zones/stretches requiring special attention during certain weather conditions.	Some areas have special weather conditions. By reviewing historical weather data such areas can be identified and special actions taken.
B07	Training maintenance personnel to interpret forecast information appropriately	Maintenance personnel are not meteorologists, but they do need to make use of weather data significantly more complex than just whether it will snow tomorrow.
B08	RWIS data (the standard suite of instruments, plus, camera image and pavement grip)	RWIS can be an extremely valuable and important tool in winter highway maintenance operations, telling us what the actual condition of the road is around a road network.
B09	VAM (Value Added Meteorology)	VAM can provide much more tailored and targeted weather information for an agency thus allowing the agency to make better decisions.
B10	Pavement temperature	The pavement temperature is critical in knowing whether salt (or other chemicals) is going to be effective and in determining how much salt should be applied at a given location.
B11	Network of Weather Sensor Data	A single weather sensor can provide very useful information at one point on a road system, but a network can provide a nearly complete picture of the whole road system.

152
153

TABLE 6 Topics in the Area of Equipment (Group C)

ID #	Topic	Explanation
C01	Equipment and equipment calibration	Having the right equipment to dispense product for a given winter maintenance task is half of the issue. The other half is making sure it is calibrated correctly, so you know what exactly it is doing
C02	Precision salt spreading	Both for reasons of economy and environmental stewardship, it is important to put salt where we need to place it and keep it there. Equipment today can place salt very accurately and effectively.
C03	Equipment maintenance program (preventative and routine)	Making sure that your equipment can perform as needed during a storm requires some sort of program to do both preventative and routine maintenance on that equipment.
C04	Equipment selection (ROI - payback, amortization and depreciation, training, investment in onboard systems to improve performance and maximize use of liquid)	More capable equipment (for example a spreader with the ability to pre-wet and to collect data tied to location on salt distribution) is often more expensive than a traditional spreader. However, that higher up-front cost may be made up by the greater utility of the equipment. Considering such trade-offs is a critical part of winter maintenance equipment selection.
C05	Using more advanced and sophisticated plows & cutting edges	A major key to good winter maintenance is getting the snow and ice off the road. The right plows and cutting edges are critical in getting this done.
C06	Ensuring adequate traction by using the right winter truck tires.	There can be a major problem where trucks are not equipped with suitable tires for winter conditions. A stuck truck does very little in the way of winter maintenance.
C07	Technology transfer	There is new stuff being done all the time that can help with winter maintenance, but if we do not have the right channels in place to learn about the new approaches, nothing will change.
C08	AVL and automatic data collection from maintenance vehicles about ongoing activities	Knowing where your vehicles are, what they are doing, and what the road is like where they are at is a very valuable tool for managing a winter storm.
C09	Development of data acquisition and compilation (from vehicles, RWIS, meteorological information)	Collecting and digesting all the data that are out there could be extremely valuable for winter maintenance practices.
C10	Mobile data collection from vehicles about road surface condition	All sorts of vehicles, not just our plow trucks, are out on the road during a winter storm. Gathering data from them can provide a much more complete picture of our road network condition than just using reports from our trucks.
C11	Pavement temperature measurement	The salt (or other chemical) has to act at the pavement surface to be effective, and the temperature there determines how the salt will perform. It is the single most important weather data point we can have.

154
155

TABLE 7 Topics in the Area of Operations and Tactics (Group D)

ID#	Topic	Explanation
D01	Communication between operation controllers and drivers	Good winter maintenance needs responsiveness to changing conditions during and after a storm and good communications between drivers and supervisors is critical to achieving this.
D02	Quality assurance	If you don't measure it, you cannot improve it. QA provides a system for us to measure and improve what we do in winter maintenance.
D03	Salt management (acquisition, storage, shipping and application)	From when that salt arrives in your yard to when it departs off the road after a storm is over, you need to manage it. You need to measure it, track it, store it, move it from one place to another, dispense it, and keep it on the road where you need it.
D04	Responsiveness.	No winter storm is the same all the way through and it is not just the weather that changes. Traffic changes according to the time of day and may also get backed up because of incidents. The ability to respond well to these changing circumstances is a good measure of an agency's program.
D05	Traffic management	A plow stuck in a traffic jam is not doing much good. So making sure that does not happen is pretty important.
D06	Contracting (outsourcing or insourcing of road winter maintenance)	It is not always efficient to try and do every task in winter maintenance with your own workforce. Do you use contractors? When and why? How should you write the contract? Does it make your service better to have them?
D07	Effectively determine anti-icing decision points and resource allocation.	Anti-icing is a great tool, but knowing when to use it is very important. How much lead time, what degree of uncertainty in the forecast and what resources are available all play a role in figuring out when to use it.
D08	Efficiency in operations - intelligent use of resources	Any agency has a finite number of resources – trucks, people, materials, time. Using those resources in the most efficient way possible is always a key goal.
D09	Innovation	If you do things the way you always have, you will get the results you have always got. If those results aren't good enough then you have to change what you do – you have to innovate.
D10	Maintenance facility design, operation and maintenance	Designing your yard layout so you have safe and efficient traffic flow, proper storage facilities, indoor operations where possible, good housekeeping practices, drainage management, vehicle washing and wash water runoff management can enormously improve efficiency.
D11	Networking – sharing knowledge	Someone, somewhere has almost certainly faced the problem you are facing, so why not learn from their mistakes rather than making your own?
D12	Drift control and snow fence.	In areas that are prone to snow drifting, the use of snow fences gives about a 100 to 1 payback.
D13	Plowing / Mechanical Removal	Getting the snow off the road is a fundamental part of winter maintenance.
D14	Human Factors (training, shift management)	A tired snow plow operator is much more likely to make mistakes than a well-rested one. So too, an ill prepared operator will mess up more often than a well prepared operator.
D15	Morale, Teamwork, Leadership	Getting the job done is a lot easier when your folks feel proud of their work, act as a team, and build strong leadership.
D16	Professionalization of the Snowfighter (respected, emergency services personnel)	Are your operators employees or professional snowfighters? Which way of thinking about themselves and their jobs is likely to be more effective?
D17	Trained and experienced decision makers	All the equipment, materials, and well trained personnel in the world will not help if the wrong decisions are made.

TABLE 8 Topics in the Area of Strategies, Public Relations, and Training (Group E)

ID #	Topic	Explanation
E01	Performance measurement (measuring the ability to achieve prescribed levels of service)	If you don't know where you're going you'll end up somewhere else, and the same is true of performance measurement – what are you trying to do, and did you do it? If you don't know...
E02	Performance measurement (traffic mobility, traffic accidents, residual salt, friction)	There are a variety of tools by which we can measure performance measurement beyond levels of service, such as safety, friction, and traffic mobility. Measuring those factors gives us a real yardstick for winter maintenance.
E03	Planning (contingency planning and emergency response planning)	A plan is where it all starts. Knowing what to do, when, even in an emergency, is extremely important.
E04	Snow plans (Include operational evaluation/continuous improvement)	A detailed plan for an agency is an absolute must and should be the guide for all actions before, during, and after a storm.
E05	Standards in winter-service	What standards are you trying to achieve? Are they the standards your community wants or are you not giving them what they need?
E06	Communication with road users	During really bad storms, the safest place for road users is at home. Letting them know whatr is really going on, so that they believe you, is very important.
E07	Education for the police & public (Social Media)	Winter maintenance requires a lot of different things to work together properly and often the public and police do not realize this. Social media can be a very effective way of getting our message out.
E08	Media relations (public and political relations)	Keeping the media in the loop and fully informed is a very valuable process that really pays dividends during severe weather. Of course, if you only do it then, you are missing the benefit.
E09	Customer oriented maintenance	The road users pay the bills, ultimately, so why don't we treat them as our customers? Doing so can make a big difference.
E10	Defined levels of service	Most agencies are required to provide differing levels of service on different road types. Having those levels of service well defined is a critical part of a winter maintenance program.
E11	Document management and record keeping	If you don't measure it, you can't improve it. And if you don't have a system to manage your records, you'll be in a big mess!
E12	Legal issues	The possibility of a law suit when an accident occurs should not determine our winter maintenance policies biut should certainly be a factor we consider when we develop them.
E13	Multi-Agency Collaboration & Mutual Aid	When your neighbor gets clobbered by a storm do you help them? And do they help you when you need it? What form does that help take and how do you formalize that good neighbor behavior?
E14	Workforce selection, development and training	No program, regardless of the quality of the equipment, the quantity of materials, or the excellence of the strategy, can ever be better than its workforce. It follows that selecting that workforce and ensuring their appropriate training and development, is rather important.
E15	Measurement of and Reliance on residual road salt	The more you know about how much salt is on the road right now, the less salt you will need to use to achieve your level of service goals.
E16	Certification regime for all contractors performing winter service (inclusive of all sub-contractors)	There is a strong argument to be made that anyone putting salt or other materials on the road should have some level of certification that speaks to their training.
E17	Competent snowplow drivers	The plow driver is the sharp end of the winter maintenance program and so must be well trained and capable.

E18	Competent, motivated staff.	At all levels of an organization, the need for both competence and motivation is extremely important.
E19	Contractor training in accurate use of equipment & understanding of requirements in the contracts.	When contractors are called in to supplement the activities of an agency, they need to be brought up to speed rapidly on how everything works – not just mechanically but operationally too.
E20	Retain and train our own winter service specialists.	Winter maintenance is a complex set of tasks, and the constraints and tools for those tasks are changing all the time. If we are to build for the long term, we must have ways to develop the careers of those in winter maintenance.

160

161 The survey was made available for a period of two months from May 1 through June 30,
 162 2014. Information was provided by use of the list-serve and through various other email contacts
 163 available to the authors (including, for example, the membership list of the PIARC 2-4 Working
 164 Group).

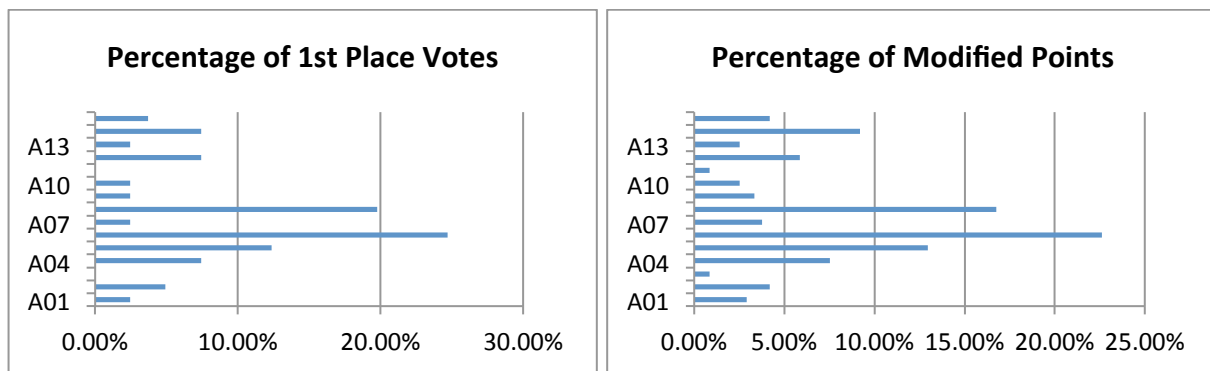
165 **RESULTS OF SURVEYS**

166 A total of 85 respondents took the survey. No data on job description (or any other potentially
 167 identifying information) was requested as part of the survey so it is not possible to break down
 168 responses according to job type or employer. Analysis was conducted by a simple frequency
 169 count of first place votes and a modified count of first and second place votes combined (in
 170 which first place votes counted for two points and second place votes counted for one point). In
 171 all cases, the count was normalized by the total number of votes (or in the case of the modified
 172 count, of points) and thus the results are expressed as a percentage of votes. In the results for
 173 groups A, B and C (Figures 1, 2, and 3) there was no difference in the order for the top two items
 174 in either of the two methods of analysis. In group D, three topics tied for “second place” (the
 175 second most popular topic) in the first place votes analysis but the modified count “broke the tie”
 176 (Figure 4). In group E, two topics tied for “second place” in both methods of analysis (Figure 5).

177

178 **Figure 1 Survey Results for Group A**

179

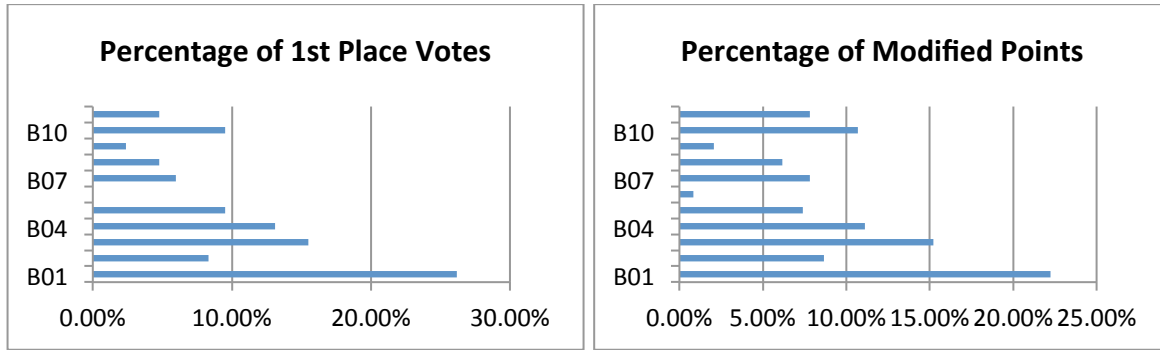


180

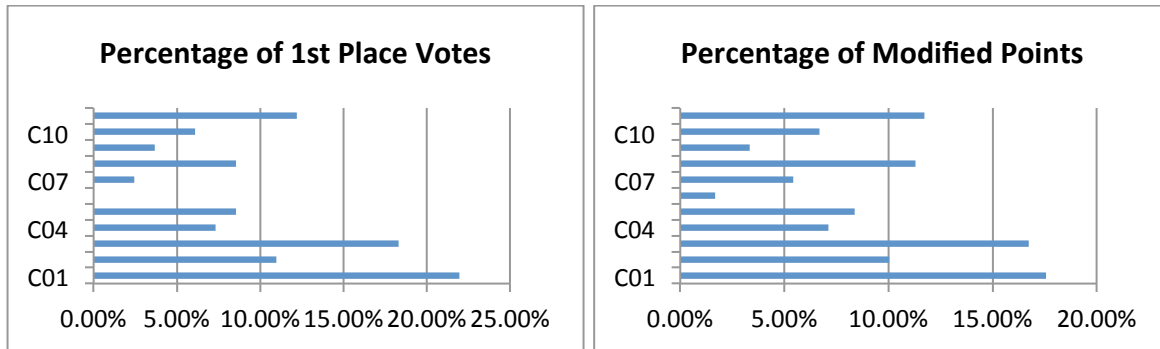
181

182

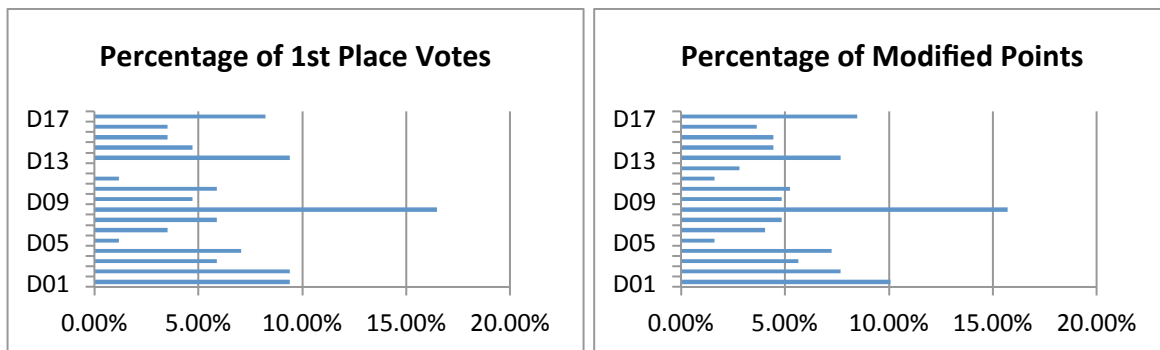
183 **Figure 2 Survey Results for Group B**
 184



185
 186
 187 **Figure 3 Survey Results for Group C**
 188

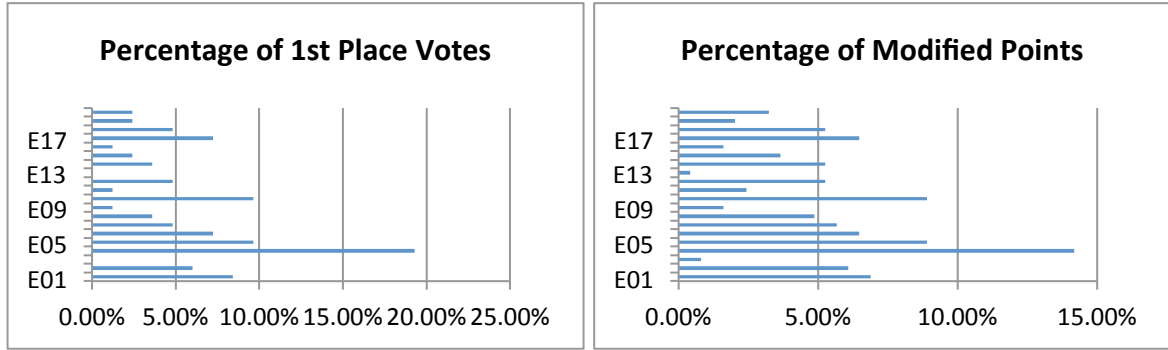


189
 190
 191 **Figure 4 Survey Results for Group D**
 192



193
 194
 195

196 **Figure 5 Survey Results for Group E**
 197



198
 199

200 Table 9 lists the top ten topics (in fact, because of the tie in Group E, the top 11) found in
 201 the analysis. In contrast with the analysis conducted by the WMTSP Steering Committee, none
 202 of the issues in Table 9 would be considered surprising. Item D10, which related to maintenance
 203 yard design and which was seen as one of the two most important issues by the steering
 204 committee did not get selected in the survey and in fact finished in 7th place in group D out of 17
 205 issues.

206 In terms of identifying a unifying theme in the selected issues, perhaps the most obvious
 207 such theme is a desire for efficiency and effectiveness. This may in turn suggest that the survey
 208 respondents, and (to the degree that the respondents reflect the community) the winter
 209 maintenance community in general see the need for efficiency and effectiveness in their
 210 activities but do not feel they have the tools to be as efficient and effective as they would like or
 211 as they feel their organizations could be (or perhaps as their organizations are expected to be).

212
 213

214
215

TABLE 9 Top Ten Topics Identified by Survey

ID #	Topic	Explanation	%age Votes
Group A (Materials, Sustainability and the Environment) Identified Topics			
A06	Adequate funding for operations and sustainability	No money, no workee! Or, more seriously, a sustainable winter maintenance program requires appropriate long term funding levels.	24.7
A08	Using sustainable winter maintenances practices	Sustainability requires balancing three factors – economics, the environment, and the public need. Building a winter service program around these three legs creates a system that can provide optimal benefits to all.	19.8
Group B (Weather and Information) Identified Topics			
B01	Accurate and timely weather forecast	Especially when anti-icing is being used by an agency, accurate forecasts are critically important and they must be delivered in a timeframe that is appropriate for the agency with regard to staffing decisions.	26.2
B03	Optimal route planning	With limited resources, getting the most out of our trucks is critical. Optimizing routes is one way of doing this.	15.5
Group C (Equipment) Identified Topics			
C01	Equipment and equipment calibration	Having the right equipment to dispense product for a given winter maintenance task is half of the issue. The other half is making sure it is calibrated correctly, so you know what exactly it is doing	22.0
C03	Equipment maintenance program (preventative and routine)	Making sure that your equipment can perform as needed during a storm requires some sort of program to do both preventative and routine maintenance on that equipment.	18.3
Group D (Operations and Tactics) Identified Topics			
D08	Efficiency in operations - intelligent use of resources	Any agency has a finite number of resources – trucks, people, materials, time. Using those resources in the most efficient way possible is always a key goal.	16.5
D01	Communication between operation controllers and drivers	Good winter maintenance needs responsiveness to changing conditions during and after a storm and good communications between drivers and supervisors is critical to achieving this.	9.4
Group E (Strategies, Public Relations, and Training) Identified Topics			
E04	Snow plans (Include operational evaluation/continuous improvement)	A detailed plan for an agency is an absolute must and should be the guide for all actions before, during, and after a storm.	19.3
E05	Standards in winter-service	What standards are you trying to achieve? Are they the standards your community wants or are you not giving them what they need?	9.6
E10	Defined levels of service	Most agencies are required to provide differing levels of service on different road types. Having those levels of service well defined is a critical part of a winter maintenance program.	9.6

216
217
218
219

220 **CONCLUSIONS**

221 By using a variety of electronic tools, including an email list-serve and an online survey, the
222 winter maintenance community has been able to engage a broader array of personnel into the
223 process of identifying research needs. While many of the research needs identified through this
224 process were not particularly surprising, a number of them were very clearly novel and had not
225 been considered by the decision makers in the winter maintenance community. The new research
226 topics will be moved forward by the various groups charged with fostering and encouraging
227 research in the winter maintenance community.

228 **ACKNOWLEDGEMENTS**

229 The authors would like to thank their colleagues on the WMTSP Steering Committee who helped
230 them to sort the ideas obtained from the initial email invitation: Lee Smithson, Steve Lund, Mike
231 Lashmet, Mark DeVries, Greg Parker, Max Perchanok, Ben Dow, and Mike Fitch. We would
232 also like to thank all those who responded to the initial email invitation, and those who took the
233 survey. Without their input, there would, of course, be no results.

234 **REFERENCES**

- 235 1: Nixon, W. A. and Smithson, L.D., “A Consistent Methodology for Conducting Research into
236 Winter Highway Maintenance,” Proc. 4th International Symposium on Snow Removal and Ice
237 Control Technology, TRB/NRC, Paper A-10, Vol. I, Reno Nevada, August, 1996.
238 2: W. A. Nixon and M. A. Wilson, “Development and Use of an E-Mail-Based List-Serve for
239 Winter Highway Maintenance,” Transportation Research Record, Journal of the Transportation
240 Research Board, No. 1741, pp. 124 – 128, 2001.
241 3: Nixon, W. A., “Grand Challenges: A Research Plan for Winter Maintenance,” Final Report of
242 NCHRP 20-07 Task 287, December 2010.
243 4: [http://www.westerntransportationinstitute.org/professionaldevelopment/peer-](http://www.westerntransportationinstitute.org/professionaldevelopment/peer-exchange/default.aspx)
244 [exchange/default.aspx](http://www.westerntransportationinstitute.org/professionaldevelopment/peer-exchange/default.aspx), accessed on July 24, 2014.
245 5: <http://sicop.transportation.org/Pages/default.aspx> accessed on July 24, 2014.
246 6: <http://clearroads.org/> accessed on July 24, 2014.
247 7: <http://www.aurora-program.org/> accessed on July 24, 2014.
248 8: <https://sites.google.com/site/trbcommitteeahd65/> accessed on July 24, 2104.
249 9: <https://www.surveymonkey.com/s/GS7R9FT> accessed on July 24, 2014.

250