



Maintenance Research Unit
Statewide Biannual Report

2003-2005

July 2003 - June 2005



Minnesota Department of Transportation

Office of Maintenance—Operations Section

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I. Acknowledgements

In this ever-changing world opportunities abound which may better our lives, provide for our families, and improve our workplaces. However, this cannot occur without someone moving forward and taking that first step, research.

The Mn/DOT Maintenance Operations - Research Unit appreciates this opportunity to recognize all District personnel who participated in current and past NTREC/MOR projects. These are the individuals that make our program successful. The articles contained herein are a minute portion of the overall accounting of MOR funded projects since its inception in the early 1990's. Successful projects have been numerous and many are in place as Mn/DOT standards today.

A great benefit has also been realized through partnerships with other research organizations. The University of Minnesota Center for Transportation Studies is just one which deserves recognition in this acknowledgement. Other benefits that should be mentioned are the sound working relationships with the Mn/DOT Traffic Office, Maplewood Materials Lab, Environmental Services, Work Zone Safety, and Fleet Management. Equally important are the members of the NTREC Committee and the variety of offices that they represent. They are a great asset to this program. It is difficult to list all so we are best served by expressing our sincere gratitude to the others.

There are few (if any) constants in this world making change inevitable. Research is the first step on the pathway to success and positive improvement during these uncertain economic times.

Thank you,

Mn/DOT Maintenance Operations – Research Unit

II. Maintenance Operations Research Program

Report Purpose

The purpose of this report is to document the maintenance operations research project activity from July 2003 to June 2005. Due to the large number of projects, this report is not able to cover each in detail; it is more geared towards providing an overview. This Statewide Biannual Maintenance Operations Research Report is intended to be a useful resource and guide for all levels of maintenance personnel and others interested in maintenance research.

Program History

In 1990, Mn/DOT Area Maintenance Engineers (AME), realizing the increasing need for optimal expenditure of resources, committed \$750,000 annually from the statewide maintenance operations budget to maintenance operations research. This was seen as necessary since despite the shrinking workforce and budget, the traveling public continued to expect the same or even better level of service. A full-time Maintenance Operations Research Engineer position was created to direct the program. This position was first filled in May, 1992. The Maintenance Operations Research Engineer (MORE) works closely with the New Technology Research and Equipment Committee (NTREC), Mn/DOT's Office of Research Services (ORS), Office of Materials Research & Engineering (MR&E), and other Mn/DOT offices. Having such an operating unit within Mn/DOT that funds and administers its own research initiative is considered unique nationally and internationally. It is unfortunate that the program has suffered reductions in funding and staffing of the program in the past several years.

Program Goals

The goal of the Maintenance Operations Research Program is to maintain an active and visible research effort that involves all Mn/DOT maintenance areas. The program addresses all elements of maintenance operations including snow and ice control technology, roads and bridge maintenance, roadside maintenance, maintenance management, general maintenance, work zone safety, electrical maintenance, as well as technology transfer. It seeks to develop the most effective maintenance procedures, materials and equipment and to build on research conducted or supported by other agencies, other states, Federal Highway Administration (FHWA), Local Road Research Board (LRRB), Transportation Research Board (TRB), academia, other countries, and private industry.

Program Focus

The Maintenance Operations Research Program focuses on "on the road" or applied research. It takes developed methods, materials, products or prototypes out on the road and field-tests them in an array of environments, varying weather conditions, assorted traffic volumes, and more. An emphasis is placed on innovation and encourages the submission of project proposals from all levels of Mn/DOT maintenance personnel.

Truck station personnel, university persons with Mn/DOT sponsors, Lab and Materials personnel, and the Maintenance Research Staff have all sponsored or submitted proposals for projects.

The objective is for statewide or individual maintenance area implementation of successful processes and methods as well as to acquire and use any equipment or material developed through this research. The program’s primary research effort is to take a preferential look at projects that take a preventive stance instead of reactive.

Project Approval and Funding

The 2005 fiscal year budget committed to maintenance operations research through Mn/DOT was \$470,000 which includes salaries. The program involves large research projects which may have funding approved for over two or more fiscal years, as well as spontaneous “skunk work” type projects costing less than \$12,000. Research proposals with funding requests of more than \$12,000 are considered for approval by NTREC. NTREC typically meets twice a year to consider project proposals submitted to MORE. MORE (Maintenance Operations Research Engineer) has individual authority to authorize projects costing less than \$12,000.

Topic	# Projects	Dollars
Winter Maintenance	12	\$174,000
Winter Material	5	\$19,000
Road and Bridge Maintenance	7	\$272,000
Safety, Traffic Control and Work Zone Safety	15	\$104,000
Roadside Maintenance	9	\$127,000
Equipment Tools	17	\$207,000
Total	65	\$903,000

District	# Projects	Dollars
1	2	\$62,000
2	2	\$6,000
3	5	\$14,000
4	7	\$45,000
Metro	10	\$94,000
6	11	\$84,000
7	8	\$106,000
8	4	\$13,000
M.O.R	16	\$479,000
Total	65	\$903,000

Research Criteria

A set of criteria was developed with assistance from NTREC. It is used to ensure that the proposals submitted meet the goals and the purpose of the program. The criteria subjects are as follows:

1. Statewide Implementation/Technology Transfer
2. Safety (Public and Employee)
3. Potential Return
4. Innovation
5. Matching Resources
6. Priority to Mn/DOT Maintenance
7. New to Mn/DOT Maintenance
8. Mn/DOT proposal

These criteria are further detailed in the NTREC Manual of Procedures and may change to meet the needs of the program.

Summary of Maintenance Research Projects

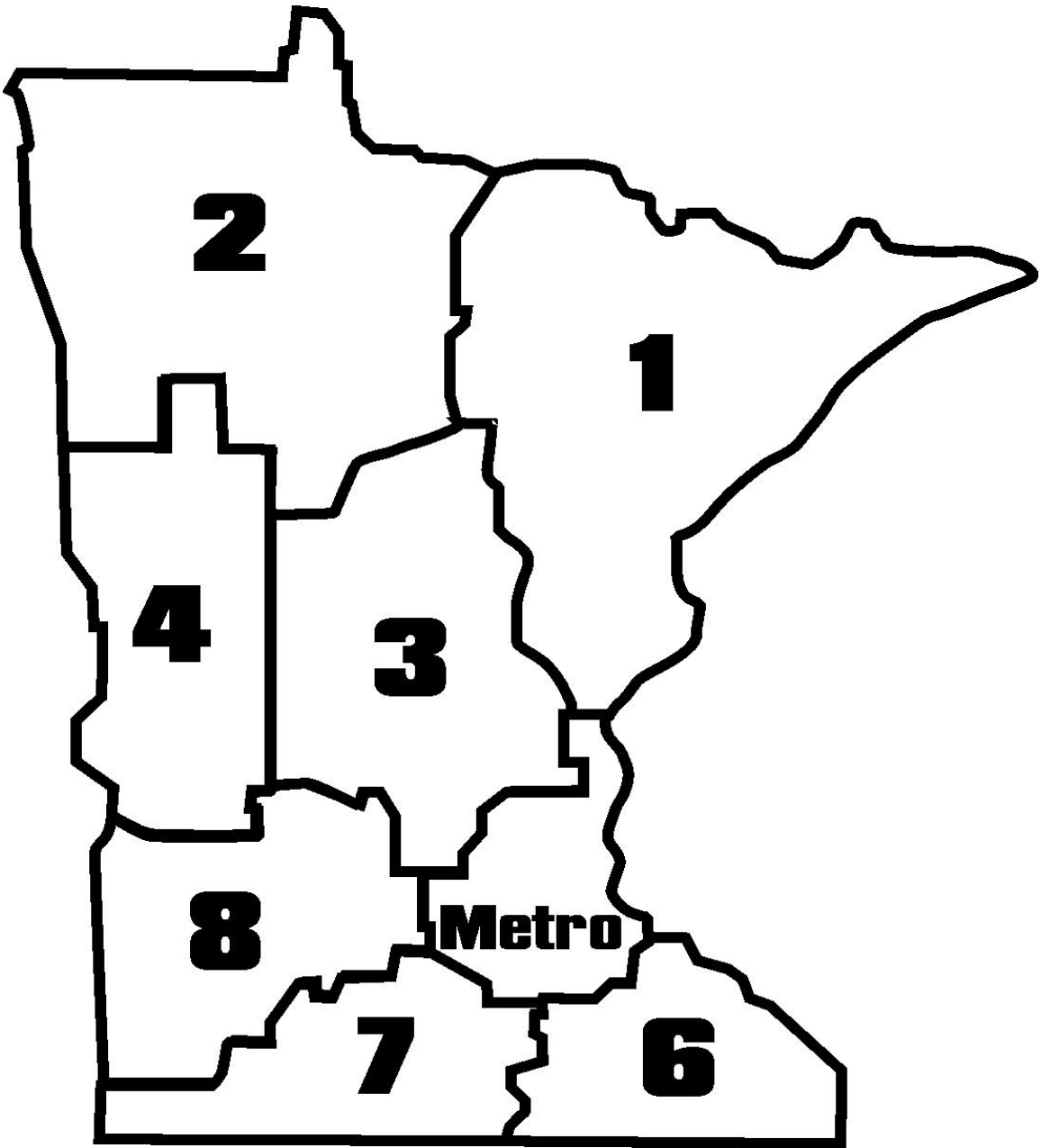
This report consists of completed and on-going projects from July 2003 to June 2005. Projects are in the areas of Winter Maintenance, Winter Chemicals, Road and Bridge Maintenance, Traffic/Work Zone Safety, Roadside Maintenance, and Equipment/Tools. Individual projects are summarized in the following section. Identical projects may be summarized as one project although it may have been conducted in more than one district.

The New Technology Research Executive Committee (NTREC) oversees all research funds. This group is made up of approximately twenty members who represent many factions in the Transportation Department.

In this report you will locate a general overview of each project; the project contact is listed for further information.



<http://wwwdev.dot.state.mn.us/maint/research.htm>



Minnesota Department of Transportation Districts

The Importance of District Research and Development Committees

The 2004-2005 Maintenance Research Program witnessed many changes both with the Maintenance Research program and within Mn/DOT itself. Budget cuts, personnel changes, responsibilities, and program directions, created an atmosphere of uncertainty. However, also through this time period, the Research Unit found new importance in the job at hand and in past accomplishments. Seen was a renewed vigor in research, development, and interest in the implementation of successful projects from the past.

District personnel from all areas continued their interest by applying for funds with new proposals for research. Probably one of the most outstanding and important things to take place in this venue was the continuation of the Research and Development Committees in several of Mn/DOT Districts. As a result of these committees, the R & D concept was kept in front of all of their fellow employees. This created a comfortable avenue for projects to spring to life through the MOR Program and receive funding. Rewards to the individual districts were many as well as the knowledge gained which benefits all of Mn/DOT, and in turn, the State of Minnesota.

MOR Representatives make every attempt to attend the District R & D Meetings and to offer assistance when possible. Supplying information and answering questions in regards to the inner workings of the MOR Program gives committee members a clear and precise understanding of the proposal and the funding process. Information can then be easily shared with others in the district, which results in a renewed vigor and participation with R & D.

MOR highly recommends the formation of District R & D Committees. Due to the number of project proposals submitted and the success of projects by the few existing ones, it is readily apparent that great importance lies within them.

John Tarnowski
Maintenance Research Project Manage

III. Winter Maintenance

Dultmeier Brine Production

Sponsor: John Shallow

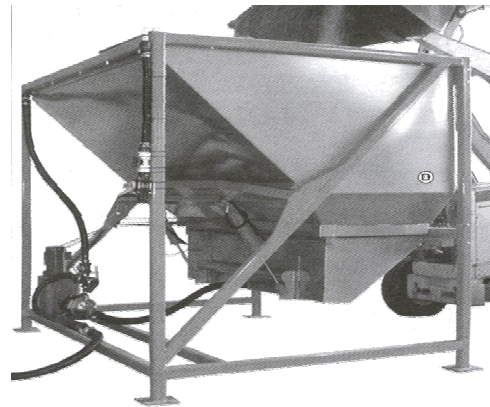
District/Office: District 1A – Pike Lake

Project Contact:

John Shallow (218) 729-3946

Project Cost: \$5,850

Funding Source: MOR



Background: Up until this point space has been limited for a brine production system in the Duluth Sub-area. The new facility at Pike Lake has a building in place for such a system and would eliminate the need for trucking in brine from other facilities.

Purpose: This project is to evaluate a new brand and type of production system that is not currently in use by Mn/DOT locations. This unit features a new and unique clean out design.

Test Procedure: The brine system will be set up at the Pike Lake shared facility. Performance will be monitored as to meeting the demands of use and also for the clean out capabilities. Operators will be asked to comment on use of the system and its operation.

Results: The brine production unit worked well. We had one problem with it when the float stuck in the open position. After the initial repair no other problems were detected. Cleaning out the production system is much faster. Considerable time is saved although care must be taken when performing this task so the unit is not damaged.

Recommendation: This brine production system would perform well at any facility and reduce the labor necessary for cleanout maintenance.

Status: Closed

Expansion and Implementation of Anti-ice Methods

Sponsor: Tim Sheehy

District/Office: Virginia

Project Contact:

Tim Sheehy (218) 747-7793

Project Cost: \$10,626

Funding Source: MOR



Background: Many new chemicals in the field of snow and ice control have been introduced and are now on the market. The question of whether or not a complete liquid program would perform better than the traditional granular method needs to be explored.

Purpose: Project will test, evaluate, and compare the results of both liquid and solid chemicals in a side by side winter environment.

Test Procedure: Liquid anti-icing and de-icing will be accomplished using only a magnesium chloride product with a corrosion inhibitor added. Another section of the same highway will be treated with granular material only. Both salt and a salt/ sand mixture will be utilized for this purpose. This test will be completed at the end of one winter season.

Results: The liquid only route proved to be 11 percent more costly when compared to the granular route. The data also showed that regain times were similar. The liquid only treatments were feasible in the far northern areas of Minnesota. Several customers were concerned that the wet roadways left a mess on their cars and that it was slippery when first applied.

Recommendations: This project proved that an all liquid chemical arsenal could be used in northern Minnesota winters with a comparable effectiveness as granular. Another evaluation will have to be completed in an area with high sweeping costs to determine if the liquid method can reduce this and render the overall cost more effective.

Status: Closed

Anti-icing Unit and Geomelt M

Sponsor: Curt Larson/Herb Nelson

District/Office: Roseau D-2/Morris –D4

Project Contact:

Curt Larson (218) 463-2821
Herb Nelson (320) 589-7300

Project Cost: \$6,265.18

Funding Source: MOR



Background: Anti-icing is becoming more common place in Minnesota. The implementation in rural areas leads to several challenges that rarely are encountered in the more heavily populated areas. Also new chemicals have become available which need to be evaluated for their possible use in these rural areas.

Purpose: To explore advances in anti-ice equipment, a new chemical, and the implementation of this practice in rural areas.

Test Procedure: The equipment will be evaluated for durability and user friendliness. Operators will be asked to complete field test reports and comment on the use of the equipment and practice.

Results: The equipment and practice had some drawbacks like tracking of chemical, minor equipment problems, foaming, but overall showed promise. This project has officially ended, however we will continue to work with anti-icing and the equipment. A different chemical is being looked at for next season. (Note: Geomelt M is located in a different part of this report.).

Recommendation: We feel that more work needs to be done to gain knowledge and experience with anti-icing. We have seen some benefits but would like to explore its use in other areas and conditions. The sprayer and hose unit that came with the anti-ice unit will explored for possible weed and vegetation spraying this summer. Overall this was a good unit and would work well for any small to medium anti-ice operation.

Status: Closed

Anti-icing Unit

Sponsor: Lee Purdham/Jim Anderson

District/Office: Baxter/Brainerd 3A

Project Contact:

Jim Anderson (218) 828-2174

Project Cost: \$6,000

Funding Source: MOR



Background: Anti-icing is being used in most Mn/DOT Districts with some degree of success and benefits. To further complement our winter maintenance arsenal and explore the anti-icing process we are interested in this system.

Purpose: Evaluate and collect data in regards to the anti-icing process and add to Mn/DOT's growing implementation and use of this activity.

Test Procedure: The anti-ice unit was used to disperse salt brine on bridge decks and in other critical areas that were prone to frost build-up. The treated areas were then monitored for frost build-up and other slippery conditions.

Results: The overall operation of the unit was good. Salt brine worked well at temperatures above 20 degrees F. There were some limitations in the unit's capacity however we did use it to pre-treat hazards and bridge decks. We did feel there was a labor and material savings through the use of anti-icing. This project has officially ended, however we plan to increase our effort with anti-icing in the future.

Recommendation: The anti-ice unit proved to be particularly useful early and late in the winter season when frost is most likely to form. We do have concerns relating to the construction of the unit itself. We feel that several parts of the unit should have been manufactured out of a more corrosion resistant material, possibly stainless steel.

Status: Closed

Joma 6000

Sponsor: Terry Newgard

District/Office: District 3B, St. Cloud

Project Contact:

Terry Newgard (320) 983-6789

Project Cost: \$4,000

Funding Source: MOR



Background: Carbide cutting edges for plows are a huge expense for Mn/DOT each winter season. Getting the most from these edges without risking damage to the plow reduces both time and material costs. The Joma blades were tried in another MOR project several years ago with less than desirable results. As a direct result of the previous evaluation, changes have now been made that show promise in eliminating the negatives previously encountered.

Purpose: The Joma 6000 cutting blade project will re-evaluate the blades to determine if new changes have increased their durability.

Test Procedure: The blades will be installed on a plow truck and run in a side by side comparison with our current standard carbide cutting edges. Miles and hours of use of both will be monitored and recorded. Operator comments will be recorded and visual observations will be made. On board counters will keep track of the plow up and down modes while in operation.

Results: Project to start in the plow season of 2004/2005

Recommendations: A determination and recommendation will be made upon completion of the project

Status: Active

Salt Brine Injection

Sponsor: Randy Glaser

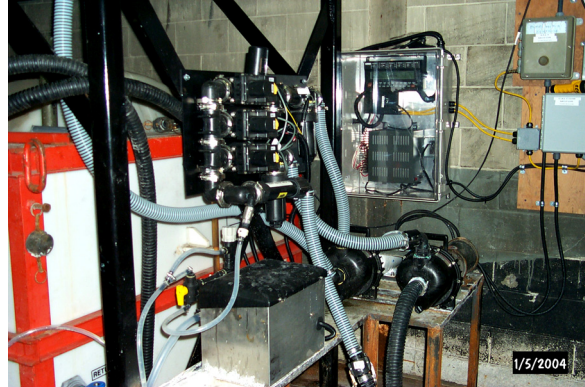
District/Office: District 7A Mankato

Project Contact:

Randy Glaser (507) 389-2848

Project Cost: \$7,200

Funding Source: MOR



Background: A 10% calcium chloride solution added to salt brine can reduce the working temperature of the brine 3 to 7 degrees. The higher percentage added, the lower the working temperature will be making the brine even more effective in freezing temperatures. However, there are problems with mixing and blending that make quality control a difficult procedure in the field.

Purpose: To demonstrate how an advanced mixing injection system can be used to carefully blend different approved chemicals for winter maintenance.

Test Procedure: This system will be set up and will mix the chemicals before they enter the truck mounted tanks. The solution use will be recorded and all regain times will be compared against similar areas where injection is not used for mixing. This procedure will go on for at least one winter season and possibly two until enough data has been received to reach a conclusion as to its use.

Results: A final report will be completed at the end of the project

Recommendation: Upon project is completion

Status: Active

Pre-wet Tanker

Sponsor: Randy Glaser

District/Office: District 7E Mankato

Project Contact:

Randy Glaser (507) 389-2848

Project Cost: \$12,000

Funding Source: MOR



Background: Anti-icing has proven its ability to effectively provide an additional tool in the mechanics of snow and ice control. The biggest drawback encountered in this area is how to apply at a greater application rate and speed to help reduce the impact on traffic flow.

Purpose: Explore the use of a semi tanker as a means to apply anti-icing solution at higher rates and at a greater speed than has previously been accomplished.

Test Procedure: A special high capacity pump and spray bar system will be used for this project. Mounted on a stainless steel semi tanker it will deposit materials at different speeds and rates. Effectiveness will be determined by comparing the treated routes with the results and regain times of routes that did not receive the treatments. Operator comments will be recorded and evaluated throughout the project.

Results: A final report will be completed after the winter season of 2004-2005

Recommendations: To be included in final project report

Status: Active

Dual Carbide Underbody Edges

Sponsor: Dave Schettler

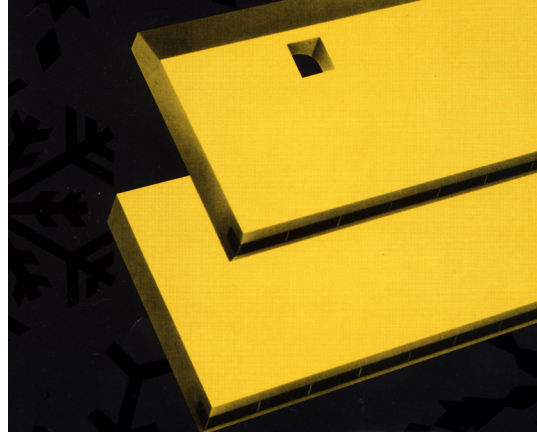
District/Office: Windom District 7W

Project Contact:

Dave Schettler (507) 831-1224

Project Cost: \$4,200

Funding Source: MOR



Background: There are many different carbide cutting edges available that make claims to last longer and be more cost efficient than the standard carbide edge Mn/DOT currently uses. Some have different style carbide inserts, some have dual carbide inserts, and there are others depending on the manufacturer. It is very difficult to determine if the new style edges really are better or more efficient.

Purpose: To select several different carbide edges and put into use at the same time. They will be used for underbody plowing on routes that have very similar road surface materials and will be located close together to hopefully produce the same basic weather conditions.

Test Procedure: The carbides will be mounted and the project will commence at the same time. Although it will not be possible to determine an exact length of time for wear, the estimated miles and hours used for plowing will be monitored and recorded.

Results: After the first season of use the edges are holding up well. None have had to be replaced. This project will continue through the 2004-2005 season and then reviewed. This project will continue until enough information has been collected to make a decision about the longevity of these blades.

Recommendations: Will be included in final project report

Status: Active

Hydraulic Wing Push Arm

Sponsor: Craig Gertsema

District/Office: District 8 - Willmar

Project Contact:

Craig Gertsema (507) 836-6738

Project Cost: \$3,000

Funding Source: MOR

Background: As roads and shoulder areas get wider it is becoming more difficult to plow the driving lanes in one pass. Currently we are using a 51 inch push arm that is set which limits any adjustment. By simply adding to their length would add undo stress to the unit and result in damage to the equipment.

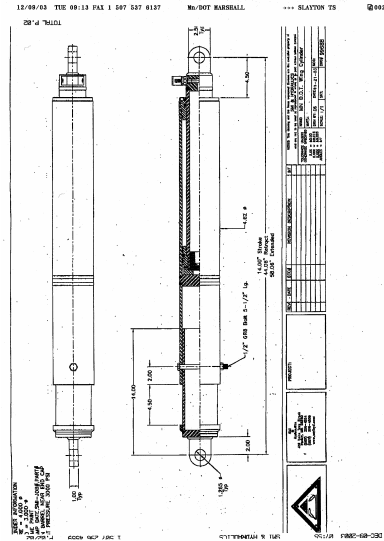
Purpose: Design and then enlist an outside vender to construct a push arm that would be a self contained shock absorber type of arm. This is intended to allow for a wider plowing pass without resulting in damage if an object is struck unintentionally. The push arm would be adjustable lengthwise to be better suited for varying areas and conditions.

Test Procedure: The only way to test and evaluate this project is to install several of these specially constructed push arms and use them under actual plowing conditions by several different operators and in varying locations. This project is scheduled to begin during the winter of 2004-2005.

Results: Final report and conclusion will be issued upon close of project

Recommendation: To be included in final report

Status: Active



KT-90 Active Adapters

Sponsor: George Bowman

District/Office: District 8, Willmar

Project Contact:

George Bowman (507) 537-3615

Project Cost: \$3,000

Funding Source: MOR



Background: Carbide cutting edges are expensive but a necessity for Mn/DOT to accomplish an effective plowing operation. Much time is spent installing new carbide edges as well as other costs in hardware and materials. Longevity of carbide edges is crucial in keeping costs to a minimum.

Purpose: To evaluate and determine if using a flexible shock absorbing mounting system will increase life of cutting edges. And will the extended life period be long enough to justify the additional costs of the system.

Test Procedure: The Active Adapters will be installed on several plow trucks with new cutting edges. They will be compared both in hours used and miles accumulated before replacement is necessary to standard edges.

Results: A final report will be issued summing up the project and worth of the adapters.

Recommendation: A recommendation will be included in the final report whether or not to continue uses or implementation of this system.

Status: Active

Transfer Pump Station

Sponsor: Mark Fischbach
Joel Dixon

District/Office: Metro District – Waters Edge

Project Contact:

Mark Fischbach (651) 582-1429
Joel Dixon (651) 779-5209

Project Cost: \$4,517.17

Funding Source: MOR

Background: Currently liquid storage tanks in the Metro District have internal pumps for transferring the liquid de-icing chemicals. Over the past two years numerous problems have required the replacement and repair of many of these. This poses a difficult and sometimes dangerous task for our personnel because of the location of the pump and the method needed to perform the repairs.

Purpose: An external chemical transfer pump may prove to be more economical and safer to use. This project will look at the possibility of additional safety and ease of maintenance of the new pumps.

Test Procedure: One of the stations and pump systems will be installed at the Mendota Heights Truck Station near the liquid storage tank. Its performance and reliability will closely be monitored. Operator comments as to the use and filling times will be recorded.

Results: All operators of the system were very pleased with the reliability and performance of the automated transfer pump station.

Recommendations: Our recommendation is that these systems are a good replacement for internal pumps. The Metro District will be installing more transfer pump stations in the near future.

Status: Closed



Slap Me Wipers

Sponsor: Alan Lightfoot

District/Office: Metro District – North Branch

Project Contact:

Alan Lightfoot (651) 237-0479

Project Cost: \$4,000

Funding Source: MOR



Background: During snow and ice operations it can be extremely difficult to keep freezing precipitation from building up on the wiper blades. This causes impaired vision and presents a dangerous situation. Cleaning off the snow and ice can also be dangerous for the operator since it usually requires hanging from the side of the truck while standing on unsafe footing areas.

Purpose: To evaluate a new product that uses air pressure to raise wiper away from the windshield and “slap it” back in place. The effect of this motion is intended to break off and dislodge the snow and ice without causing damage to the windshield. This would then allow the wipers to resume their proper function resulting in a clear windshield.

Test Procedure: Five sets of these wipers will be installed and used throughout the winter season of 2004-2005. Operators will monitor their effectiveness in clearing the frozen precipitation. This project is to begin during the winter of 2004-2005 and end in the spring of 2005.

Results: After enough data has been collected a final project report will be issued

Recommendations: To be included in the final report

Status: Active

Quick Edge Replacement

Sponsor: Steve Hufnagle

District/Office: District 2, Thief River Falls

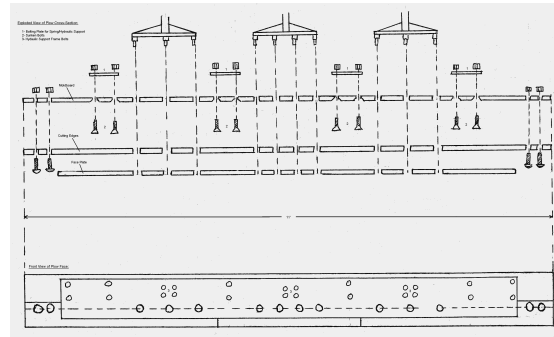
Project Contact:

Craig Shankwitz U of M (612) 625-0323

Michael Etheridge U of M

Project Cost: \$10,316

Funding Source: MOR



Background: Changing underbody plow cutting edges is a routine maintenance procedure that must be accomplished at the right time. This prevents damage to the mold board of the plow and also insures that maximum life is achieved from the carbide edges.

Purpose: The investigator's aim is to create and evaluate a new system for replacement of cutting edges on underbody plows. This new design should decrease effort and reduce risk of injury for this procedure.

Test Procedure: This system will be designed, constructed, and installed on an underbody plow in the Metro area. It is to be used under actual working conditions plowing and scraping frozen precipitation off of highway surfaces throughout the winter season. The design and construction will be evaluated for sturdiness and durability. Ease of cutting edge changes will be determined by the operators.

Results: There are no results at this time to report. This project has begun and will continue through the winter of 2004-2005. Depending on the time and weather for data collection it may be continued into the winter of 2005-2006.

Recommendation: Recommendations will be included in the final report

Status: Active

Mobile Anti-ice System

Sponsor: Mark Fischbach

District/Office: Metro – Waters Edge

Project Contact:

Mark Fischbach (651) 582-1429

Project Cost: \$7,500

Funding Source: MOR



Background: Anti-icing has proven itself as a valuable tool in snow and ice control. At the present time budget restraints and other reasons prevent us from expanding our program to cover a broader range of high traffic crash areas. This mobile system may help provide a higher level of safety in critical locations until a more permanent solution can be found.

Purpose: To test and evaluate a new mobile anti-ice system that promises to perform an anti-icing procedure for critical areas and is easily movable to other locations.

Test Procedure: This system will be set up on a traffic lane that is plagued with crashes due to slippery driving conditions. Snow and ice and also frost have often been a contributing factor. Crashes will be monitored and recorded throughout the winter trial season and the results will be compared to existing data from previous years. Although weather conditions will not be identical a fairly good picture of the effectiveness of the unit should emerge. Reliability and maintenance of the unit will be recorded and reported.

Results: The project will start during the Fall of 2004 and continue until spring of 2005

Recommendation: A recommendation will be included in the final project report.

Status: Active

IV. Winter Material

Cargill Clear Lane

Sponsor: Monica Hendrickson

District/Office: District 1 – Moose Lake

Project Contact:

Steve Aldrin (218) 485-5425

Project Cost: \$5,000

Funding Source: MOR



Background: Enhancing the performance of sodium chloride for winter maintenance has been an issue for many years. A lower working temperature and a reduction in corrosive properties would add to what has long been known as the main snow and ice melting chemical.

Purpose: This evaluation will compare the properties of a pre-treated salt product to the regular sodium chloride that we currently use. An attempt will be made to compare this new product to on-board pre-wetting with salt brine for similar effects

Test procedure: This product will be used for snow and ice activities and the results, operator comments, and bare lane times will be recorded and compared.

Results: The treated salt showed some promise when compared to pre-wetted salt. The operators felt that time were saved by not filling brine tanks; they could just fill their truck boxes with material and go. From visual observation it appeared that this had the same amount of bounce and scatter as pre-wetted salt. However, our pictures did not turn out. On December 27, 2003 the road to the North and the one to the South of the test section froze over and needed more chemical applied but the treated area stayed wet. When two pieces of epoxy coated rebar were used for a corrosion test, the one in the clear lane turned black but did not show any sign of blistering like the one in brine after two months.

Recommendations: Clear Lane has proven itself as an additional tool to use for winter maintenance. This appeared to be a comparable product to rock salt and at a reduced rate. A more detailed evaluation will have to be completed and we recommend further analysis of this product if possible.

Status: Closed

Geomelt M

Sponsor: Curt Larson/ Herb Nelson

District/Office: Roseau D2, Morris D4

Project Contact:

Curt Larson (218) 463-2821
Herb Nelson (320) 589-7335



Project Cost: Included in Anti-icing Project

Funding Source: MOR

Background: Anti-icing is being used more widely and new chemicals are being introduced each season. These new chemicals need to be evaluated for their cost effectiveness and for the ability to assist in providing the service levels that our customers expect.

Purpose: This project is being conducted both to continuing the introduction of anti-icing and also to evaluate a new chemical to Minnesota. This product is a result of the sugar beet industry which is prevalent in western Minnesota.

Test Procedure: The chemical will be used in different applications for anti-icing the road surface. Regain times to bare pavement will be monitored and compared to non-anti-iced areas. Operator comments will be recorded as to effectiveness of chemical in preventing the bond of the freezing precipitation. Pavement will also be monitored for the residual effect of the chemical in preventing frost in problem areas.

Results: Geomelt M worked well for frost prevention and for early anti-icing application. It did allow the road to be plowed cleaner the first time around. There were foaming problems when pumping the material and filling tanks. Also when temperatures dropped too low it became hard to pump and nozzle sizes had to increase. Because of the windy locations of this trial there were tracking problems associated with its use that sometimes reached as far as one half mile causing refreeze.

Recommendation: If the foaming problems could be remedied this would be a good product for anti-icing and frost prevention down to certain temperatures. For very cold temperatures it would have to be thinned out to remain viscous which may have other negative effects on its use.

Status: Closed

Geomelt

Sponsor: Dave Redig

District/Office: Rochester, D-6E

Project Contact:

Dave Redig (507) 285-7361

Project Cost: \$5,000

Funding Source: MOR

Background: Many new chemicals are introduced to the market each year to be used for snow and ice control. Reduced environmental concerns, less corrosion, and a wider range of effective working temperatures are some of the reasons that are addressed through these. This product when mixed with salt brine for on-board pre-wetting promises to do all of the above.

Purpose: To test and evaluate this chemical mixed with salt brine in producing a superior winter maintenance chemical used for pre-wetting.

Test procedure: The Geomelt liquid will be introduced into the salt brine utilizing an adjustable chemical mixing apparatus. The mixtures will be recorded and monitored closely by reviewing operator observations and bare lane regain times. Frost prevention will also be watched for visually and compared to prior years' experiences.

Results: Project has not started at time of report. Project will begin at the start of the winter season and end in the spring of 2005.

Recommendation: Determinations in regards to continued use of this project will be made in the final project report.

Status: Active



LCS 5000

Sponsors: Tom Fergusson

District/Office: Albert Lea Truck Station/D-6B

Project Contact:

Tom Fergusson (507) 433-0554



Project Cost: \$7,745

Funding Source: MOR

Background: With concerns for more environmentally friendly chemicals for snow and ice control on the rise, new chemicals have to be researched and evaluated. Anti-corrosive properties are very important and the residual effects can be very beneficial for frost prevention.

Purpose: This project will explore LCS (liquid corn salt) in an attempt to make a determination of the cost effectiveness of this new product.

Test Procedure: The LCS will be used throughout the district in several different processes and procedures. It will be used for pre-wetting, anti-icing, and for the pre-treatment of stockpiles.

Results: We saw no significant difference in regain times however there was a significant reduction in material usage when used as a pre-treatment for stockpile wetting. We feel that this product has shown enough promise that we plan to use it again next winter season.

Recommendation: This product should be evaluated and tested further for use as a winter maintenance chemical.

Status: Closed

Andersons Additive

Sponsor: Randy Glaser

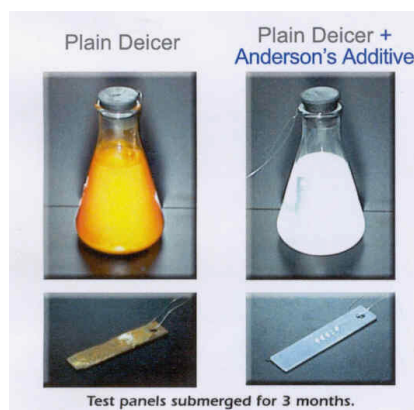
District/Office: Mankato/District 7E

Project Contact:

Randy Glaser (507) 389-2848

Project Cost: \$5,000

Funding Source: MOR



Background: Salt brine is still the most inexpensive liquid chemical for snow and ice control. However it does have several negative qualities. The Eutectic temperature is minus six degrees Fahrenheit and it can be quite corrosive to ferrous and non-ferrous metals alike.

Purpose: MOR has funded a chemical mixing system for us in the past. What we are proposing to do is to utilize this system for further research in enhancing salt brine and custom blending it to reduce its corrosive properties and to lower its working temperature range.

Test Procedure: Salt brine will be blended with an inhibited calcium chloride to lower its working temperature. It will also be blended via the chemical mixing system with Anderson's Chemical which will reduce the corrosiveness of the salt brine and enhance even further the melting and anti-icing properties.

Results: Project has started and is to continue until spring of 2005

Recommendation: When enough data has been collected to complete a final project report a recommendation will be made.

Status: Active

V. Road and Bridge Maintenance

Top Down Cracking

Sponsor: Bill Zerfas

District/Office: Mn/DOT Material Lab

Project Contact:

Bill Zerfas (651) 779-5289

Project Cost: \$15,000

Funding Source: NTREC



Background: Pavement rehabilitation has long been the method for getting the most from road surfaces at a cost affordable price. With the cost of pavements increasing each day it is imperative that materials are explored which promise to extend life expectancy.

Purpose: This project will compare the use of several products that are used to repair transverse cracks in road surfaces before a surface treatment is applied. They will also be evaluated for their performance in repairing wheel paths before the surface treatment.

Test Procedure: Several products will be used for this purpose in test sections set up at Mn/Road. The sections will be monitored for signs of the re-appearance of transverse cracking. Wheel path sections will also be included.

Results: Project has started and will conclude after enough time has elapsed to make a determination on the use of these test materials.

Recommendation: Final report is to include recommendations as to the use of these materials.

Status: Active

GPS-GIS Edge Drain Mapping

Sponsor: Jerry Miller

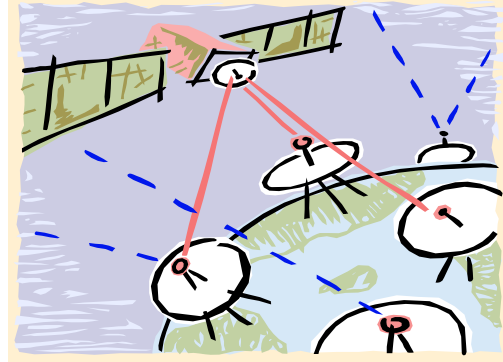
District/Office: Morris D-4

Project Contact:

Shannon Wait (320) 763-5045

Project Cost: \$20,000

Funding Source: NTREC



Background: As budget deficits continue to cut deeper into operating funds it becomes more imperative to use resources to the best of our ability. Traditionally edge drains must be monitored for damage or possible failure each year. The question to be asked is, “Is this amount of coverage necessary?” Could much of this time be deleted if only the potential or problem areas be identified?

Purpose: GPS will be used to map and identify edge drains that need or will need repair or maintenance and when. This can then be monitored for failure rate and also information can be used to determine actual resources needed to maintain the drainage system.

Test procedure: The drains will be mapped and recorded as to repairs/maintenance required and the potential for future maintenance. The percentage of correct information recorded can then be used to determine where and when costs will be acquired.

Results: There are no results to report at this time. Project has started and will be on-going for several seasons until enough information has been accumulated and determinations of accuracy can be made.

Recommendation: A recommendation will be made upon completion of the project

Status: Active

Bituminous Thermal Crack Repair

Sponsor: Gordon Regensheid

District/Office: Mankato D-7E

Project Contact:

Steve Oakey

Gary Martinson (507) 389-6858

Project Cost: \$12,000

Funding Source: NTREC



Background: There are many miles of bituminous roadways that are not meeting customer criteria do mainly to thermal cracks creating a rough ride. This is unacceptable by consumers and repairs need to be completed.

Purpose: This project proposes to repair thermal cracking using several different premium materials instead of treating the entire surface area with a re-surfacing method.

Test Procedure: A section of highway will be set aside for each repair material used in this evaluation. The material will be monitored for ease of use, quality and longevity of repair, and ride-ability.

Results: Bi-yearly evaluation for ride and structure will be accomplished periodically. Project has started and is on-going.

Recommendation: The final report on this project will contain recommendations as to which product has proven it to be most advantageous to use.

Status: Active

Tailgate Paver

Sponsor: Randy Glaser

District/Office: Mankato D-7E

Project Contact:

Randy Glaser (320) 389-2848

Project Cost: \$27,250

Funding Source: NTREC



Background: Smooth roads are one of the priorities Mn/DOT customers expect. It is safer both for them and also provides a much less demanding maintenance schedule for Mn/DOT work crews.

Purpose: This project will evaluate a tailgate paving machine with new innovative equipment so that it is more versatile. These new features were not available on previous units and greatly enhance the paving unit abilities.

Procedure: The production of this unit will be measured against previous methods of completing small pavement jobs. Tonnage can be compared for each days work. Also this unit promises the ability to complete repairs pertaining to wheel tracking on older bituminous which will be monitored and evaluated.

Results: We will provide results of the evaluation as soon as enough information has been collected. At the time of this report the project has not been begun. It will start as soon as the equipment arrives and is in full operation.

Recommendation: Cannot be included at this time

Status: Active

Ribbon Lift

Sponsor: Craig Mittlestadt

District/Office: CO Construction

Project Contact:

Craig Mittlestadt (651) 296-5714

Project Cost: \$11,000

Funding Source: MOR



Background: With more maintenance and repair work being done at night, improved lighting systems are a necessity. Improved lighting will help insure both worker and public safety.

Purpose: A new adjustable lifting system for lighting night work zones is to be evaluated. It is easily mobile, height adjustable, and also enables our lighting balloons to be raised and lowered to best suit each location.

Test Procedure: These systems will be used and evaluated in various work zones throughout the Metro area. They will be evaluated for ease of use and dependability.

Results: The ribbon lift system was found to be very stable regardless of the height. It was able to raise the balloon lighting to a height of fifty feet in a matter of seconds creating a safer and more efficient work zone. Work crews found it to be easy to use, fast, and dependable.

Recommendation: One option the Construction office is considering is setting up a standard requiring utilization of these systems for night time construction projects. We will encourage District maintenance personnel to considering purchasing one or two of these systems and rotating it throughout their night time operation.

Status: Closed

VI. Safety, Traffic Control, and Work Zone Safety

Solar Traffic Lights

Sponsor: Larry Waletzki

District/Office: District 6E- Bridge

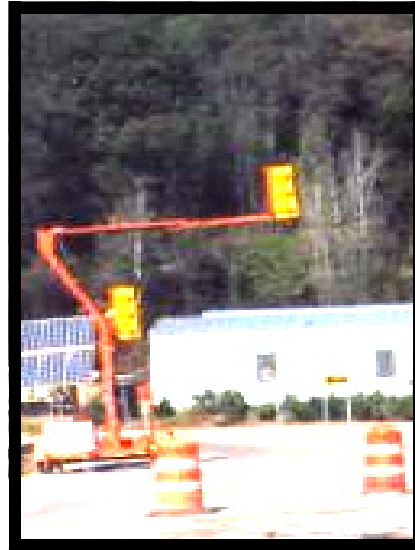
Project Contact:

Larry Waletzki (507) 453-2908

Project Cost: \$27,500

Funding Source: NTREC

Background: Although the idea of portable traffic control for bridge work is not new, over the past several years technology has changed dramatically. Past rental units have showed us that units be hardwired together and others used radio as a communications device which also proved unsatisfactory because of interference and reliability issues.



Purpose: This project will evaluate the latest solar/battery powered portable traffic lighting for bridge work and maintenance. These units are wireless and improvements in radio communications should make them more reliable. They are able to be set up as far away as one mile from each other and also have the ability to expand to four units.

Test Procedure: These solar powered lights will be used and evaluated during actual field working conditions. They will be looked at for ease of set up and use, reduction in manpower, and reliability. The expense of owning will be compared to the cost associated with renting as has been done in the past. They will also be compared to the costs of flagging operations.

Results: No results at this time to report. Due to budget and purchasing delays this project will commence as soon as possible.

Recommendation: There will be recommendations issued regarding the use and purchasing of these units included in the final project report.

Status: Active

Cone Setter

Sponsor: Randy Glaser

District/Office: District 7E - Mankato

Project Contact:

Randy Glaser (507) 389-2848

Project Cost: \$12,000

Funding Source: MOR



Background: Setting and picking up cones and other traffic control devices is one of the most dangerous jobs at Mn/DOT. When setting up a long traffic lane closer it could greatly reduce this risk if a machine could accomplish this effort.

Purpose: To evaluate a new style of automated cone setter and remover. A special operator platform will be constructed by the district and will be able to easily mounted and used on different trucks when necessary.

Test Procedure: This unit will be used several times in the lot and then evaluated under actual traffic control operations both setting and picking up cones. There will be more than one operator and in different applications as well as varying weather conditions.

Results: At the present time enough data has not been collected to issue a report on the results.

Recommendation: At the end of the project a recommendation will be made as to its possible implementation and continued use. This will be dependant on the final results summary.

Status: Active

EL Conspicuity Light Signs

Sponsor: Sue Lorentz

District/Office: Metro District – Waters Edge

Project Contact:

Sue Lorentz (651) 582-1415

Project Cost: \$6,000

Funding Source: MOR



Background: The “Stay Back Stay Alive” safety program is considered a success at getting out the message to motorists that following too close places them in a dangerous situation. The lighted signs intent is too reinforcing the message and bring a new look to it. Visibility and awareness should be increased through their use.

Purpose: These light signs will be used with the “Stay Back Stay Alive” safety program. Motorists are cautioned as to the dangers of following too close to the back of Mn/DOT Trucks which is prevalent during slow speeds of plowing operations.

Test Procedure: This project will test and evaluate the performance and reliability of these signs. Motorists will be visually monitored by operators for compliance with the safety message displayed.

Results: Surveys were taken of the shops and personnel participating in this project. It was decided upon by the operators that these signs improved visibility and increased awareness of the plowing operation.

Recommendation: These signs should be mounted on the tailgates so that when the box is up in the air they are still visible. After viewing the comments by operators, the Metro Work Zone Safety Committee would like to see the use of these lighted signs expanded.

Status: Closed

LED Lighting

Sponsor: John Tarnowski

District/Office: Maintenance Research/CO

Project Contact:

John Tarnowski (651) 297-1843

Project cost: N/C

Funding Source: Vender Supplied



Background: LED Emergency Lights are becoming more common on trucks and other equipment in the maintenance and construction fields. These new systems do have advantages in that they last much longer and also use a very low amount of electrical current to operate. With Mn/DOT trucks already drawing close to the maximum amperage output this can be extremely beneficial in reducing alternator and other electrical problems producing a substantial reduction in shop time and repairs.

Purpose: This project will install, compare, and evaluate several of the latest LED systems available on Mn/DOT plow trucks.

Test Procedure: The emergency lighting systems will be used while under actual working conditions during all types of weather. These will be mounted on the MOR Test Bed Tandem and changed periodically. Operators will be polled for their comments and suggestions. Pictures and other visual evaluations will be conducted.

Results: This project will last approximately two years while data is being collected. Project is underway at this time.

Recommendation: At the present time all plow truck lighting should follow Mn/DOT rules and regulations for emergency lighting. This project is connected with other lighting projects being conducted within the Department and data will be reviewed when enough has been collected to make an informed decision as to the use of these units.

Status: Active

Avoiding Collisions with Plows

Sponsor: Sue Lodahl

District/Office:

Mn/DOT Maintenance Research/CO

Project Contact:

Albert Yonas
Lee Zimmerman
University of Minnesota (612) 624-6805

Project Cost: \$31,000

Funding Source: NTREC



Background: Previous research has shown that a driving condition exists during fog that affects motorists in a negative way. Speeds are actually increased rather than decreased relating to a hazardous condition. Also during plowing operations these conditions are closely repeated by snow clouds associated with that type of work. The term for this is low luminance contrast.

Purpose: This project will assess how much of the low-luminance contrast illusion can be accounted for by information flowing along the chromatic pathways. Colors, shapes, and other factors may come into play which will be examined in this project to improve visibility of plows in adverse conditions.

Test Procedure: This project will utilize a driving simulator and evaluate drivers' reactions to varying conditions of the approach to plow trucks. The studies themselves will evaluate the effects of lighting methods, etc.

Results: Project has started and is scheduled for completion in June of 2005

Recommendation: A recommendation is to be made upon completion of the project in regards to what colors, shapes, lighting and other factors will aid in the improvement of visibility during inclement weather associated with snow and ice control.

Status: Active

Lighted Safety Vests

Sponsor: Sue Lorentz/Ken Nelson

District/Office:

Metro Work Zone Safety/Waters Edge
Work Zone Safety/CO

Project Contact:

Gene Lorentz – (651) 582-1416

Project Cost: \$2,500



Funding Source: MOR

Background: Night maintenance is becoming more of a common practice and wide spread each year. There are very important safety concerns that need to be addressed while performing night and other low light work and visibility of personnel is the highest rated among them. New technology personal safety equipment needs to be explored to continue to provide the safest work place for Mn/DOT employees.

Purpose: To test and evaluate the latest product for personnel visibility while working in low light conditions, lighted safety vests. These are still retro-reflective with the amount of material Mn/DOT requires, but in addition they possess a rechargeable battery lighting system utilizing electroluminescence light strips.

Test Procedure: These “lighted vests” will be distributed to the Metro night maintenance crew and tested in the field under working conditions. They will be monitored for their additional visibility characteristics, durability under all weather conditions, and ease of use by the night crew personnel.

Results: Preliminary results look favorable.

Recommendation: The final project report will contain recommendations whether or not the use of these vests should be continued.

Status: Active

Lighted Slow Moving Vehicle (SMV) Signs

Sponsor: Sue Lorentz/John Tarnowski

District/Office:

Metro Work Zone Safety-Waters Edge
Maintenance Research-CO

Project Contact:

Gene Lorentz (651) 582-1416

Project Cost: \$4,000

Funding Source: MOR



Background: Currently all of Mn/DOT's slow moving vehicle signs (SMV) meet or exceed state and federal requirements. New technology in the use of electroluminescence lighting has opened a new door for possibly improving the visibility of our slow moving equipment during low light and dark working conditions.

Purpose: The electroluminescence lighted signs will be evaluated for their enhanced visibility characteristics on slow moving vehicles and equipment.

Test Procedure: Ten SMV signs will be installed on rollers, skid steers, loaders, etc. that are used frequently by the night crews in the Metro District. Operators will monitor their visibility and compare them to the standard SMV signs. They will also be evaluated for their durability under actual working conditions.

Results: None at this time. Project has started and is schedule for completion during the spring of 2005

Recommendation: At the completion of the project

Status: Active

EL Lighted Mudflaps

Sponsor: Sue Lorentz/John Tarnowski

District/Office:

Metro Safety/Maintenance Research

Project Contact:

Sue Lorentz (651) 582-1415

Project Cost: N/C

Funding Source: Vender Supplied



Background: Many new ideas in safety lighting are introduced each year. Electroluminescence technology has been applied to Stay Back Stay Alive signs and lighted mud flaps. These will be mounted low to the ground to increase visibility of Mn/DOT trucks during plowing operations. Many times snow is lifted up when plowing resulting in snow clouds. The lighted mud flaps hopefully will allow approaching motorists an increased view of the truck under these adverse conditions.

Purpose: These lighted mud flaps will be tested and evaluated for their durability under adverse weather conditions associated with winter snow and ice control.

Test Procedure: Ten sets of the flaps will be installed on Metro trucks which already have EL lighted signs installed from the first electro-luminescence project. The same power pack can then be utilized for both. The signs and mud flaps will be used during plowing and sanding operations for the coming winter. Operators will be polled for motorist compliance to the message and their reactions, such as changing lanes, following farther back, etc. Durability of the flaps will be monitored and recorded.

Results: Project is to start during the 2004-2005 snow and ice season.

Recommendation: After enough data has been collected and a final report issued a recommendation will be made.

Status: Active

VII. Roadside Maintenance

Beaver Abatement

Sponsor: Lee Purdham

District/Office: Baxter/Brainerd-D - 3A

Project Contact:

Tom Wryck (218) 927-3316

Project Cost: \$5,000

Funding Source: MOR



Background: Damage caused from beavers is abundant in Minnesota. When streams, ditches, and other drainage structures are blocked, waters back up causing washouts, flooding, and other erosion problem.

Purpose: This project proposes to test and evaluate a new method of ridding an area of the nuisance causing animals without harming them.

Test Procedure: The Infra-red Beaver Abatement Systems will be installed in beaver dam prone areas. These areas will be chosen by their amount of beaver related maintenance work in the past. After installation, the areas will be monitored for beaver activity and specifically, dam building.

Results: There are no results to report at this time. Project will be starting as soon as the equipment is set up during the late summer or early fall of 2004

Recommendation: After the evaluation is completed a recommendation as to the use of these systems will be made.

Status: Active

Just In Time Sign Replacement

Sponsor: Jerry Miller

District/Office: Morris-District 4

Project Contact:

Jerry Miller (507) 320-7301

Project Cost: \$10,000

Funding Source: NTREC

Background: The life of traffic signs varies due to many parameters. It would seem just prior to the end of the useful life of the sign it should be replaced. Presently Mn/DOT uses a replacement program that is based on experience of the life over a certain preset number of years.



Purpose: The “Just in Time Sign Replacement” should be piloted to determine its value. This project will determine the effectiveness and reliability of this program.

Test Procedures: By monitoring the signs retro-reflectivity in the field a degradation curve could be developed to determine the life of various signs. By doing night time surveys we can monitor the color contrast that is needed. BY utilizing both measurements the just in time sign replacement can be determined for any type of sign.

Results: The project has begun however there are no results to report at this time.

Recommendation: Upon issuance of a final report, recommendations will be made as to use or not use this system.

Status: Active

Bobcat Wolf Disc

Sponsor: Thomas Johnson

District/Office: Albert Lea – D-6W

Project Contact:

Andrew Kubista (507) 446-5907

Project Cost: \$3,770

Funding Source: MOR



Background: Damage to roadsides caused from accidents and from vehicles leaving the roadway for other reasons sometimes causes deep tire tracks in the soil. This is common year around but especially when rain or snow softens the top soils. This can impair drainage and also cause damage to maintenance equipment and create a hazard for personnel.

Purpose: This project will work with and evaluate a disc attachment for a skid steer that promises to breakup and level the ruts. It can also be used for weed control, and for preparing the soil for reseeding.

Test Procedure: The Wolf Disc will be used in various locations around the district and for a wide variety of roadside soil repairs. Operators will compare the skid steer mounted disc to similar tractor mounted units. The time to load and move the skid steer will be compared to driving a tractor mounted unit to sights.

Results: There are no results to report at this time of these writings.

Recommendation: When project has been completed a recommendation will be included in the final report.

Status: Active

VIII. Equipment – Tools

Reiter Plastic Truck Body

Sponsor: Herb Nelson

District/Office: Shore Sub Area – D-1A

Project Contact:

Herb Nelson (320) 834-4442

Project Cost: \$12,000

Funding Source: MOR



Background: The standard steel truck bodies require maintenance in painting, rust and dent repair, and also because of the type of rock in this area they become dented. This does not permit materials to slide out freely when dumping and especially during sanding operations.

Purpose: A plastic truck body will be mounted and compared to the steel bodies now in use under a variety of conditions. These are claimed to not dent, rust or corrode, are very low maintenance, are easily removable to access under components of the lift system. They also allow materials to slide out very easily.

Test Procedure: The slide qualities and durability will be monitored by employees during actual working conditions. A variety of materials under all weather conditions will be used for this. Durability and maintenance will be recorded.

Results: The boxes slide properties exceeded our expectations. Snow, winter sand and salt, gravel, rock, clay, and other excavation materials were hauled and unloaded with no complications due to sticking or piling up in the box. Materials flowed freely and there was little if any visible wear out of the ordinary.

Recommendation: We would like to see plastic truck bodies be allowed as an alternative to aluminum or steel. The employees involved in this project were so impressed with this product that they requested another plastic box for a different truck in their fleet.

Status: Closed

Motorovac MCS245

Sponsor: Steve Lueken/Ron Seifert

District/Office:

Owatonna Mechanics Shop – D6W

Project Contact:

Steve Lueken (320) 446-5907

Project Cost: \$2,659

Funding Source: MOR



Background: Preventive maintenance is the key to many fuel related problems on gasoline engines in today's automobiles and pickups. We have sent out several vehicles to have fuel injectors cleaned and have had success with them.

Purpose: This will use and evaluate a preventative maintenance fuel injector cleaning machine that is claimed to remedy 80% of fuel related problems on today's vehicles.

Test Procedure: This unit will be utilized on vehicles for PM maintenance each year. The result should be a reduction in fuel related problems over the next several seasons. This will be tracked and recorded which can then be related to savings in maintenance and repair costs.

Results: Project is underway. No results to report at time

Recommendation: Once enough data has been collected on the use of this machine a recommendation will be made.

Status: Active

Skidloader Backhoe

Sponsor: Roland Wagner

District/Office: Owatonna D-6W

Project Contact:

Roland Wagner (507) 446-5958



Project Cost: \$4,350

Funding Source: MOR

Background: Utilizing skid steers for a variety of jobs is becoming more and more common. Many new attachments have made this already versatile piece of equipment even more valuable to maintenance related fields. One of the problems in the past with backhoe attachments for these is the short reach of the unit. With this new extendable feature these problems should be overcome.

Purpose: To evaluate a new skid steer backhoe attachment that promises to be comparable to much larger and expensive tractor mounted units. This unit has an 11 foot extendable reach which should allow it to do all of the jobs that we normally do with a tractor backhoe. This will allow us to better utilize our existing skid steers.

Test Procedure: This unit will be compared against our tractor backhoe. Ease of use, mobility, and job performance will be monitored and evaluated. Operators of each piece of equipment will be polled for their comments.

Results: There are no results to report at this time

Recommendation: Upon completion of project recommendations as to continued use of this equipment will be made.

Status: Active

6 Way Dozer Blade

Sponsor: Andrew Kubista

District/Office: Owatonna – D6W

Project Contact:

Andrew Kubista (507) 446-5907

Project Cost: \$3,485

Funding Source: MOR



Background: Skid steers are a valuable piece of equipment to maintenance crews everywhere in state. These units are in many cases, the backbone of the maintenance workers arsenal of equipment. They perform a huge variety of tasks that would otherwise have to be accomplished manually resulting in a great reduction in hours of labor and lighter duty equipment.

Purpose: To add more versatility to the skid loader. It will be outfitted with another quick-change attachment in the form of a 6-way dozer blade utilizing steel tracks for increased performance. This unit will be able to accomplish many tasks that would otherwise have to be accomplished with a much heavier and expensive dozer, which has limited uses.

Test Procedure: The attachment will be installed on a John Deere 280 skid steer. This unit will be used with and without the steel tracks to investigate them for their additional traction capabilities. This unit will be used on a variety of soils and at many job sights. Mud, clay, rock, and sand will be encountered which will provide a good variety for evaluation.

Results: This unit worked very well and performed over our expectations under most weather and terrain encountered. The undertaken tasks were performed timely and in an efficient manner. There were some concerns with traction loss when encountering muddy terrain when using tracks.

Recommendation: It is felt that a set of rubber tracks may be the only improvement that could be made to this unit. The overall performance was exceptionally well and it could be used in limited movement areas such as ditch bottoms that would be very difficult to work with other larger pieces of equipment. This unit would be beneficial to every maintenance crew statewide.

Status: Closed

Snap-on HD35 Fluid Changer

Sponsor: Steve Lueken/Ron Seifert

District/Office: Owatonna Mechanics Shop-D6W

Project Contact:

Steve Luekin (507) 446-5945

Project Cost: \$6,495

Funding Source: MOR



Background: Automatic transmissions are very expensive to rebuild or replace. Many of the problems encountered with them can be reduced or even eliminated by proper service and simply changing of the fluid. Venders have been used for changing fluid in the past however they are unable to service our medium and heavy-duty trucks.

Purpose: This project will test and evaluate the only unit on the market that has the capability of changing the fluid on Allison medium and heavy-duty automatic transmissions.

Test Procedure: This unit monitors and notifies shop personnel when transmission filters are becoming blocked. This action will be watched and should considerably reduce the amount of filters being changed. This system will also change fluid faster, more thorough, and more efficiently than our standard method of doing it. It will also be tried and monitored for servicing power steering systems.

Results: Preliminary results look good. Machine is easy to use and so far shows a reduction in labor to service transmissions.

Recommendation: Enough data has not been collected to issue a recommendation at this time.

Status: Active

Heated Bituminous Truck Box

Sponsor: Randy Glaser

District/Office: District 7E - Mankato

Project Contact:

Randy Glaser (507) 389-2848

Project Cost: \$4,699.68

Funding Source: MOR



Background: During cool weather patching and bituminous repair operations it can be difficult to use the material before it cools down. Many times driving time from the batch plant to the job sight also adds to this. This makes materials difficult to work with and can also have a negative effect on the repair itself.

Purpose: To modify a truck box with an in floor heating system. This system will be designed to sustain a good working temperature of the bituminous material until it is used.

Test Procedure: The only way to test this project is to use it under actual working conditions and varying weather temperatures. Operators will record the results and comments from work crews as to the pliability and working temperature of the materials.

Results: This heated box system worked very well. Materials were kept warm and pliable with less waste. We were able to haul larger more efficient loads a greater distance and were able to keep the patching crew moving with less down time.

Recommendation: We would be happy to assist other Mn/DOT areas with a design if they are interested in constructing one of these. We were so impressed with the results that we are building another of these for a one-ton truck to be used during the winter.

Status: Closed

6x9 BDS Mirrors

Sponsor: Mike Cirks

District/Office: Willmar – D8

Project Contact:

Mike Cirks (507) 537-3610

Project Cost: \$391.35

Funding Source: MOR



Background: Currently we are using the standard 8-inch round convex mirrors on our plow trucks to enhance visibility to the sides and rear of the vehicle.

Purpose: These 6-inch by 9-inch wide-angle mirrors promise to increase visibility by providing a wider field of vision and therefore improving safety.

Test Procedure: These mirrors will be installed and evaluated by the truck operators under actual driving conditions. They will be looking for an increase in visibility, and an improvement in overall safety. Distortion of the mirror image will be monitored as well as general optics.

Results: These mirrors did provide a wider field of view however they afforded a narrower vertical field of vision. This made it difficult for the truck operators to see the wing plow during that operation. Distortion of the image was also noted because of the curvature of the mirror lens. This project has ended in District 8. There was also a project report issued from MOR on 6x9 BDS mirrors in the spring of 2004.

Recommendation: These mirrors may have other applications but our operators felt that the standard convex mirrors were better suited for our use.

Status: Closed

Cut Off Saw

Sponsor: Dale Dombroske

District/Office :

Metro District – Spring Lake Park Bridge

Project Contact:

Dale Dombroske (763) 785-5664

Project Cost: \$2,684

Funding Source: MOR



Background: Cutting concrete can be difficult when in confined areas. Older type concrete saws are cumbersome and awkward. When a large hole is needed one must cut beyond the edge to allow for a deep enough cut which in turn can create structural problems.

Purpose: This concrete saw promises to allow us the ability to cut through concrete twelve inches thick in one pass. Also, when cutting concrete holes we will not have to cut beyond the edge of the desired area to allow for depth of cut.

Test Procedure: The Spring Lake Park Bridge Crew will use the saw for many operations on various jobs. The saw will be evaluated for its' neatness of the cut, lack of overrun at edges, and efficiency of operation.

Results: This concrete saw worked well both for cutting small square corners and also for irregular shapes in concrete. It was used in confined areas without over-cutting the desired area.

Recommendation: This unit performs well and could be used anywhere concrete work is done.

Status: Closed.

Porta Shear

Sponsor: Dale Dombroske

District/Office: Metro – Spring Lake Park Bridge

Project Contact:

Dale Dombroske (763) 785-5664

Project Cost: \$5,375

Funding Source: MOR



Background: When working in the field fabrication of steel railings and other components can be difficult. Clean straight lines of cut ease fabrication by providing a better fit. This then requires less welding time and a better-finished product is achieved.

Purpose: To work with and evaluate a portable shear for metal working in the field.

Test Procedure: This shear will be evaluated for cutting ability, ease of use, dependability, and mobility.

Results: The cutting ability was good, the machine proved to be a very useful tool. Cuts were straight and professional in appearance. This machine was a real time saver and produced a quality cut and finished product.

Recommendation: This product would work anywhere a transportable metal shear is needed.

Status: Closed

Truck Washing Soap

Sponsor: Mark Fischbach

District/Office: Metro District – Waters Edge

Project Contact:

Mark Fischbach (651) 582-1429

The logo for 'CHLOR*WASH' is displayed in a bold, yellow, blocky font with a black outline. The asterisk is positioned between the words 'CHLOR' and 'WASH'.

Project Cost: \$7,575

Funding Source: MOR

Background: Corrosion and rust caused by sodium chloride creates a huge expense each year for Mn/DOT. The average price for a paint and refinish job on one of the class 35 tandems runs around \$7000.00.

Purpose: This project is to use and evaluate a special additive that promises to reduce chlorides on the metal significantly which would result in less corrosion and maintenance costs.

Test Procedure: Trucks will be washed both with and without the added solution. Test kits will be used to determine the remaining chlorides on the trucks and determine the effectiveness of the increased washing and cleaning ability of the new product. The corrosion and rust will be visually monitored over a period of time to watch for a reduction instead of acceleration of the corrosion problem.

Results: Project has begun. There are no results to report at this time.

Recommendation: Upon completion of the project a recommendation will be made as to its use.

Status: Active

Steel Max Saw

Sponsor: Robert Braukman

District/Office: District 4, Pelican Rapids

Project Contact:

Robert Braukman (218) 846-7396

Project Cost: \$494.68

Funding Source: MOR



Background: When cutting metals bridge, construction, and other crews are constantly dealing with the handling of super heated metals caused by friction of the cutting action. Chips and sparks are also a hazard with saws presently used.

Purpose: The Steelmax Circular Saw promises to cut mild steel quickly and also to perform bevel cuts with little heat transfer or created from the cutting action. Also it claims to have a chip and spark reduction system which greatly reduces flying debris.

Test Procedure: This saw and blades will be used in the field under actual working conditions. A comparison will be easily accomplished between our current saws and this new technology.

Results: Although the project is not completed the preliminary results are very impressive. More time and additional use is required to determine longevity of the blades.

Recommendation: Depending on the final outcome of this project a determination and recommendation will be made in the MOR Field Test Report.

Status: Active

IV. 2006 – 2007 Focus -Implementation

NTREC/MOR Project Implementation

Implementation of successful projects is a key role that the Research Unit will be undertaking in the coming biennium. Funding has been set up to see some of these successful projects implemented. At the April 2005 NTREC meeting the committee voted to change the funding distribution for implementation from 10% to 25%. An implementation flow chart has been developed and is currently under review. The committee felt strongly that their role is to review and recommend successful research projects for future implementation.

As research projects are completed, the final Field Test Reports will be reviewed and given a rating directly relating to the potential for statewide implementation. This review will be conducted by MOR, and may include evaluations and opinions from other Mn/DOT personnel, offices, and organizations.

The results of the MOR implementation project review will be distributed to Maintenance Personnel and Management in several ways. A Project Implementation Report will be sent via groupWise messaging. Presentations will be offered to the Operations Management Group (OMG), Operations Advisory Group (OAG) and to other pertinent Mn/DOT meetings and assemblies.

It is understood that the MOR recommendations of projects for implementation is not be recognized as standard operating practices for procedures or equipment. What the intent is to provide a starting point for the continued success of certain projects which have proven their value. This way they will remain on that pathway through the process of implementation within Mn/DOT.

Special circumstances surrounding work zone safety, plow trucks standardization, and other areas within Mn/DOT, may require additional groups to become involved with these recommendations. Every attempt will be made to communicate with the proper contacts and obtain necessary blessings from any additional parties.

Funding budgeted to the MOR program for implementation purposes will be utilized whenever possible. MOR participation will vary depending on the project cost and balance of funds remaining in the Implementation Fund. For instance, less costly projects for implementation may be purchased and distributed statewide by MOR while others would not due to budgeting restraints. There is also the possibility that implementation for certain projects would receive partial funding through the program. NTREC and the Operations Management Group (OMG) feel that project implementation should have some buy in from the districts.

X. Appendix A

Previous Biannual Statewide Maintenance Operations Research Reports

In the infancy stages of the MOR Program, the initial research focused on snow and ice field studies and projects were very limited. As the MOR Program matured and developed, it expanded into other fields of maintenance including roadside and bridges. Other offices became involved with the quality and evaluation of the projects. As projects were completed and possibly implemented, there was a need to communicate these results to the rest of the state and others.

Following is a list of the project reports that have been published since 1992. Some projects had been carried over from year to year due to improvements made as results are reached. The projects listed below are in the report as it was first introduced to the program and may have conclusions in later reports. If you are interested in any of these projects, you may contact the Maintenance Operations Research Engineer.

1992-1993 Winter Season Report:

- Camden Pre-wetting Field Study
- Lakeville Pre-wetting Field Study
- Plymouth Anti-icing Field Study

1993 Report:

- Corrosion Research
- Road Weather Information System
- Truck Ergonomics Task Force
- Snow Fence Research
- Vehicle Conspicuity Research
- Solar Powered Culvert Deicer
- Quality Control of Premixed Sand/Salt Blender Hopper
- Laserlux Road Striping Management
- Smooth Pavement Task Force
- Remote Driven Vehicle
- Remote Slope Mower
- Zero Velocity Salt/Sand Spreader
- Timesheet Generated Interface
- Short Grass Research Plots
- Extendable Snow Plows
- Portable Interactive Weather Prediction System
- Municipal Waste Salt Water as a Pre-wetting Agent

1994 Report:

- Culvert Rehabilitation
- Thermal Mapping
- Portable Interactive Weather Prediction System

- Temperature Sensors
- Snow Fence Research
- Work Zone Safety Projects
- Circuit Rider Program
- Finnish Emulsion Gravel Pavement
- Automated Call-Out System
- Timesheet Generated Interface & MMS/TIS Interface
- Bar-coding
- Maintenance Research Project Tracking System
- CB Radios
- Innovative Sprayers
- Band Cleaner
- NIDO Liquid Spreader
- Wash Water Recycling System
- Salt Brine Mixing Systems
- SHRP cutting edges
- Gravel Shoulder Reclaimer

1995 Report:

Winter Maintenance:

- Maintenance Concept Vehicle Partnership Project
- System 2000 Stationary Salt Speeder
- Automated Liquid Bridge Deck Deicer
- Brine Applicator
- Power Liquid Spreader Control Unit
- Electronic Pre-wet hang Tanks
- Integrated Tailgates Research
- Improved Snow Plow Design
- Grader End Gates
- Combined Front-Slush Plows
- Ice Buster
- Norsemeter Friction Meter
- Magnetic Pavement Taping

Road and Bridge Maintenance:

- Slurry Seal Patching Machine
- MicroSurfacing
- Automated Pothole Patcher
- Cascadia Enduraseal 300 Asphalt Rejuvenator
- Highlift Flatbed
- Earth Penetrating Radar Concrete Delamination Detecting System
- Lightweight Power Screed
- Retrofit Dowel Bars
- Culvert Rehabilitation Project

- Culvert Grapple Extractor (Beaver Dam Grapple)
- Stenciling Unit for Message Painting

Maintenance Management:

- Thermal Mapping
- Pavement Condition and Weather Reporting
- Interactive Travel Information Systems (Minnesota Travel Partners)
- Travel Partners Demonstration Project
- Mobile Road Weather Information Systems
- Timesheet Generated Interface & PMS/MMS/TIS Interface
- Pavement Marking Management System
- Dial in Server for Operations Management System Pilot
- Bar-coding
- Paperless Field Data Collection
- Maintenance Research Project Tracking System

Roadside Maintenance:

- Herbicide Sprayer
- Flexstake Weedmats
- Remote Slope Mower
- Biological Control of Canada Thistle

General Maintenance Management:

- All Terrain Crawler Tractor; Posi-Track
- Tracks and Dozer Blade on Skid steer Loader
- Kentrol Gate Material Control System
- Tire Experiment, Michelin

Technology Transfer:

- International Worker Exchange Program
- Finnish Emulsion Gravel Partnership Project

1996 Report:

Winter Maintenance:

- Heated Truck Box Using Exhaust System
- Truck Box with a Fiberglass Floor
- Snow Shield Research
- Combined Front Slush Plows
- Anti-icing using Brine from Wash Water Recycling (North Branch)
- Anti-icing using a Herbicide Sprayer Attachment, Spraytronics (Metro)
- Mn/DOT – Hennepin County Anti-icing Project
- Fiber Optic Lighting Research
- Wing Plow Research (mounted at the rear of the truck)
- National Friction Measurement Study (FHWA)

- Integrated Tailgate Research
- Extendible Hood Snow Plow
- 21-Foot Snow Plow
- Cutting Edge Research
- Multiple Uses for Low-Boy Tractor
- Dual Spinner
- Elkin Spreader
- Salt Brine Mixing Systems
- Oscillating Underbody Scraper

Road and Bridge Maintenance:

- Evaluation of Radar for Snowplows
- Automatic Pothole Patcher
- Front mounted Shoulder Retriever
- Bunyan Friction Screed
- Crack Sealing
- Color Flexi Probe Inspection System
- Culvert Rehabilitation Project
- Peel-A-Way Lead Paint Removing Process for Bridges
- Lite Stripe Laser and Camera Pointer Systems

Maintenance Management:

- Automatic Low-Visibility Warning System Using Video Cameras
- ARCTIC Dispatch Center
- CD Authoring, Writing, and Sharing Project
- Automated Route Planning and Optimizing Software

Roadside Maintenance:

- Boom Sprayer Rebuild
- Hooded Ground Sprayer
- Polecat Obstacle Mower

General Maintenance Research:

- Reusable Energy Absorbing Crash Terminal
- ProPatch Head Cover, Prototype
- Bioremediation Pilot Project
- Portable Hot Water Pressure Washer
- Multi-purpose Utility Vehicle with Electrical Power tool Package
- Demo Maintenance Truck with Updated Hydraulic System

Work Zone Safety:

- Remote Driven Vehicle Unit #3
- Flashing Stop/Slow Paddle Implementation Project

Technology Transfer:

- Maintenance Expos – Fall and Spring
- Saving Salt – A Simple Solution

1997-1998 Report:

General Maintenance:

- Aerosol Alternative
- Drillco Sawblade
- Easy Bend
- Ford Smith Four Post Hydraulics Lift
- Multiple Uses of Hot Water Pressure Washers in Highway Maintenance
- Plasma Cutter
- Remote controller for Boom on Sign Truck
- Vacutec Leak Detector
- Video Image Scope

Maintenance Management:

- Blowing and Drifting Snow Control Market Research
- Evaluating Locating and Record Keeping Technology
- Fleet Management System Coordinator
- GIS Project Specialist
- Maintenance Business Planning: Measuring Quality
- From the Customer's Viewpoint
- Pavement Marking Market Research RFP
- Transmap GIS Mapping for Sign Inventory
- Striper Record Keeping/Downloading Using a Laptop Computer
- Maintenance Business Planning: Winter Operations Survey.

Road and Bridge Maintenance:

- Epoxy Striper Research Project
- Heated Dump Box-Tapping System
- Laser Level Plane
- Patchrite Self Propelled Pothole Patching Machine
- Silane
- Vibratory Concrete Floats

Roadside Maintenance:

- Box Beam Guardrail
- Contour Tree Planter
- E-Z Dig and E-Z Grader
- Funda Flex
- Power Broom/Trimmer for Light Duty Sweeping
- Weld on Wear Pads

- Wheeled Debris Blower
- Wood Chip Blower

Technology Transfer Partnerships:

- DNR Tandem Truck
- Truck Driving Simulator

Winter Maintenance:

- ALLU Screen Crusher
- Athey Force Feed Loader
- Automated Data Logger for Odin System
- Blending System for Mixing Sand and Salt
- Chemical Storage Building
- Commercial Visibility Instrument
- Continuous Friction Measurement Techniques Research
- Culvert Deicing Resistance System
- Cutting Edge Study
- Dresbach Anti-Deicer System
- Dual Auger Spinner Sander
- Dual Rear Wing Truck
- Elkin Sander
- Enclosed Salt Brine System
- Enhanced Snowplow Visibility Using Radar Technology
- Etnyre Anti-Icing Unit
- Extendable Hood Snowplow
- Heads Up Research Summary
- Henke Heavy Duty Wing
- Hydraulic Snowblower
- I-35 Fixed Bridge Deicer System
- IceBan (Liquid Deicer)
- Large Capacity Integrated Tailgates
- Nokian Tires Part One and Two
- Pick up mounted Anti-icing units
- Rebuilding Frame Work on CL-35 Snowplow
- Road Closure Gates
- Salt Conveyor
- Salt Solutions
- Snake Creek Bridge
- Stainless Steel Integrated Tailgates
- VLB Industrial Snowblower

Work Zone Safety:

- Cone Reflective Spinners
- Cone Setter/Retriever Research Trip

- Message/Arrow Brickboard
- Portable Advisory Roll-Up Sign Assemblies
- React 350 Reusable Energy Absorbing Crash Terminal
- Remotely Driven Vehicle
- Speed Control Display Systems
- Striper Crew-Programmable Light Emitting Diode Sign on Shadow Vehicle

1999-2001

Winter Maintenance

- Cryogenically Treated Cutting Edges
- Non Rotating Carbide Bit System for Underbody Blades
- Hydraulic Driven Snowblower
- Infrared Ice Detector Maintenance Upgrade
- Swenson Precision Placement System
- Expansion and Implementation of Anti-ice Methods
- Adaptable “Slide-in’ Anti-ice/Herbicide Spray Unit
- Critical Area Spot Spreaders
- New Component Test Bed Truck

Winter Material

- Ice Ban M-50
- Medium Grade Salt (Nu-Salt)
- Anti-icing Liquid (Caliber)

Road and Bridge Maintenance

- Air Prep System
- Laser Based Clearance measuring System
- For the Birds
- Rubberized Asphalt Melter Applicator
- Aging Optimization Study
- Hot Box
- Spaulding RMV Hot Patcher/Reclaimer

Traffic/Work Zone Safety

- Smart Arrow Messenger Board
- Scorpion Truck Attenuator
- Solar Powered Warning Signals/Flashers

Roadside Maintenance

- Noxious Weed GPS/GIS Mapping
- Posi-Track Soil Compaction Reduction Project
- Harley HST 6 Shoulder Reclaimer
- Geotextile Fabric Laying Machine

- Living Snow Fence
- Dynamic GPS Performance Evaluation
- New Holland Disc Mower
- TRACC System
- ET-2000 Guardrail End Treatment
- (GS-ED-60-50) Side Dozer

Equipment/Tools

- Spray on Box Lining and Irathane Systems
- Wire Feed Welder
- Laxo Quick Lock System
- Brake Watch
- JAGZ Interlocking System.
- Retractaflap
- Mud Flap Jack
- Clear View Wiper Mirror
- Lane Scan Mirrors
- Heated Windshield Wiper Blades/Blizzard Blades
- High Intensity Discharge Lighting
- Trailer Safety Lights
- Cordless Impact Drivers
- Mini Skid Loader
- Underbody Grease Banks
- Truck Mounted Roller
- Collision Avoidance Monitors
- Electronic Hearing Protectors
- On-board Truck Scale
- Connect Under Pressure Hydraulic Couplers

Building

- Pre-cast T Panels for Cover-all Storage Buildings
- Wireless for Truck Stations

Technology Transfer

- Truck Weight Education Project
- Field Works
- Snow and Ice Pamphlet
- Snowplow Simulator Phase 1
- Electronic Multi-meter
- Electronic Technical Data Collection

2001-2003

Winter Maintenance

- Critical Area Anti-icing D-8

- Dultmeir Brine Production System
- Hydraulic Driven Snowblower
- LED Wing Lights
 - Stainless Steel Hopper
 - Precision Placement System
 - Plow Guards
 - GPS Tire Road Friction
 - GPS Gang Plowing
 - Expansion of Anti-icing Methods
 - D-3A Rear Mount Wings
 - Micro-Trac Anti-icing
 - Blizzard Plow
 - Pre-wetting Liquid Storage Tank
 - Anti-icing Equipment
 - Wing Wheels
 - Crash Attenuator Anti-icing
 - Dultmeir Anti-ice Unit
 - Liquid Chemical Transfer Pump Station
 - Dual Carbide Underbody Edges

Winter Material

- Anti-icing Liquid

Road and Bridge Maintenance

- Hollow Deck Machine
- Over-height Vehicle Detection System
- Silicone Pump
- High Mast Light Pole Inspection
- Night Time Wet Line Recovery
- Air Prep System
- Laser Based Clearance Measuring System
- GL 3000P Laser Guidance System
- Aging Optimization Study
- Wedge Paver
- Bridge Sweeper
- Universal Maintenance Unit

Traffic Control and Work Zone Safety

- Voice Activated Message Sign
- Roo Guard Barriers
- Active Portable Warning System
- Emergency traffic Control Truck
- Scorpion Truck Attenuator

- Stabilization of Aggregate Shoulders
- Safety Light Wand

Roadside Maintenance

- Sprout Guard
- Brown Mower
- Tree Shear
- Erosion Control Equipment
- Noxious Weed GIS/GPS Mapping
- Ditch Hitch
- New Holland Disc Mower
- ATV Swisher Mower

Equipment – Tools

- Lane Scan Mirrors
- Dynamic Performance Evaluation
- Rear Vision Color Monitors
- Backup Safety Cameras
- Ready Welder
- HID Sander Lights
- Clear View Mirror Wiper
- Underhood Air Compressor
- Protective Coated Oil Pans
- Reiter Plastic Truck Body
- Hydraulic Ground Level Trailer
- Laxo Quick Lock System
- Boss Light
- Mud Flap Jack
- Mini Concrete Mixer
- Trailer Safety Lights
- Test Bed Tandem
- Accu Place Spreader
- Ribbon Lift
- Retro Reflective Mud Flaps
- Electro Luminescence Light Signs
- Open Systems Architecture for RWIS
- RWIS RPU Modifications
- Sylvania Silverstar Lights
- Quicksilver Bed Liner

Building

- Wireless for truck Stations

X. Executive Summary

A look to the future

As a function of changing economic times the MOR office has witnessed a significant reduction in its operating budget. We view this as another challenge. Smaller, less costly projects involving maintenance field personnel will be the priority resulting in an increase in numbers of research projects of this type. Applied research will be a narrow focus and ‘on the road’ and similar projects will be the direction of the Maintenance Research Unit.

Education/Marketing

With the start of the new biennium the Maintenance Research Unit will need to ensure that all Mn/DOT employees are informed and have access to the program. To accomplish this goal we intend to visit each district sharing information with fellow employees and management in regards to funding research projects through the MOR program. Our web site will also provide information and a contact point for people at all times. The site is kept up to date and relevant with all the newest application forms and information.

Implementation

Another focus for the future of maintenance research is to push successful research into implementation. In the past this has been a struggle. It is very difficult to get all the districts to buy into successful projects. Funding and other considerations must be taken into account. Over the next biennium MOR will determine implementation plans for research. These will be methods of getting successful results out to the districts and funding methods for implementation. The goal is to utilize and implement more productive equipment, processes, and material research projects into standard operating practice. The program’s research effort is to move from reactive to preventive maintenance.

In closing I would like to say I am very excited about Maintenance Research and that we have a viable and important function to perform. The next two years will be exciting with many new technologies and projects to explore.

Benjamin Zwart P.E.
Maintenance Operations Research Engineer