EXHIBIT A
SCOPE OF SERVICES

FIELD USAGE OF ALTERNATIVE DEICERS FOR SNOW AND ICE CONTROL

BACKGROUND

Currently, chloride based deicers and anti-icers are the most commonly used products for snow and ice control operations, due to their ease of use, low initial cost, and working temperature ranges. Chlorides can be applied as solids (deicers) such as rock salt, or as liquids (anti-icers) such as salt brine. Commonly used chloride based deicers include sodium chloride, magnesium chloride, and calcium chloride.

For decades, chloride based products have been applied during snow and ice control operations to increase mobility and safety for the driving public. Over time, these chlorides have migrated to the near road environment and have been slowly accumulating in soil and groundwater, such as in shallow wells. Additional environmental impacts from chloride based products have been observed in plants and aquatic systems. In addition, chlorides impact infrastructure, such as corrosion to vehicles, equipment, and roadway infrastructure" or is it "such as corrosion to vehicles and equipment, and deterioration of roadway infrastructure. These impacts represent real costs to tax payers that are not considered in the initial purchase price of chlorides. While the annual cost of corrosion damage from chlorides has been estimated in the millions of dollars, it is more difficult to quantify the costs of damage to the environment.

To alleviate the impacts to the environment and infrastructure from the use of chloride based products, the MnDOT and the Minnesota Local Road Research Board (LRRB) are interested in identifying any alternative (non-chloride) based deicers that work as well or better than chlorides, are cost competitive, and have fewer impacts to the environment and infrastructure.

At this time, there are non-chloride based products available for snow and ice control, but they are not as commonly used on roads. Interestingly, many of these non-chloride products are routinely used at airports because of their anti-corrosive properties. These include acetates, formates, succinates, glycols, and glycerols. There is a need to summarize the current state-of- knowledge on these non-chloride products to determine if they are feasible alternatives to chlorides. Specific questions include:

- Do they perform as well or better than chlorides?
- Are they cost-effective or cost-competitive?
- Are they available in large enough quantities?
- How much investment is needed for storage and application?
- What are the potential impacts to the environment and infrastructure as compared to those imparted by chlorides for snow and ice control?

The Transportation Research Synthesis (TRS) offers an opportunity to document this information and provide implementation guidance to city and county engineers on the use of non-chloride snow and ice control products.

OBJECTIVE

The goal of this project is to identify alternative deicers to chlorides for snow and ice control operations, with a specific focus on potassium acetate and succinate. The products will be assessed to determine if they allow transportation agencies to meet their defined level of service standards, are cost competitive, and have fewer impacts to the environment and infrastructure. Relevant information will be gathered using a comprehensive literature review, practitioner survey and interviews. The primary deliverable will be a concise synthesis report.

SCOPE

The proposed research will build on the foundation of preliminary work completed for the MnDOT LRRB in 2014, titled *Chloride Free Snow and Ice Control Material.* The purpose of continued research on this topic is to identify effective and available alternatives to chlorides that MnDOT can potentially use to reduce salt use in snow and ice control operations. For this reason the following products will be considered:

- Potassium acetate
- Potassium succinate
- Other acetates
- Formates

- Glycols
- Glycerols
- Other newly identified products (if found).

The scope of work for this project will include a comprehensive literature search, survey and interviews, and development of a synthesis report based on the information gathered. Task specifics are described in greater detail in the following Work Tasks section.

ASSISTANCE

MnDOT staff will be asked to assist with coordination of TAP members and provide meeting space for TAP meetings. MnDOT staff will be asked to assist with the timely review of deliverables and correspondence to ensure the project keeps to the timeline.

WORK PLAN

Task Descriptions

Task 1: Literature Review

To gather information on non-chloride snow and ice control products, the research team will conduct a review of several databases, including: Transportation Research Information Service (TRIS), Google Scholar, ISi Web of Science, and sources through the University's Library. Research conducted in other countries will be reviewed as available, along with the ongoing research and existing documents published by state Departments of Transportation (DOTs), Clear Roads, Pacific Northwest Snowfighters (PNS) Association, University Transportation Centers (UTCs), Strategic Highway Research Program (SHRP), the Federal Highway Administration (FHWA), National Cooperative Highway Research Program (NCHRP), Airport Cooperative Research Program (ACRP), American Public Works Association (APWA), and American Association of State Highway and Transportation Officials (AASHTO), as well as information presented at the Winter Maintenance Peer Exchanges and other relevant conferences.

For this project, the University will synthesis available literature to document the feasibility of using non-chloride alternatives for snow and ice control. For each product assessed, every effort will be made to identify the functional temperature range, the application range for varying conditions (black ice, near freezing, colder conditions, etc.), known impacts to the environment and infrastructure, and costs. The research team has extensive familiarity with the effectiveness and impacts of various snow and ice control chemicals on infrastructure and the environment, through both laboratory and field experiments. The team also has extensive experience conducting literature searches and synthesizing this information in the fields of snow and ice control products, operations, corrosion, equipment, application methods, environmental impacts, and identification of best practices.

A summary of the information gathered in the literature search will be submitted to MnDOT's Technical Liaison (TL) and the Technical Advisory Panel (TAP) as the deliverable for this task. Following submission of the Task 1 deliverable, the University will participate in telephone or web-based conference call to present the findings of this task. The purpose of the meeting is to generate feedback, facilitate discussion of any suggested changes from the TL and TAP, and discuss next steps.

Task 2: Agency Survey and Interviews

For this task, the University will develop a web-based survey based on information gained from the Task 1 literature review. The survey will target snow and ice control practitioners who have experience using non-chloride products. The web-based survey will seek information on non-chloride products used, cost, application methods and rates, temperatures ranges used for each product type, and observed or quantified impacts to the environment and/or infrastructure.

A draft web-based survey will be developed in an on-line survey tool (such as SurveyMonkey) and submitted to the TL and TAP for review, comment, and testing. Following testing of on-line survey tool by the TL and TAP, the University will participate in telephone or web-based conference call with the TL and TAP to generate feedback and facilitate discussion of any suggested changes. Following refinement and additional testing by research team, the survey will be distributed to agencies and individuals identified in the literature search who use non-chloride products, as well as to Clear Roads Program members, and via the Snow and Ice ListServ. Every effort will be made to ensure the survey receives a high response rate in a timely manner.

The University will use follow-up interviews, as needed, to capture more detailed information on non-chloride products. Vendors and manufacturers of non-chloride products may be contacted via the survey or interviews. Any information gathered from vendors or manufacturers will be noted.

The University will submit a summary of the survey and interview findings to the TL and TAP as the deliverable for this task.

Task 3: Draft Transportation Research Synthesis (TRS) Synthesis Report
The University will develop a draft TRS synthesis report based on the information gained from the Task 1 literature review and Task 2 survey and interviews. The draft TRS synthesis report will be developed in a concise and usable format, such as Microsoft Word and Adobe PDF documents. The report will utilize figures and tables to summarize information when possible. The target audience for the report will be city and county engineers; therefore, the University will organize and draft the report to meet the needs of this audience.

The University will submit the draft synthesis to the TL and TAP for review and comment.

Task 4: TAP Comment Meeting
The University will participate in an in-person, telephone, or web-based conference call to present the findings of the draft TRS report. The purpose of the meeting is to generate feedback on the report and facilitate discussion of any suggested changes from the TL and TAP.

Task 5: Final TRS Synthesis Report
The University will incorporate the TAP's comments from the technical and editorial reviews into the Final TRS report. The report will be prepared in accordance with MnDOT's TRS and/or MnDOT's research report publishing guidelines.

Following submission of the Task 5 final TRS report, the University will participate in telephone or web-based conference call with the TL and TAP to either accept the task deliverable as completed or to provide feedback of any suggested changes. If additional changes are required, the revised deliverable will be submitted to the TL and TAP prior to the task completion date.

Task Deliverables

Task:	Deliverable(s):
1:	Summary of Identified Literature
2:	Summary of Survey and Interview Responses
3:	Draft TRS Report
4:	TAP Meeting
5:	Final TRS Report

PROJECT SCHEDULE

	2016		2017					
Months:	1	2	3	4	5	6	7	8
Task 1	X	X						
Task 2			X	X				
Task 3					X	X		
Task 4							X	
Task 5								X

Task:	Draft Deliverable Due Date:	Final Task Approval Date:
1:	December 16, 2016	December 30, 2016
2:	February 17, 2017	February 28, 2017
3:	April 17, 2017	April 30, 2017
4:	May 17, 2017	May 31, 2017
5:	June 17, 2017	June 30, 2017