EXHIBIT A
SCOPE OF SERVICES

PERMEABLE PAVEMENT FOR ROAD SALT REDUCTION

BACKGROUND

Road salt (sodium chloride) is used for de-icing roadways during winter months, but can have a negative impact on the environment. There are already streams and lakes in the Twin Cities metropolitan area that are impaired for chloride, and other metropolitan areas in Minnesota are sure to follow. This research will investigate the reduction in road salt application during winter months that can be attained with permeable pavements, while still providing for acceptable road safety. Some initial investigations have suggested that road salt application can be substantially reduced, even eliminated, with permeable pavement systems. The proposed research will investigate this hypothesis more thoroughly, and further document the reduction in road salt application that can be expected with permeable pavement. The outcomes of this research will 1) document the winter performance of permeable pavement to provide for safe driving conditions without salt addition; 2) investigate the temperature profile in the permeable pavement system under various winter conditions; 3) develop a simulation model that can predict permeable pavement performance under various winter conditions; and 4) provide education (outreach) through webinars, seminars and online publications including articles in UPDATES, a stormwater research e-newsletter distributed to 2,400 subscribers.

OBJECTIVE

Chloride in the streams, lakes and groundwater is currently resulting in lake and stream impairment notification in many locations throughout the Twin Cities metropolitan area, and investigations will likely result in similar notifications in all Minnesota cities. The primary cause is salt addition to roadways, which is added to provide safe roads for drivers. To save the lakes and rivers, and to have drinking water that can be consumed, we need to reduce or eliminate the salt that the state places on the roads. There are indications that permeable pavement can accomplish the reduction or elimination of salt addition while still providing a relatively safe driving surface. This research will document the winter performance of permeable pavement as a safe driving surface without the addition of salt. Another benefit to Minnesota will be the safety increment that permeable pavement has over unsalted impermeable pavement. The comparative costs of the two will be considered and applied for each location of permeable pavement placement. The research will therefore result in:

1. *Reduced Environmental Impacts* – Every permeable pavement road replacement that is installed as a result of the project will help reduce the chloride load to our receiving water bodies.
2. *Improved Road Safety* – A permeable pavement road without salt may be safer than a traditional pavement road without salt in cold Minnesota conditions.
3. *Reduced Risk* – If permeable pavement is successful at reducing required salt additions, there will be a reduced risk to aquatic life and to traffic on the road during winter months.

SCOPE

This project will investigate the performance of a number of unsalted permeable pavement roads compared to salted and unsalted traditional roads. The purpose is to test the hypothesis that the driving conditions on unsalted permeable roads are similar to salted traditional roads and better than unsalted traditional roads. Permeable and impermeable roads will be tested in Robbinsdale, Minnesota (asphalt) and in Shoreview, Minnesota (concrete). Photo/video cameras will be mounted to visually record the surface condition, comparing unsalted permeable sections to salted and unsalted traditional (impermeable) pavement sections of the road. In addition, the cities will deploy traffic counters to measure the average daily traffic for the test locations. Finally, temperature profiles will be continuously recorded below the surface of the permeable pavement to investigate the process of melting and infiltrating water during winter months. The temperature data will be used to calibrate and verify a numerical model of temperature under permeable pavement that can then be used to extrapolate the observations of snow and ice on the surface of the road to other weather conditions that have not occurred during the study period. Correlations between snow and ice cover, temperature, and snowfall will be made for the measurements and model predictions to describe the performance of unsalted permeable pavement during winter months.

WORK PLAN

Task Descriptions

Task 1: Review of Literature and Available Data
Under this task, the University will review the scientific literature to identify observations of snow and ice on permeable pavement that have been made in the past. The available existing data on the Robbinsdale site will be reviewed to determine if the information can be useful in this project.

Task 2: Install Equipment at Field Sites
Field sites with permeable pavement have already been chosen in Shoreview (1 site) and Robbinsdale (1 site) for the installation of field equipment. Under this task, the University will place remote cameras at six locations to monitor the presence of snow and ice at permeable pavement locations (two unsalted) and impermeable pavement locations (two salted, two unsalted) chosen to be otherwise similar to the permeable pavement locations. The University will install arrays of six temperature sensors to measure air temperature above ground, and soil temperature at 0.5, 2, 6, 12, and 18 inches below the surface at the two permeable pavement sites and at or near one impermeable site. The University will test field equipment during December 2016.

Tasks 3: Measurement of Permeable Pavement Response to Snow and Ice and Comparison with Impermeable Pavement – Year 1
Under this task, the University will document the response of permeable pavement to snow and ice and compare the data with the response of the four impermeable sites (two unsalted, two salted). All sites will be plowed as normal. Of particular interest are the percent and duration of snow and ice coverage and the temperatures of the media under the permeable pavement versus the impermeable site. The University will use traffic counts for the test locations for comparison between sites. The University will complete an analysis of the factors that influence ice formation and disappearance.

Task 4: Develop and Verify a Model of Snow and Ice on Permeable Pavement
Under this task, the University will use the temperature data of Task 3 to calibrate and verify a computational model of temperature under the permeable pavement that can be used to 1) help characterize the heat transfer processes that control snow and ice dynamics on permeable pavement, and 2) investigate winter conditions that do not occur during the study period. The University will develop a physically-based model of the effect of weather conditions and vehicle loading on snow and ice over permeable pavement during this process. The model can then be applied to selected historical periods of cold and snow, with different traffic levels, to broaden the analysis of permeable pavement performance.

Tasks 5: Measurement of Permeable Pavement Response to Snow and Ice and Comparison with Impermeable Pavement – Year 2
Under this task, the University will revise and improve the measurement techniques of Task 3 and apply the techniques to the Year 2 measurements. The University will further verify the computational model and use it to simulate the snow and ice conditions of Year 2.

Task 6: Public Outreach and Civic Engagement
The project team has a long history of dialogue and collaboration with public entities including watershed districts, municipalities, counties, universities, the Minnesota Cities Stormwater Coalition, and statewide entities working on stormwater management. The project team will be working closely with entities specifically interested in the reduction of road salt through implementation of permeable pavement throughout this project. Educational outreach will occur through presentations and online publication including articles in UPDATES, a stormwater research e-newsletter distributed to over 2,400 subscribers. The University will provide presentation materials and meeting outcomes in electronic form. The project results will also be utilized in the University's coursework. In addition, the University will publish one or more professional, peer-reviewed journal articles from the results of this project. Outreach activities will continue throughout Years 2 and 3 of this project.

Task 7: Compile Report, Technical Advisory Panel Review and Revisions
Under this task, the University will prepare a draft report, following MnDOT's publication guidelines, to document project activities, findings and recommendations. This report will be reviewed by the Technical Advisory Panel (TAP), updated by the University's Principal Investigator and then approved by Technical Liaison before this task is considered complete. A TAP meeting will likely be held to present the results of the project.

Task 8: Editorial Review and Publication of Final Report
The Approved Report will be processed by MnDOT's Contract Editors. The editors will review the document to ensure the document meets the publication standard. A Final Report will then be prepared by the University's Principal Investigator and submitted for publication through MnDOT's publishing process.

Task Deliverables

Task:	Deliverable(s):
1:	Literature review describing the literature observations, the existing data that will be used in the project, and how the data will be used
2:	An interim report summarizing the installed equipment at the sites and its performance during the first few months
3:	An interim report summarizing the results from the task, including a description of the comparative data collected.
4:	An interim report summarizing the development of the model, the algorithm used for the effect of vehicle passage on snow and ice and the results of model runs on selected historical periods.
5:	An interim report summarizing the results from the task, including a description of the comparative data collected.
6:	An interim report describing outreach activities and presentations.
7:	Approved Draft Final Report
8:	Final Published Report

PROJECT SCHEDULE

	2016						2017											
Months:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1	X	X	X	X	X													
Task 2				X	X	X	X	X	X									
Task 3						X	X	X	X	X	X	X						
Task 4											X	X	X	X	X	X	X	X
Task 5																		X
Task 6																		
Task 7																		
Task 8																		

	2018												2019					
Months:	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Task 1																		
Task 2																		
Task 3																		
Task 4	X	X																
Task 5	X	X	X	X	X	X	X	X	X									
Task 6							X	X	X	X	X	X	X	X	X			
Task 7										X	X	X	X	X	X			
Task 8																X	X	X

Task:	Draft Deliverable Due Date:	Final Task Approval Date:
1:	September 30, 2016	November 30, 2016
2:	January 31, 2017	March 31, 2017
3:	April 30, 2017	June 30, 2017
4:	December 31, 2017	February 28, 2018
5:	July 31, 2018	September 30, 2018
6:	January 31, 2019	March 31, 2019
7:	January 31, 2019	March 31, 2019
8:		June 30, 2019