



# Transportation Research Division



## **Problem Solving 07-1** *Evaluation of 6 Modified Salt Spreaders*

*July 2007*

# Transportation Research Division

## *Evaluation of 6 Modified Spreaders*

### **Introduction**

In the Summer and Fall of 2006, the Maine Department of Transportation (MaineDOT) began a retro-fitting process on six of their conventional salt spreaders. MaineDOT contracted with H.P Fairfield of Skowhegan, Maine to complete this work.

The intent of the retro-fit was to modify the spreaders to allow for a 70 percent granular salt/30 percent salt brine application. MaineDOT's previous experience with the Schmdit-STRATOS Spreader (Report Available – Evaluation of the Schmidt-STRATOS Spreader, July 2005), which is manufactured in Germany, showed much promise using this combination of materials. Preliminary results from the STRATOS spreader evaluation indicated that the potential for material and monetary savings exists when using the 70/30 mixture. The theory behind significantly increasing the amount of liquid used to treat the granular salt is that the salt begins reacting faster with the presence of additional liquid and the material stays on the roadway better with the increased saturation.

### **Modifications**

The two primary modifications included the replacement of liquid tanks and all plumbing associated with the tanks and changing the bed-chain delivery system of the hopper to a belt-over-chain system. The two existing tanks (100 gallons each) were replaced with four smaller tanks with a total capacity of 540 gallons. This increased capacity allowed for the 30 percent liquid application to be applied to the typical eight yard capacity of the hopper, without prematurely running out of liquid. Additional minor changes were also completed which included a plastic cover over the drop-end of the belt delivery assembly and moving the nozzles that apply the liquid to a location in close proximity to the spinner. Existing liquid pumps were successfully re-calibrated to supply the desired increase of liquid material.

The approximate cost of these modifications was \$7,500.00 per unit.

### **Evaluation Methodology**

The first step in developing the methodology for this evaluation was to designate a control vehicle/plow route for each modified unit. When selecting these control areas, consideration was given to truck type (similar or equal in size, etc.) and geographic location (proximity/similarities to plow route treated by modified unit). All six of the modified units were located in the Bangor (Eastern), Region 4 area. Trucks were located in Bangor, Beddington, Carmel, Enfield, Pembroke and Orland (see attached map). The modified truck located in Orland had a series of mechanical issues throughout the winter. For this reason, no valid data was collected at this location. These and other mechanical problems associated with the modifications are discussed in the Mechanical Issues portion of this report.

A Storm Data Sheet was developed and drivers of the control and modified trucks, as well as their supervisors, were briefed on the proper method for filling out the sheet. Drivers were asked to complete the sheets for every storm they worked, beginning February 1, 2007.

A copy of the Storm Data Sheet is presented in Appendix A.

## **Data Review/Analysis**

When the Storm data sheet was originally developed, it was anticipated that the completed form would provide the following information for each storm event; weather conditions throughout the storm event, pavement conditions as they existed when salt/brine was applied, snow depth at the time salt/brine was applied, the time/date at which the salt/brine was applied, amount of salt/brine applied, how many miles were treated, whether the material was applied in a windrow, or dropped “off-the-spinner” and how many times the section was scraped by the plow between applications. From these pieces of information, it was further anticipated that not only could the total amounts of material be calculated, but also if the modified truck provided a higher quality of roadway condition with less effort (less material used and less scrapes necessary to clear the road of snow and ice).

Unfortunately, the level of detail with which the forms were completed did not allow for all of the above listed information to be collected accurately. In an effort to retrieve as much pertinent information as possible, the following data was summarized; date of storm, number of applications, total pounds of granular salt applied per mile, gallons of liquid used per mile and the total amount of salt used per mile. The total amount of salt used (granular and salt in brine solution) was calculated by simply adding the pounds of granular salt applied and 2.2 pounds of salt for every gallon of salt brine applied (granular + (gallons of salt brine x 2.2)).

The most significant piece of information that was not captured was the quality of road conditions throughout the event. Because of this, all data reported assumes equal conditions and focuses on the difference in the amount of salt applied to the roadway.

Appendix B includes a summary of all the storm reports received from the earlier mentioned start date of February 1, 2007 to the end of the winter season in April, 2007.

A more detailed summary is included in Appendix C. This summary compares only the storm events that had storm information from both the control and modified trucks. For this information, it is assumed that the trucks were in a working mode for approximately the same amount of time during the event.

Additionally, interviews were conducted with the drivers and their respective supervisors after the winter season was over.

It should be noted that with the exception of the Bangor location, operators and supervisors had virtually no experience with this significant increase in liquid application. For this reason, it is assumed that much of the data collected in the remaining locations was subject to a steep learning curve and may not be typical of what can be expected with respect to material savings.

Below is a summary of results and interviews for each location.

## **Bangor – Interstate 95**

Both trucks from this location had plow routes located on Interstate 95. The modified truck was responsible for the travel lane in both the north and south bound lanes from Hogan Road in Bangor to Route 16 in Alton. The control truck was responsible for the passing lane in the same area. This represents a distance of 23 lane miles for each truck.

Results reported by the drivers provided comparable information for seven storms. For these storms, 19 applications were reported by the operator of the control truck and 18 were reported by the driver of the modified truck. A total of 8,795.7 pounds per mile was applied by the control vehicle and 8,086.3 pounds for the modified. These values indicate a 709.4 pound (8 percent) savings per mile was achieved by the modified unit for the seven events. Using the 23 mile distance, a total of 16,316.2 pounds (8.16 tons) were saved by the modified unit during these seven events. Utilizing this total and the average statewide cost of salt per ton for the 2006-2007 winter season of \$52.58, a savings of \$428.95 was realized for the seven reported events.

In an effort to further identify potential savings; these values were projected over a complete winter season. Assuming 30 events, as much as 69,926.6 pounds (34.96 tons) of salt could possibly be saved. This would translate into a dollar savings of \$1,838.20 for this 23 mile section.

These results are presented in tabular form in Appendix C.

### **Interview Summary**

Interview results indicate that the Crew Supervisor and each of the drivers believe the 70/30 mix outperforms the 6, 8, or 10 gallon per ton application method. The Crew Supervisor stated that typically the Modified truck would apply a heavier first application than the Control truck. Subsequent applications with the Modified truck were less than the Control unit. For example; on the first application, the control truck would apply 400 pounds of Granular salt treated by two gallons of brine per lane mile. This was a total salt application of approximately 405 pounds. The Modified truck would apply 420 pounds of granular, treated by 17.14 gallons of brine. This was a total application of 458 pounds of salt, 53 pounds greater than the Control unit's application. Typical subsequent applications continued to be 400 (405 total) pounds for the Control, while the Modified unit would decrease its application to a total of 305 pounds per lane mile. The Crew Supervisor believes this method, along with the minimization of "bounce and scatter", are the primary reasons for the Modified unit using less salt. As stated earlier, this is the most experienced crew in MaineDOT with using the 70/30 mix strategy.

Mechanical concerns that were discussed during the interview process are addressed in the Mechanical Issues portion of this report.

## **Beddington – Route #9**

Both of the trucks from the Beddington location treated sections of Route #9. The Control truck treated approximately 21 lane miles, while the Modified unit treated approximately 22 miles. The Modified section was located to the east of the Beddington maintenance facility and the Control section located west of the facility. The Modified section began where the Control section terminated.

Four storms of those reported had comparable information. A total of 12 applications were reported for each truck. A total of 5,959.4 pounds of salt per mile were applied by the Control truck and 3,985.4 pounds were applied by the Modified unit. For these four events, data reported by the Control truck

operator indicated he applied 1,974 pounds more per mile than the Modified unit. This translates to a 33 percent savings. Using the 21 mile distance, a total of 41,454 pounds (20.73 tons) of salt were saved by the Modified unit during these four storm events. This would represent a dollar value of \$1,089.82 saved during the four reported events. Projecting these numbers over a complete winter season (30 events), a savings of \$8,173.65 is possible.

This total is recognized as potentially excessive. A review of the individual storm reports validated the accuracy of the summary compiled. It is interesting to note that an equal number of applications were reported for each of the four events.

These results are summarized in Appendix C.

### Interview Summary

Those involved at the Beddington location believed that the 70/30 did an excellent job at minimizing bounce and scatter. They also indicated that a heavy application at the outset of the storm, followed by smaller subsequent applications worked best. The Crew Supervisor stated that lane drops (the practice of spreading the salt/brine mixture over much of the targeted lane) worked well when using the 70/30 mix. The driver of the modified unit also stated that it was critical to get out and apply salt/brine early in the storm. Overall, the individuals at this location indicated that the 70/30 mix worked better than the typical 6, 8 and 10 gallons/ton in most conditions.

Jason Campbell, the driver of the modified unit, designed and fabricated a chute (see picture below) to replace the existing chute on his hopper. This chute is located just below the end of the belt delivery system and is much narrower than the typical box-shape chutes on a majority of MaineDOT's hoppers. The chute tapers at the bottom to an opening approximately 3 inches in diameter. This concentrating of salt before it contacts the spinner assembly is important for proper placement and to minimize bounce and scatter. This chute is discussed further in the Recommendations section of this report.

Mechanical issues similar to those encountered by the other locations were discussed and are detailed in the Mechanical Issues section of this report.



Modified Salt Chute.

## **Carmel – Routes #2 and #9**

For the Carmel location, the Control truck treated a 22.7 lane mile section of Route #9 in the Newburgh/Dixmont area. The Modified vehicle treated a section of Route #2 located in the Carmel/Hermon area. This section was a length of 23.7 lane miles.

Comparable information for eight events was available from this location. Each truck reported 16 applications during the events. The Control truck reported applying 5,737.6 pounds of salt and the Modified truck reported a total of 5,225.6 pounds applied, representing an 8.9 percent savings. These totals indicate the Control truck applied 512 pounds more per mile than the Modified unit during the eight events reported. Using an average distance of 23 miles, 11,776 pounds (5.89 tons) was saved by the Modified unit. This translates into a dollar savings of \$309.70. These savings could potentially increase to \$1,161.38 for a 30 event season.

These results are also summarized as part of Appendix C.

### **Interview Summary**

Discussions with the Crew Supervisor and the two drivers indicated that the 70/30 mix worked well at this location. After having the Control and Modified units use the same application rates for much of the winter, the Crew Supervisor learned that a heavier application on the first application by the modified unit followed by smaller applications worked better. This method was the same one found to work best for three of the other locations. The driver of the Modified unit was very happy with the results he achieved. It was noted that the section of Route #2 treated by the Modified unit was very rutted and distorted, while the section of Route #9 treated by the Control truck was smoother, with relatively new pavement. The Control unit was also equipped with a Precision Placement System (PPS) that worked very well during this evaluation. The PPS “spins the salt out the back of the truck in a windrow pattern, at the same speed the truck is traveling, negating the speed of the truck. This “zero velocity” effect minimizes the bounce and scatter of material.

Both the Crew Supervisor and driver of the Modified unit commented on how well the 70/30 mix minimized bounce and scatter. It is interesting to note that even though the Control unit at this location was equipped with the PPS system, the Modified unit used less salt.

Several mechanical issues with the Modified unit were experienced during the winter of 2006-2007 and are discussed in the Mechanical Issues portion of this report.

## **Enfield – Interstate 95**

The trucks working from this location each treated a section of Interstate 95. The Modified truck provided service on 19 miles in the Lincoln/T2-R9 area. The Control unit treated a 17.5 mile section of Interstate 95 in the Howland/Edinburg area. This places the Modified units plow route approximately 20 miles north of the Control trucks route. The Modified unit at this location is also the most northerly positioned unit in this evaluation.

Five storm events with comparable data were reported for this location. A total of 13 applications were made by each truck. The Control unit applied a total of 4,094.6 pounds of salt per mile and the Modified truck applied 3,928.7 pounds per mile during the five reported events. This indicates a savings

of 165.9 pounds (4 percent) per mile was realized by the Modified truck for the five events. Using an average distance of 18 miles, the Modified truck applied 2,986.2 pounds (1.49 tons) less than its Control counterpart, representing a dollar savings of \$78.51 for the five reported storm events. For a 30 event season, this savings could potentially increase to \$471.06.

Results are summarized in Appendix C.

### Interview Results

Drivers at this location also indicated that a heavier initial application, followed by smaller subsequent applications works best when using the 70/30 mixture. They also noted that it was very important to get out early, before too much snow and ice have formed on the roadway. For lighter snow fall storms, the 70/30 mix worked very well. They believed the additional liquid definitely minimized the bounce and scatter of material.

Mechanical issues and suggestions for improvement are discussed in the Mechanical Issues section.

### Orland – Interview Summary

As stated above, numerous mechanical issues plagued the modified unit in this location throughout the winter of 2006-2007. For this reason, no valid data was collected. An interview of the Crew Supervisor and drivers was conducted to document the mechanical problems encountered (detailed in the Mechanical Issues section) and to gather any opinions pertaining to the performance of the 70/30 percent mixture. For the limited time that the driver was able to apply the 70/30 mixture, he was very impressed with the results. He indicated that with storms where the air temperature exceeded 20 degrees, the mixture worked much better than the conventional (6, 8 and 10 gallons/ton) method. In the colder storms, he believed it worked about the same. The Crew Supervisor agreed with this assessment.

Another related issue that was discussed was the availability and storage of salt brine. Many times during the winter this location had an insufficient salt brine supply and had to apply granular salt only. This location has only a 3,000 gallon storage tank and the crew can potentially use a full tank of brine in just one storm. Region #4 is continuing to evaluate its salt brine needs and managers are working to make salt brine more available at several locations and to enhance storage facilities.

### Pembroke – Route #1

Each of the two trucks from this area treated a section of Route #1. The Control units plow route was from Whiting to Pembroke (27.8 lane miles) and the Modified truck treated from Robbinston to Calais (24.7 lane miles).

Comparable data was submitted for seven storm events for this location. A total of 17 applications were made by the Control truck, while 19 were made by the Modified unit. The Control truck applied a total of 5,998 pounds of salt per mile for the seven events and the Modified truck applied 6,984.1 pounds. These numbers indicate that the Modified truck applied 986.1 pounds (14 percent) more per mile than the Control unit for the seven events reported. In this instance, the Control truck showed a savings of 25,638.6 (12.82 tons) when using an average distance of 26 miles. When applying this total to a 30 event season, the Control unit was actually more cost effective, saving 109,885.7 (54.94 tons) of salt. This reported savings translates into a potential dollar value of \$2,888.75.

This was the only location where the Modified truck actually applied more salt than the Control unit. Discussions with the two drivers and Crew Supervisor indicated that the Modified units plow route historically receives significantly more snow than the Controls area. For this reason, results from this location may not be indicative of the overall advantages to applying the 70/30 mix.

Results are presented in Appendix C.

### Interview Summary

Overall, the Crew Supervisor and two drivers were of the opinion that the 70/30 mix did not work well in their area. They believed that the changing weather conditions along Route #1 and colder temperatures were contributing factors. The driver of the Modified unit did indicate that he saw a significant lessening of “bounce and scatter” when applying the additional liquid material.

Numerous mechanical issues were encountered with the modified unit and are discussed in the Mechanical Issues section, below.

### **Mechanical Issues**

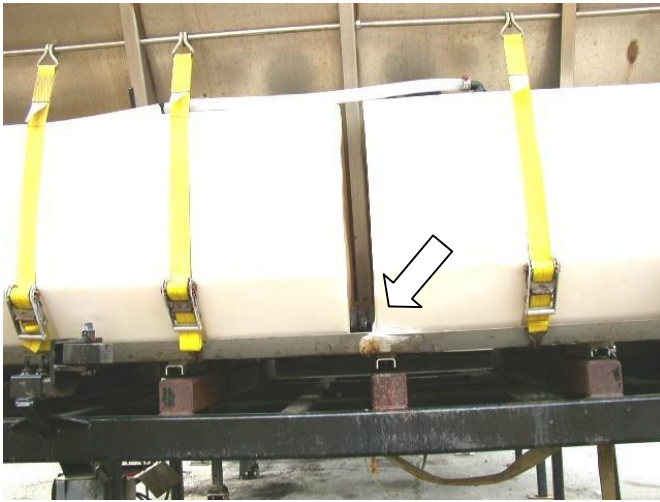
Mechanical issues related to the modifications of the hoppers occurred at several of the locations. The new liquid tanks encountered leaks on each of the six hoppers. With the exception of the Enfield location, each hopper leaked at the interface (PVC pipe) of the two 135 gallon tanks (see picture below). The Enfield location had leaks caused by a hole in one the tanks. Bangor was the only location to experience leaks at both the tank interface and because of a hole in one of the tanks. Indications from each of the locations are that the leaks have been repaired.

The second most occurring problem was the breaking away of the rubber strips installed to keep salt from getting under the sides of the belt (see picture below). This problem occurred at the Bangor, Orland and Pembroke locations. It is interesting to note that these locations also had issues with the belt delivery system plugging because of large pieces of salt lodging against the gate. The Enfield location typically screens their salt supply using a Grizzly (see picture below), in an effort to minimize the large pieces reaching the hopper. The unit located in Beddington has screens attached to the top of the hopper to keep large pieces of material from getting into the hopper. Carmel reported having only one plugging issue the entire winter, which was believed to have been caused by the use of wet salt.

The only other mechanical issue encountered was the breaking of the bed chain on the Orland hopper. This problem was believed to be a function of the age of the hopper and not associated with the modifications made.

Two other modifications were made to a majority of the six hoppers after they were returned to MaineDOT. It was originally believed that the ideal location to introduce liquid material was at the spinner. After some consideration, the location was changed to above the delivery belt, just as the salt passes through the gate. A small PVC pipe was drilled at multiple locations and the brine was allowed to flow over the entire width of salt as it traveled along the belt. It is believed that this location allows the brine to better absorb into the granular salt, allowing for better saturation. The second adaptation was to add a broom at the bottom of the delivery belt to clean the salt/brine off the belt as it passes back under the hopper. These modifications are pictured below.

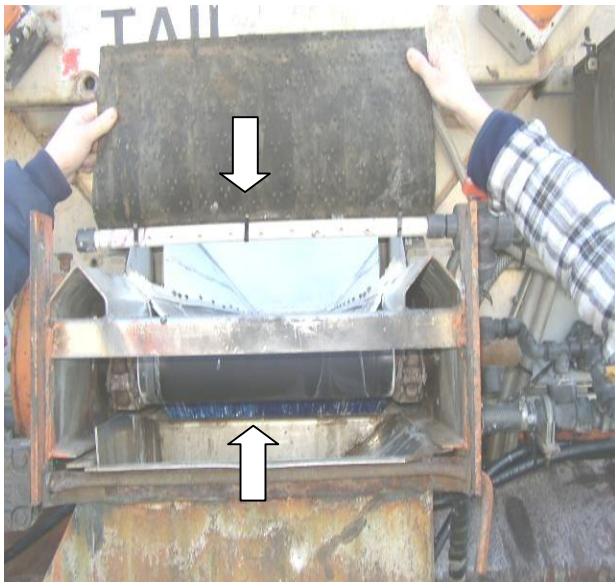




Location of Leak Between Tanks.



Rubber Strips Used for Confining Salt.



Liquid Applicator and Cleaning Broom.



Grizley Screening Device.

## Conclusions

Four of the five locations for which data was collected reported a saving of salt when using the 70/30 mixture. The average savings per mile when combining the five locations was 76.6 pounds (7.8 percent). Using this value and assuming a typical plow route is approximately 22 miles in length, each unit would save 1,685 pounds of salt for every storm event. If you again assume a 30 event season, the savings would total 50,556 pounds (25.28 tons). This would calculate to an annual monetary savings of approximately \$1,329.00 per unit when using the average salt price for the 2006-2007 winter season. A summary of this information is included in Appendix C.

With the exception of the Pembroke location, crews using the 70/30 mix indicated that it outperformed the typical treatment of 6, 8 and 10 gallons/ton. All of the crews indicated that it did a better job of minimizing bounce and scatter. Treating the roadway early, at the outset of a storm event was also mentioned by most of the crews involved as being critical. Each location also determined that a heavier

first application, followed by smaller subsequent applications appeared to work best when using the 70/30 mix.

Four of the five locations reporting data believed that the belt-over-chain delivery system was far superior to the chain delivery system typically found in MaineDOT hoppers. Crews indicated that the belt systems virtually eliminated the issues of uneven material distribution commonly experienced with the chain system.

## Recommendations

Data collected for this evaluation indicates the potential exists for saving salt when using the 70/30 mix. For this reason, it is recommended that data be collected during the 2007-2008 season on at least several of the modified units. It may be worthwhile to focus on the Bangor location because of the additional experience with heavy liquid applications as well as the proximity to the Bangor office. Consideration should also be given to putting technicians in the trucks during several storms to document application rates, weather and road conditions, etc. This has the potential of increasing the level of accuracy of the data collected.

Each of the six units should be retro-fitted with a chute similar to the one designed and manufactured at the Beddington location. By confining the salt until it impacts the spinner, it is believed that even greater savings can be realized.

Consideration should be given to using a Grizley to screen salt before it is loaded to eliminate large pieces of salt from getting into the hoppers. Another possibility is to install screens to the top of the hoppers. Either of these options should minimize any issues associated with the belt assembly becoming plugged.

The liquid application system should be moved from the spinner to above the belt assembly to allow greater saturation of the granular salt.

A broom or brush should be installed just below the belt to clean salt and brine off the belt system.

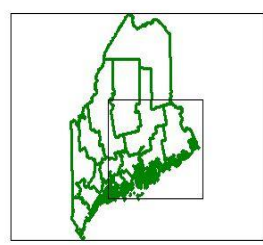
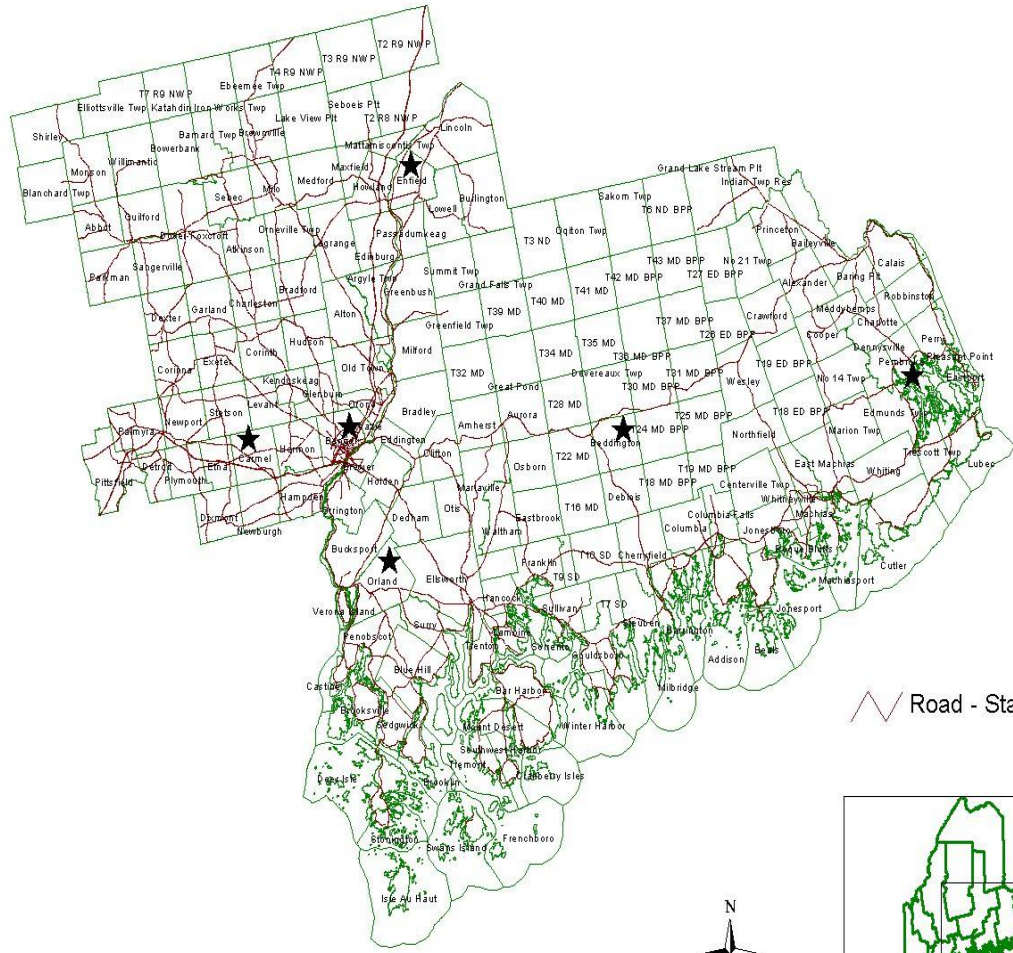
At this time, it is recommended that no additional units be modified until a more detailed evaluation can be completed during the 2007-2008 winter season.

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# Region 4 Modified Spreader Locations



# Appendix A

**\* Storm Cycle Information (Driver) \***

**Cycle (Application) #1 (Complete Before Application)**

Truck Number: \_\_\_\_\_ Driver: \_\_\_\_\_

Current Weather Condition: \_\_\_\_\_  
1-Clear, 2-Partly Cloudy, 3-Cloudy, 4-Rain, 5-Freezing Rain, 6-Sleet, 7-Lt. Snow, 8-Heavy Snow

Current Pavement Condition: \_\_\_\_\_  
1-Bare and Dry, 2-Bare and Wet, 3-Snow/Pavement, 4-Ice/Pavement, 5-Slush/Pavement

Current Air Temperature: \_\_\_\_\_ Current Pavement Temperature: \_\_\_\_\_

Current Snow Depth (This storm): \_\_\_\_\_

Current Cycle Time: \_\_\_\_\_ (Include AM or PM)

Current Cycle Date: \_\_\_\_\_

Application Rate Used (On Control Box): \_\_\_\_\_ Liquid Type/Setting (L, M, H) \_\_\_\_\_

Miles That Material Was Applied: \_\_\_\_\_ Off-the-Spinner Drop  Windrow Drop

Clean-Up Mode  Unit Running in Manual Mode

Number of Times Scraped before Cycle #2 \_\_\_\_\_

Comments: \_\_\_\_\_

\_\_\_\_\_

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**Cycle (Application) #2 (Complete After Application)**

Truck Number: \_\_\_\_\_ Driver: \_\_\_\_\_

Current Weather Condition: \_\_\_\_\_  
1-Clear, 2-Partly Cloudy, 3-Cloudy, 4-Rain, 5-Freezing Rain, 6-Sleet, 7-Lt. Snow, 8-Heavy Snow

Current Pavement Condition: \_\_\_\_\_  
1-Bare and Dry, 2-Bare and Wet, 3-Snow/Pavement, 4-Ice/Pavement, 5-Slush/Pavement

Current Air Temperature: \_\_\_\_\_ Current Pavement Temperature: \_\_\_\_\_

Current Snow Depth (This storm): \_\_\_\_\_

Current Cycle Time: \_\_\_\_\_ (Include AM or PM)

Current Cycle Date: \_\_\_\_\_

Application Rate Used (On Control Box): \_\_\_\_\_ Liquid Type/Setting (L, M, H) \_\_\_\_\_

Miles That Material Was Applied: \_\_\_\_\_ Off-the-Spinner Drop  Windrow Drop

Clean-Up Mode  Unit Running in Manual Mode

Number of Times Scraped before Cycle #3 \_\_\_\_\_

Comments: \_\_\_\_\_

\_\_\_\_\_

**Appendix B**

**Summary of All Storm Reports**

## All Storm Reports - Bangor

| <b>Storm Date</b>   | <b># of Applications</b>        | <b>Total Pounds /Mile</b> | <b>Total Gallons of Liquid/Mile</b> | <b>Total Salt Used Brine/Granular (Lbs.)</b> |
|---------------------|---------------------------------|---------------------------|-------------------------------------|--|
| <b>Truck Number</b> | <b>01-420 ( Bangor-Control)</b> |                           |                                     |  |
| 2/1/2007            | 1                               | 300                       | 1.5                                 | <b>303.3</b>                                 |
| 2/2/2007            | 4                               | 1500                      | 7.5                                 | <b>1516.5</b>                                |
| 2/14/2007           | 6                               | 3000                      | 15                                  | <b>3033.0</b>                                |
| 2/18/2007           | 1                               | 500                       | 2.5                                 | <b>505.5</b>                                 |
| 3/2/2007            | 3                               | 1500                      | 7.5                                 | <b>1516.5</b>                                |
| 3/4/2007            | 1                               | 500                       | 2.5                                 | <b>505.5</b>                                 |
| 3/5/2007            | 1                               | 400                       | 2                                   | <b>404.4</b>                                 |
| 3/6/2007            | 1                               | 500                       | 2.5                                 | <b>505.5</b>                                 |
| 3/16/2007           | 3                               | 1500                      | 7.5                                 | <b>1516.5</b>                                |
| <b>Truck Number</b> | <b>01-131 (Bangor-Modified)</b> |                           |                                     |  |
| 2/1/2007            | 1                               | 280                       | 11.43                               | <b>305.1</b>                                 |
| 2/2/2007            | 3                               | 1120                      | 45.72                               | <b>1220.6</b>                                |
| 2/14/2007           | 5                               | 1925                      | 78.57                               | <b>2097.9</b>                                |
| 2/18/2007           | 1                               | 420                       | 17.14                               | <b>457.7</b>                                 |
| 3/2/2007            | 4                               | 1820                      | 74.29                               | <b>1983.4</b>                                |
| 3/5/2007            | 1                               | 385                       | 15.71                               | <b>419.6</b>                                 |
| 3/16/2007           | 3                               | 1470                      | 60                                  | <b>1602.0</b>                                |
| 3/18/2007           | 2                               | 560                       | 22.86                               | <b>610.3</b>                                 |

## All Storm Reports - Beddington

| <b>Storm Date</b>   | <b># of Applications</b>            | <b>Total Pounds /Mile</b> | <b>Total Gallons of Liquid/Mile</b> | <b>Total Salt Used Brine/Granular (Lbs.)</b> |
|---------------------|-------------------------------------|---------------------------|-------------------------------------|--|
| <b>Truck Number</b> | <b>01-157 (Beddington-Control)</b>  |                           |                                     |  |
| 2/1/2007            | 3                                   | 1500                      | 7.5                                 | <b>1516.5</b>                                |
| 2/19/2007           | 3                                   | 1500                      | 7.5                                 | <b>1516.5</b>                                |
| 3/2/2007            | 4                                   | 1900                      | 9.5                                 | <b>1920.9</b>                                |
| 3/16/2007           | 3                                   | 1500                      | 5                                   | <b>1511.0</b>                                |
| 4/12/2007           | 2                                   | 1000                      | 5                                   | <b>1011.0</b>                                |
| <b>Truck Number</b> | <b>01-119 (Beddington-Modified)</b> |                           |                                     |  |
| 2/19/2007           | 3                                   | 1050                      | 42.86                               | <b>1144.3</b>                                |
| 3/2/2007            | 4                                   | 980                       | 40                                  | <b>1068.0</b>                                |
| 3/16/2007           | 3                                   | 1030                      | 25.72                               | <b>1086.6</b>                                |
| 4/12/2007           | 2                                   | 630                       | 25.71                               | <b>686.6</b>                                 |



## All Storm Reports - Carmel

| Storm Date                                   | # of Applications | Total Pounds /Mile | Total Gallons of Liquid/Mile | Total Salt Used Brine/Granular (Lbs.) |
|--|-------------------|--------------------|------------------------------|---------------------------------------|
| <b>Truck Number 01-165 ( Carmel-Control)</b> |                   |                    |                              |                                       |
| 2/2/2007                                     | 2                 | 600                | 1.8                          | 604.0                                 |
| 2/14/2007                                    | 4                 | 1400               | 4.2                          | 1409.2                                |
| 2/18/2007                                    | 1                 | 300                | 0.9                          | 302.0                                 |
| 3/2/2007                                     | 3                 | 1050               | 3.15                         | 1056.9                                |
| 3/3/2007                                     | 1                 | 400                | 1.2                          | 402.6                                 |
| 3/5/2007                                     | 2                 | 750                | 2.25                         | 755.0                                 |
| 3/7/2007                                     | 1                 | 350                | 1.05                         | 352.3                                 |
| 3/16/2007                                    | 2                 | 900                | 2.7                          | 905.9                                 |
| 3/20/2007                                    | 1                 | 300                | 0.9                          | 302.0                                 |
| 3/22/2007                                    | 1                 | 400                | 1.2                          | 402.6                                 |
| <b>Truck Number 01-432 (Carmel-Modified)</b> |                   |                    |                              |                                       |
| 2/1/2007                                     | 1                 | 175                | 0                            | 175.0                                 |
| 2/2/2007                                     | 2                 | 420                | 17.14                        | 457.7                                 |
| 2/14/2007                                    | 4                 | 1050               | 42.86                        | 1144.3                                |
| 2/18/2007                                    | 1                 | 210                | 8.57                         | 228.9                                 |
| 3/2/2007                                     | 3                 | 1015               | 41.43                        | 1106.1                                |
| 3/5/2007                                     | 2                 | 770                | 31.43                        | 839.1                                 |
| 3/16/2007                                    | 2                 | 770                | 31.43                        | 839.1                                 |
| 3/18/2007                                    | 1                 | 385                | 15.71                        | 419.6                                 |
| 3/20/2007                                    | 1                 | 280                | 11.43                        | 305.1                                 |
| 3/22/2007                                    | 1                 | 280                | 11.43                        | 305.1                                 |

## All Storm Reports - Enfield

| <b>Storm Date</b>                             | <b># of Applications</b> | <b>Total Pounds /Mile</b> | <b>Total Gallons of Liquid/Mile</b> | <b>Total Salt Used Brine/Granular (Lbs.)</b> |
|---|--------------------------|---------------------------|-------------------------------------|--|
| <b>Truck Number 01-429 (Enfield-Control)</b>  |                          |                           |                                     |  |
| 2/2/2007                                      | 2                        | 550                       | 2.75                                | <b>556.1</b>                                 |
| 2/14/2007                                     | 3                        | 1200                      | 6                                   | <b>1213.2</b>                                |
| 2/18/2007                                     | 1                        | 300                       | 1.5                                 | <b>303.3</b>                                 |
| 3/2/2007                                      | 4                        | 1200                      | 6                                   | <b>1213.2</b>                                |
| 3/5/2007                                      | 3                        | 800                       | 4                                   | <b>808.8</b>                                 |
| <b>Truck Number 01-118 (Enfield-Modified)</b> |                          |                           |                                     |  |
| 2/2/2007                                      | 3                        | 910                       | 37.14                               | <b>991.7</b>                                 |
| 2/14/2007                                     | 2                        | 770                       | 31.42                               | <b>839.1</b>                                 |
| 2/18/2007                                     | 2                        | 490                       | 20                                  | <b>534.0</b>                                 |
| 3/2/2007                                      | 2                        | 560                       | 22.86                               | <b>610.3</b>                                 |
| 3/5/2007                                      | 4                        | 875                       | 35.71                               | <b>953.6</b>                                 |

## All Storm Reports - Pembroke

| <b>Storm Date</b>                              | <b># of Applications</b> | <b>Total Pounds /Mile</b> | <b>Total Gallons of Liquid/Mile</b> | <b>Total Salt Used Brine/Granular (Lbs.)</b> |
|--|--------------------------|---------------------------|-------------------------------------|--|
| <b>Truck Number 01-447 (Pembroke-Control)</b>  |                          |                           |                                     |  |
| 2/3/2007                                       | 2                        | 800                       | 3.2                                 | <b>807.0</b>                                 |
| 2/14/2007                                      | 6                        | 2100                      | 6.4                                 | <b>2114.1</b>                                |
| 2/19/2007                                      | 2                        | 850                       | 3.4                                 | <b>857.5</b>                                 |
| 3/2/2007                                       | 3                        | 1000                      | 4                                   | <b>1008.8</b>                                |
| 3/3/2007                                       | 1                        | 300                       | 1.2                                 | <b>302.6</b>                                 |
| 3/4/2007                                       | 1                        | 300                       | 1.2                                 | <b>302.6</b>                                 |
| 3/5/2007                                       | 1                        | 400                       | 1.6                                 | <b>403.5</b>                                 |
| 3/6/2007                                       | 1                        | 400                       | 1.6                                 | <b>403.5</b>                                 |
| 3/16/2007                                      | 2                        | 600                       | 2.4                                 | <b>605.3</b>                                 |
| 4/2/2007                                       | 1                        | 300                       | 1.2                                 | <b>302.6</b>                                 |
| 4/3/2007                                       | 1                        | 300                       | 1.2                                 | <b>302.6</b>                                 |
| <b>Truck Number 01-463 (Pembroke-Modified)</b> |                          |                           |                                     |  |
| 2/3/2007                                       | 3                        | 910                       | 37.14                               | <b>991.7</b>                                 |
| 2/14/2007                                      | 6                        | 2310                      | 61.42                               | <b>2445.1</b>                                |
| 2/19/2007                                      | 2                        | 770                       | 31.42                               | <b>839.1</b>                                 |
| 3/2/2007                                       | 3                        | 980                       | 40                                  | <b>1068.0</b>                                |
| 3/3/2007                                       | 1                        | 350                       | 14.29                               | <b>381.4</b>                                 |
| 3/4/2007                                       | 1                        | 210                       | 8.57                                | <b>228.9</b>                                 |
| 3/5/2007                                       | 1                        | 420                       | 17.14                               | <b>457.7</b>                                 |
| 3/16/2007                                      | 3                        | 945                       | 38.58                               | <b>1029.9</b>                                |
| 3/20/2007                                      | 1                        | 245                       | 10                                  | <b>267.0</b>                                 |
| 4/2/2007                                       | 1                        | 315                       | 12.86                               | <b>343.3</b>                                 |
| 4/3/2007                                       | 1                        | 245                       | 10                                  | <b>267.0</b>                                 |

## **Appendix C**

### **Summary of Storm Reports with Comparable Data**

## Bangor

| Storm Date          | # of Applications               | Total Pounds /Mile | Total Gallons of Liquid/Mile | Total Salt Used Brine/Granular (Lbs.) |
|---------------------|---------------------------------|--------------------|------------------------------|---------------------------------------|
| <b>Truck Number</b> | <b>01-420 ( Bangor-Control)</b> |                    |                              |                                       |
| 2/1/2007            | 1                               | 300                | 1.5                          | 303.3                                 |
| 2/2/2007            | 4                               | 1500               | 7.5                          | 1516.5                                |
| 2/14/2007           | 6                               | 3000               | 15                           | 3033.0                                |
| 2/18/2007           | 1                               | 500                | 2.5                          | 505.5                                 |
| 3/2/2007            | 3                               | 1500               | 7.5                          | 1516.5                                |
| 3/5/2007            | 1                               | 400                | 2                            | 404.4                                 |
| 3/16/2007           | 3                               | 1500               | 7.5                          | 1516.5                                |
|                     | <b>19</b>                       | <b>8700</b>        | <b>43.5</b>                  | <b>8795.7</b>                         |
| <b>Truck Number</b> | <b>01-131 (Bangor-Modified)</b> |                    |                              |                                       |
| 2/1/2007            | 1                               | 280                | 11.43                        | 305.1                                 |
| 2/2/2007            | 3                               | 1120               | 45.72                        | 1220.6                                |
| 2/14/2007           | 5                               | 1925               | 78.57                        | 2097.9                                |
| 2/18/2007           | 1                               | 420                | 17.14                        | 457.7                                 |
| 3/2/2007            | 4                               | 1820               | 74.29                        | 1983.4                                |
| 3/5/2007            | 1                               | 385                | 15.71                        | 419.6                                 |
| 3/16/2007           | 3                               | 1470               | 60                           | 1602.0                                |
|                     | <b>18</b>                       | <b>7420</b>        | <b>302.86</b>                | <b>8086.3</b>                         |

## Beddington

| Storm Date          | # of Applications                   | Total Pounds /Mile | Total Gallons of Liquid/Mile | Total Salt Used Brine/Granular (Lbs.) |
|---------------------|-------------------------------------|--------------------|------------------------------|---------------------------------------|
| <b>Truck Number</b> | <b>01-157 (Beddington-Control)</b>  |                    |                              |                                       |
| 2/19/2007           | 3                                   | 1500               | 7.5                          | <b>1516.5</b>                         |
| 3/2/2007            | 4                                   | 1900               | 9.5                          | <b>1920.9</b>                         |
| 3/16/2007           | 3                                   | 1500               | 5                            | <b>1511.0</b>                         |
| 4/12/2007           | 2                                   | 1000               | 5                            | <b>1011.0</b>                         |
|                     | <b>12</b>                           | <b>5900</b>        | <b>27</b>                    | <b>5959.4</b>                         |
| <b>Truck Number</b> | <b>01-119 (Beddington-Modified)</b> |                    |                              |                                       |
| 2/19/2007           | 3                                   | 1050               | 42.86                        | <b>1144.3</b>                         |
| 3/2/2007            | 4                                   | 980                | 40                           | <b>1068.0</b>                         |
| 3/16/2007           | 3                                   | 1030               | 25.72                        | <b>1086.6</b>                         |
| 4/12/2007           | 2                                   | 630                | 25.71                        | <b>686.6</b>                          |
|                     | <b>12</b>                           | <b>3690</b>        | <b>134.29</b>                | <b>3985.438</b>                       |

## Carmel

| Storm Date                                   | # of Applications | Total Pounds /Mile | Total Gallons of Liquid/Mile | Total Salt Used Brine/Granular (Lbs.) |
|--|-------------------|--------------------|------------------------------|---------------------------------------|
| <b>Truck Number 01-165 ( Carmel-Control)</b> |                   |                    |                              |                                       |
| 2/2/2007                                     | 2                 | 600                | 1.8                          | 604.0                                 |
| 2/14/2007                                    | 4                 | 1400               | 4.2                          | 1409.2                                |
| 2/18/2007                                    | 1                 | 300                | 0.9                          | 302.0                                 |
| 3/2/2007                                     | 3                 | 1050               | 3.15                         | 1056.9                                |
| 3/5/2007                                     | 2                 | 750                | 2.25                         | 755.0                                 |
| 3/16/2007                                    | 2                 | 900                | 2.7                          | 905.9                                 |
| 3/20/2007                                    | 1                 | 300                | 0.9                          | 302.0                                 |
| 3/22/2007                                    | 1                 | 400                | 1.2                          | 402.6                                 |
|  | <b>16</b>         | <b>5700</b>        | <b>17.1</b>                  | <b>5737.6</b>                         |
| <b>Truck Number 01-432 (Carmel-Modified)</b> |                   |                    |                              |                                       |
| 2/2/2007                                     | 2                 | 420                | 17.14                        | 457.7                                 |
| 2/14/2007                                    | 4                 | 1050               | 42.86                        | 1144.3                                |
| 2/18/2007                                    | 1                 | 210                | 8.57                         | 228.9                                 |
| 3/2/2007                                     | 3                 | 1015               | 41.43                        | 1106.1                                |
| 3/5/2007                                     | 2                 | 770                | 31.43                        | 839.1                                 |
| 3/16/2007                                    | 2                 | 770                | 31.43                        | 839.1                                 |
| 3/20/2007                                    | 1                 | 280                | 11.43                        | 305.1                                 |
| 3/22/2007                                    | 1                 | 280                | 11.43                        | 305.1                                 |
|  | <b>16</b>         | <b>4795</b>        | <b>195.72</b>                | <b>5225.6</b>                         |

## Enfield

| Storm Date          | # of Applications                | Total Pounds /Mile | Total Gallons of Liquid/Mile | Total Salt Used Brine/Granular (Lbs.) |
|---------------------|----------------------------------|--------------------|------------------------------|---------------------------------------|
| <b>Truck Number</b> | <b>01-429 (Enfield-Control)</b>  |                    |                              |                                       |
| 2/2/2007            | 2                                | 550                | 2.75                         | 556.1                                 |
| 2/14/2007           | 3                                | 1200               | 6                            | 1213.2                                |
| 2/18/2007           | 1                                | 300                | 1.5                          | 303.3                                 |
| 3/2/2007            | 4                                | 1200               | 6                            | 1213.2                                |
| 3/5/2007            | 3                                | 800                | 4                            | 808.8                                 |
|                     | <b>13</b>                        | <b>4050</b>        | <b>20.25</b>                 | <b>4094.6</b>                         |
| <b>Truck Number</b> | <b>01-118 (Enfield-Modified)</b> |                    |                              |                                       |
| 2/2/2007            | 3                                | 910                | 37.14                        | 991.7                                 |
| 2/14/2007           | 2                                | 770                | 31.42                        | 839.1                                 |
| 2/18/2007           | 2                                | 490                | 20                           | 534.0                                 |
| 3/2/2007            | 2                                | 560                | 22.86                        | 610.3                                 |
| 3/5/2007            | 4                                | 875                | 35.71                        | 953.6                                 |
|                     | <b>13</b>                        | <b>3605</b>        | <b>147.13</b>                | <b>3928.7</b>                         |



## Pembroke

| Storm Date                                     | # of Applications | Total Pounds /Mile | Total Gallons of Liquid/Mile | Total Salt Used Brine/Granular (Lbs.) |
|--|-------------------|--------------------|------------------------------|---------------------------------------|
| <b>Truck Number 01-447 (Pembroke-Control)</b>  |                   |                    |                              |                                       |
| 2/3/2007                                       | 2                 | 800                | 3.2                          | 807.0                                 |
| 2/14/2007                                      | 6                 | 2100               | 6.4                          | 2114.1                                |
| 2/19/2007                                      | 2                 | 850                | 3.4                          | 857.5                                 |
| 3/2/2007                                       | 3                 | 1000               | 4                            | 1008.8                                |
| 3/16/2007                                      | 2                 | 600                | 2.4                          | 605.3                                 |
| 4/2/2007                                       | 1                 | 300                | 1.2                          | 302.6                                 |
| 4/3/2007                                       | 1                 | 300                | 1.2                          | 302.6                                 |
|  | <b>17</b>         | <b>5950</b>        | <b>21.8</b>                  | <b>5998.0</b>                         |
| <b>Truck Number 01-463 (Pembroke-Modified)</b> |                   |                    |                              |                                       |
| 2/3/2007                                       | 3                 | 910                | 37.14                        | 991.7                                 |
| 2/14/2007                                      | 6                 | 2310               | 61.42                        | 2445.1                                |
| 2/19/2007                                      | 2                 | 770                | 31.42                        | 839.1                                 |
| 3/2/2007                                       | 3                 | 980                | 40                           | 1068.0                                |
| 3/16/2007                                      | 3                 | 945                | 38.58                        | 1029.9                                |
| 4/2/2007                                       | 1                 | 315                | 12.86                        | 343.3                                 |
| 4/3/2007                                       | 1                 | 245                | 10                           | 267.0                                 |
|  | <b>19</b>         | <b>6475</b>        | <b>231.42</b>                | <b>6984.1</b>                         |

## Summary

| Control Units         | Gallons<br>of<br>Liquid | Total<br>Pounds/Mile | # of Valid<br>Storm Reports | Average Pounds                 |   |
|-----------------------|-------------------------|----------------------|-----------------------------|--------------------------------|---|
|                       |                         |                      |                             | Per Mile<br>Per Reported Storm | Total Pounds/Mile<br>Assuming 30 Events |
| 01-420 ( Bangor)      | 43.5                    | 8795.7               | 7                           | 1256.5                         | 37695.9                                 |
| 01-157 (Beddington)   | 27                      | 5959.4               | 4                           | 1489.9                         | 44695.5                                 |
| 01-165 ( Carmel)      | 17.1                    | 5737.6               | 8                           | 717.2                          | 21516.1                                 |
| 01-429 (Enfield)      | 20.25                   | 4094.6               | 5                           | 818.9                          | 24567.3                                 |
| 01-447 (Pembroke)     | 21.8                    | 5998.0               | 7                           | 856.9                          | 25705.5                                 |
| <b>Totals</b>         | <b>129.7</b>            | <b>30585.2</b>       | <b>31</b>                   | <b>986.6</b>                   |   |
| <b>Modified Units</b> |                         |                      |                             |                                |   |
| 01-131 (Bangor)       | 302.86                  | 8086.3               | 7                           | 1155.2                         | 34655.5                                 |
| 01-119 (Beddington)   | 134.29                  | 3985.4               | 4                           | 996.4                          | 29890.8                                 |
| 01-432 (Carmel)       | 195.72                  | 5225.6               | 8                           | 653.2                          | 19595.9                                 |
| 01-118 (Enfield)      | 147.13                  | 3928.7               | 5                           | 785.7                          | 23572.1                                 |
| 01-463 (Pembroke)     | 231.42                  | 6984.1               | 7                           | 997.7                          | 29932.0                                 |
|                       | <b>1011.4</b>           | <b>28210.1</b>       | <b>31</b>                   | <b>910.0</b>                   |   |