Remediation of Deicer Contaminated Soils Using Native Montana Plants

By

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PROBLEM STATEMENT

The Montana Department of Transportation (MDT), at any given time, stores upwards of 1,000,000 pounds of salt at over 120 storage facilities. Salt can leach from these piles into the surrounding environment. Every effort is currently being made by the state to rectify this, with new salt storage facilities being built each year that cover the salt and salt-stock piles[1]. However, sites where leaching has occurred have high levels of deicer salt in the surrounding soils.

Leaching of salt from salt and salt-sand stockpiles has the potential to impact both downgradient drinking water supplies and surface water resources and can result in degradation of groundwater and surface water quality to levels above federal and state standards. In many instances, mitigating and improving impacted soils and groundwater through traditional excavation or pump-and-treat remediation methods, followed by long-term monitoring, can be costly and time intensive. Looking for alternative, cost-effective ways to mitigate the impacts of salt leaching from salt and salt-sand stockpiles could benefit transportation departments by reducing the overall remedial costs and shortening the life cycle of monitoring and mitigation.

In this study, we propose to test whether plants may be able to remediate soils in contaminated areas by absorbing chloride from the soil and water and store the chloride in above ground leaf tissue. We will start by testing plants both native and non-native to Montana that have been identified as salt tolerant. We will rely in part on the Montana Salinity Control Association list of recommended salt-tolerant forage species. This is a starting point, as many of the plants identified by this list were not necessarily tested in the very high saline soil environments that may be encountered around salt storage facilities or high-salt-use road areas.

To test this concept, we will start by collecting soil samples from roadsides to be able to focus or bracket our experiment at the correct salt levels. The greenhouse experiment will test how different plant species perform under the determined salt levels in soil. Plant tissue will be analyzed to determine if and where plants are storing absorbed chloride from the soil. If chloride is stored in above ground leaf tissue, it may be more likely that these plants would be good candidates for phytoremediation as they could be mowed, and the clippings collected. Top performing plants from the greenhouse study will be used in the field trial to test phytoremediation at contaminated sites.

[1] MDT prioritizes which facilities receive storage structures first, based on an environmental risk assessment screening tool which evaluates facilities based on proximity to surface water and ground water receptors, and human population size and recent growth and development in the immediate vicinity of the facility.

BACKGROUND SUMMARY

MDT conducted a preliminary literature search which supported this effort. From the literature, work by others indicates salt tolerant species can be used to aid in remediation of soils, surface, and shallow ground water contamination from salts. While the bulk of the literature was related to agricultural saline contamination, a few research projects assessed the feasibility of using salt tolerant plant species for remediation of deicer contaminated soils. Greenhouse and laboratory results were promising, but few studies tested field deployment of this concept.

The goal of this project is to use salt-tolerant plants (halophytes) for phytoremediation, or the removal of salt from the soil and water via plants. The literature suggests three potential mechanisms for salt uptake or tolerance/avoidance by plants. These include 1) the exclusion of salt from roots; 2) uptake into specific tissues; 3) uptake into specific organs that precipitate salt. Garcia (2020) determined the use of halophytes to remove salt from soil and water is a viable strategy. Similarly, Litalien and Zeeb (2020) evaluated the use of halophytes to remediate salinized soils and prevent leaching of salts into surface and ground water and noted it would be most effective in locations where "frequent harvesting can be incorporated," specifically recommending "road-side clippings" for the remediation of soil affected by road salts (p. 12)**.** Manousaki and Kalogerakis (2011) noted that phytoremediation of saline soils by halophytes can result in "marked decrease of soil salinity levels," depending on the species used (p. 965). Nouri et al. (2016) found that using halophytes to control soil and water salinity is "a very promising approach" depending on the species used and the method of cultivation. Additionally, Freedman et al.'s study (2014) examined the use of halophytes (particularly *b. indica*) as a strategy for dealing with excess salt, affirming that halophytes have the "potential capacity for direct uptake of salts" (pg. 282) depending on "resident time" and "nutrient supply" (pg. 286). Despite achieving positive results in a lab setting, some research found field deployment of salt tolerant grasses provided no improvement in terms of surviving the effects of deicing salts (Brown et al., 2011).

To improve the effectiveness of phytoremediation of salt affected soils, Jesus et al. (2015) recommends combining different treatment types, improved salt flow control measures, using mixed plant cultures, etc. (pg. 6521). Yun et al. (2019) found that composting plant tissue that had accumulated chlorides during phytoremediation reduced plant tissue chloride concentration by 87-89%. These strategies could potentially influence the success of field-testing phytoremediation.

Understanding the dynamics of how deicing salts move through soil and water in different landscapes can be challenging. Ongoing work by Shi et al. for Clear Roads is investigating the migration of chloride-based deicer through various soil types and should provide information on chloride dispersal and migration mechanisms and aid in identify chloride sensitive areas (CR 21-07). Work by Lundmark & Jansson (2008) found that concentrations of chloride in soils changed seasonally, and reported and modelled chloride levels associated with deicing salts in roadside soil and soil water content. Soil chloride content ranged from 10 g/m2 in November to 40 g/m2 in April. The trend observed in the data of lower chloride concentrations in the fall, spiking concentrations in the winter, followed by a decrease in concentration in late spring/summer (Lundmark & Jansson, 2008; Olofsson & Lundmark, 2009). This data shows that chloride concentrations in soils and soil water are dynamic and change seasonally based on winter deicer applications and flushing from precipitation. It is important to note that work by Olofsson &

Lundmark (2009) found that varying geologic conditions – specifically in this case of sand and glacial tills, can result in natural variation in resistivity (read: chloride) in soils and shallow ground water.

Plant species identified by the Montana Salinity Control Association will serve as a starting place for recommended salt-tolerant forage species. Work by Friell et al. (2014) developed a sod mixture that provides salt-tolerant sod for roadsides. Johnson (2000) looked at the environmental effects of road salts on soil and water, recommended the use of certain salt tolerant grasses to prevent damage to roadside vegetation, as well as suggested specific types of salt-tolerant plants that can be planted for these purposes. Schück and Greger (2022) examined wetland plants (*C. riparia* and *P. arundinacea*.) with high chloride uptake, arguing that certain species have the potential to decrease the salinity of water depending on biomass, water uptake capacity, and transpiration. Similarly, McSorley et al. (2010) identified three different halophytic grasses for phytoextraction (re: phytoremediation) in a salinized landfill (*Phragmites australis*, *Puccinnellia nuttalliana*, and *Spartina pectinate*), with *P.australis* identified as the most efficient in phytoextraction. McSorley et al. (2010) also noted that salt excretion via certain halophytes can be effective for the remediation of salinized land.

Devi et al. (2016) found that total soil ionic content decreased by approximately 8 – 19% at 8 dSm-1 and by approximately 2 – 7% at 20 dSm-1 using phytoremediation, and Shaygan et al. (2022) found that the top 10 cm of soil had a reduction in soil salinity by 33 – 38%. The authors noted that even with the high remediation potential they were not able reduce salt content of the landscape to allow for the successful growth of glycophytes, plants that are not tolerant of high salt concentrations; thus, concluding that halophytes would need to be used indefinitely to create a stable vegetative cover.

These articles support the general viability of the research idea, with some important caveats that can be further investigated in this research effort.

BENEFITS AND BUSINESS CASE

There are many benefits that could be realized through this project. We would develop a list of MT native and non-native plant species that can be used in high salt areas to remove salt from the soil. If certain plant species are found to uptake salt into their above ground leaf tissues, they could significantly reduce deicer contamination of soils at MDT salt storage facilities and potentially in the near road environment. This would reduce downstream deicer contamination in surface and ground water. Ultimately, this reduces the environmental impact of using deicing salts on roadways and improves water quality. This project could also lead to opportunities for nurseries or seed producers to supply MT-grown plants and seed for these types of remediation projects. For MDT, this project could lead to an increase of available plant species for use at MDT's salt storage facilities and roadsides. It could also inform decisions to incorporate salt-tolerant plants into reclamation plans and other features such as stabilized banks, designed stormwater retention basins, and other stormwater-type features.

OBJECTIVE

The objective of this research project is to assess the feasibility of using salt tolerant plants to remediate contaminated soils around salt storage facilities and in the near road environment. This would be accomplished through assessing existing soil contamination around salt storage facilities and the near road environment, assessing plant species that can uptake salt and remove it from the soil and surface water, and then determine the remediation potential of viable plant species. The end goal is to use the identified best performing plants around storage facilities and in high-salt-use near road environments to reduce the amount of deicing salts entering the environment.

RESEARCH PLAN

This project is divided into the following phases and tasks:

- Task 0: Project Management
- Task 1: Identify Potential Plant Species & Task 1 Report
- Task 2: Soil Sampling & Task 2 Report
- Task 3: Green House Study & Task 3 Report
- Task 4: Field Deployment
- Task 5: Final Report & Project Closeout Deliverables

TASK 0: PROJECT MANAGEMENT

Task 0 consists of managing the project. A kick-off meeting will be held as soon as the contract is in place to ensure all are aware of contractual obligations, scope of work, data requirements and source, deliverables, project milestones, timetable, and other project elements. Technical issues and any concerns will also be addressed during the kick-off meeting.

Quarterly to monthly check-in conference calls will be held with the Technical Panel using web-enabled software to obtain input on deliverables through the duration of the research project. The meetings will be kept to one hour. These meetings will ensure that the Technical Panel is kept aware of the current project status. The meeting agenda will be provided one week prior to the meeting, and it is expected that the meetings will be scheduled well in advance to ensure the availability of all participants. Meeting notes will be provided within a week after the meeting. In addition, should it be agreed upon by the panel, select monthly meeting(s) may be cancelled (e.g., during the holidays when many are out-of-the-office).

Deliverable No. 1: Kick-off Meeting

Deliverable No. 2: Monthly Check-In Conference Calls

Deliverable No. 3: Quarterly Progress Reports

TASK 1: PLANT IDENTIFICATION

Task 1.1 Identify Potential Plant Species

Information gathered during the project development process included two literature reviews conducted by MDT, and information provided by the Montana Salinity Control Association. These will serve as the basis for a more extensive evaluation of viable plant species that are not only salt tolerant, but that can also uptake salt into above ground plant tissue. Halophytic plant species will be investigated that are both native to Montana and non-native. Variables that will be considered include but are not limited to salt uptake ability, where the plant stores the salt, root depth, etc. The results of this task effort will support future task efforts. Plants identified in this task will be trialed in task 3, the greenhouse study.

The findings from this task will be summarized in the Task 1 Report. The researchers will leverage technical review staff to provide technical editing. The draft Task 1 Report would be provided to

MDT by August 31, 2024, with comments from MDT requested by September 30, 2024, and the updated version sent back to MDT by October 14, 2024.

Deliverable No. 4: Task 1 Report - Draft Identified Plant Species

TASK 2: SOIL SAMPLING

Task 2.1 Identify Potential Soil Sample Locations

In this task, the researchers will work with MDT staff to identify key locations including salt and salt/sand storage facilities and high salting zones along roadways for soil sampling. Data will be requested from MDT to help support this effort and may include GIS layers of MDT facilities and state/interstate roadways, salt storage locations and deicing salt application information, and chloride, conductivity, and/or salt concentration data from soils and ground and surface waterways. The research team will also pursue other data sources to help to support this effort include USGS Water Quality Data (https://www.usgs.gov/data/water-quality-data-montana) and NCRS/USDA Soil Surveys (https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx and https://archive.org/details/usda-montana). Following analysis of this information, a selection of salt and salt/sand storage facilities and road segments will be identified for soil sampling. The goal of the sampling is to get a representative view of deicer concentration in soils, not to perform a detailed sampling of the DOT facilities. For this reason, up to five DOT facilities and three to five roadsides will be sampled. A meeting will be held with relevant MDT staff and the project panel to discuss the identified locations and decide on which sites will be used for soil sampling.

Task 2.2 Soil Sampling

For the sites selected in the previous sub-task, soil sampling will occur.

Task 2.2.1 Develop Soil Sampling Plan

A soil sampling protocol will be developed to ensure consistency among samples collected from the various locations. The soil sampling protocol will consider the timing of sampling as soil and water chloride concentration can vary seasonally (Lundmark & Jansson, 2008; Olofsson & Lundmark, 2009). The sampling plan will be reviewed by a statistical expert to ensure sufficient data is collected for the best possible experimental design, while not over sampling.

This will be reviewed by the project panel.

Task 2.2.2 Soil Sample Collection

Using the identified soil sampling locations and soil sampling plan, a field campaign will take place in which all soil samples are collected in a one- to two-week field effort. All samples will be collected, labelled, and stored for processing. Pictures will be taken at each soil sample location and saved on the WTI-MSU server.

Task 2.2.3 Soil Chloride Analysis

For the samples collected in the field campaign, analysis to determine the salt concentration will be performed. Note that for this effort we are focused on salt loss from storage facilities, in the form of rock salt ($NaCl$, solid) and or salt/sand blend, rock salt blended with sand ($NaCl$, solid), and salt in near road environment from application to roadways.

There are two methods commonly used to measure chloride concentration or conductivity – titration (Edwards et al., 1981; Gaines et al., 1984) and using a chloride sensor (Hipp & Langdale, 1971). The most efficient and cost-effective method of chloride detection will be used to process the soil samples. Once the data is collected the findings will be summarized in a Task Report. The researchers will leverage technical review staff to provide technical editing. The draft Task Report would be provided to MDT by June 30, 2024, with comments requested by July 31, 2024, and the updated version sent back to MDT by August 15, 2024. A meeting will be held to discuss the findings and next steps.

The findings from this task will be summarized in the Task 2 Report. The researchers will leverage technical review staff to provide technical editing. The draft Task 2 Report would be provided to MDT by September 30, 2024, with comments from MDT requested by October 31, 2024, and the updated version sent back to MDT by November 14, 2024.

Deliverable No. 5: Task 2 Report - Draft Soil Sampling Results

TASK 3: GREENHOUSE STUDY

Task 3.1 Green House Testing Plan

A detailed greenhouse testing plan will be developed that incorporates information gathered in previous tasks including soil and water salt concentrations and halophytic plant species, to the phytoremediation potential of the various plants. The experimental design will be developed and reviewed by a statistician to ensure sufficient replicates are used to ensure valid findings.

This will be reviewed by the project panel.

Task 3.2 Plant seeds

We will start by obtaining seeds of the different plants identified in Task 2. Seeds will be germinated in plug trays in the heated and lighted MSU Plant Growth Center greenhouse facility. We will use real soil, compared to using a germination mix or other growing media, to best replicate in-field environments.

Task 3.3 Salt treatments

We will have control groups and multiple saline test groups for each species. Target saline levels will be determined by the data we collect in Task 1. For the saline test groups, we will have two different methods: 1. To mimic legacy contamination, we will mix salt into the initial soil media used to grow plants; and 2. To mimic sites that lose salt with each precipitation event, we will have a treatment where deicer salts are mixed into the water used to water the plants. We will test conductivity in the soil during the experiment to ensure we maintain the target saline levels.

Task 3.4 Data collection

Plant growth and performance will be assessed for each species compared to the control group by measuring germination rate, plant height and dry matter weight at harvest. One of the primary questions of this project is the potential use in phytoremediation. We want to determine where in the plant salts are being stored. We will harvest plant leaf tissue, stem tissue, and root tissue. Tissues will be weighed, then they will be dried, ground, and then digested and made into a solution to test for chlorides using the method determined in Task 1.

Plant performance, both growth under saline conditions and where plants store absorbed salts, will be reported from this experiment. Plants that show the most phytoremediation potential will be used in Task 4.

Task 3.5 Report

The findings from this task will be summarized in a Task 3 Report (Findings Report), and we will review all task findings and provide recommendations for the field deployment. The researchers will leverage technical review staff to provide technical editing. The draft Task 3 Report would be provided to MDT by March 31, 2025, with comments from MDT requested by April 30, 2025, and the updated version sent back to MDT by May 14, 2025.

It is recommended that a meeting be held to discuss the work completed thus far and discuss the path forward with field testing (Task 4).

Deliverable No. 6: Draft Green House Test Design Plan

Deliverable No. 7: Task 3 Report – Report of Findings, Recommendations

Deliverable No. 8: Meeting with the Project Panel

TASK 4: FIELD DEPLOYMENT

Task 4.1 Field Site Selection

In this task, researchers will work with MDT to identify a location for field deployment of the best performing phytoremediation plant(s), based on the greenhouse study results, at a salt or salt/sand storage facility. Information will be used from all previous tasks to make an informed decision.

Task 4.2 Field Test Plan

A field-testing plan will be developed that outlines a plot design for the plant species selected for phytoremediation. The field test plan will consider soil type present, when to sow the seeds, plant needs in terms of watering, fertilizer or compost, and timing of maturation and growth.

This will be reviewed by the project panel.

Task. 4.3 Field Deployment

The field deployment will occur at the selected site and follow the field-testing plan. Soil samples will be collected at the time of seeding and harvesting, and pictures will be taken of the plots. The plots will be monitored over the growing season. Harvesting of plant tissue will occur by cutting plants, mimicking mowing to remove the upper portion of the plant material. All samples will be bagged and labelled.

Plants may be seeded and/or planted in fall or spring depending on the species chosen. This may influence the timing and length of this task. At this time, we are planning for spring planting (March-May 2025), summer growth season, and fall harvest (August – September 2025).

Task 4.4 Soil and Plant Harvesting

The collected soil and plant tissues harvested from the test plots will be tested for chloride concentration after the initial growth season. Using the chloride data from the soil and plant tissues, phytoremediation potential assessed for each plant species and will be reported.

TASK 5: REPORT & PROJECT CLOSE-OUT DELIVERABLES

This task will be the development of a final comprehensive report that summarizes the entire project. A draft will be provided to MDT who will have one month to review. The researchers will then address the feedback in the updated final report. In addition, the researchers will create the Performance Measures Report, Implementation Report and Project Summary Report, deliverables required by MDT's Research Bureau.

This task includes the development of an Implementation Report. The Implementation Report will include an: 1) Introduction and Purpose, 2) Implementation Summary,3) Implementation Recommendations (including the Principal Investigator's recommendations and MDT's response), 4) Performance Measures Reporting, and 5) the Project Summary Report. This task also includes the development of Data Management Plan that will be developed using the MDT template and will address data collection formatting and storage, how publicly available data will be handled and shared, and data storage and security.

This task also includes the Project Close-Out Meeting which summarizes the information and is recorded, as required by MDT's Research Bureau guidelines. The presentation will include an overview of the project along with detailed discussions on the findings and recommendations. This meeting will also include a discussion of the Implementation Report.

Deliverable No. 9: Draft Final Report

Deliverable No. 10: Data Management Plan

Deliverable No. 11: Final Report

Deliverable No. 12: Performance Measures Report

Deliverable No. 13: Implementation Report

Deliverable No. 14: Project Summary Report

Deliverable No. 15: Project Poster

Deliverable No. 16: Final Presentation

Deliverable No. 17: Project Webinar

INTELLECTUAL PROPERTY

We anticipate no intellectual property issues.

MDT AND TECHNICAL PANEL INVOLVEMENT

The researchers suggest monthly to quarterly meetings with the Technical Panel throughout the duration of the project or meetings as task deliverables are due. These meetings would be kept to one hour, and they would be cancelled in advance if the meeting is not needed or at the Technical Panel's request. This will allow for continuous engagement of the Technical Panel to ensure that the results of the project are in line with expectations. This includes reviewing meeting notes and providing feedback at key decision-points.

The researchers will also ask the Technical Panel to review and provide comment on the submitted Deliverable No. 4, 5, 6, 7, the draft final report (Deliverable No. 9), the data management plan (Deliverable No. 10), the performance measures report (Deliverable No. 12), the implementation report (Deliverable No. 13), the project summary report (Deliverable No. 14), and the project poster (Deliverable No. 15).

The researchers anticipate needing access to MDT's current data on salt storage facilities location and status of covered or not, high salt application locations and other relevant data elements currently being collected by MDT. The researchers also anticipate needing access to MDT's salt storage facilities and/or roadside locations to conduct soil sampling or field deployment, along with assistance from MDT for any applicable permitting and traffic control considerations.

OTHER COLLABORATORS, PARTNERS, AND STAKEHOLDERS

The researchers will utilize the expertise of other researchers on Montana State University's campus for statistical support, GIS mapping, and laboratory facilities. Additionally, the researchers will leverage Technical Panel member expertise to support this effort.

PRODUCTS

As described in the research plan, the following seventeen deliverables are proposed:

- Deliverable No. 1: Kick-Off Meeting
- Deliverable No. 2: Monthly Check-In Calls
- Deliverable No. 3: Quarterly Reports
- Deliverable No. 4: Task 1 Report - Draft Identified Plant Species
- Deliverable No. 5: Task 2 Report - Draft Soil Sampling Results
- Deliverable No. 6: Draft Green House Test Design
- Deliverable No. 7: Task 3 Report - Report of Finding, Recommendations
- Deliverable No. 8: Technical Panel Meeting (decision-point meeting)
- Deliverable No. 9: Draft Final Report
- Deliverable No. 10: Data Management Plan
- Deliverable No. 11: Final Report
- Deliverable No. 12: Performance Measures Report
- Deliverable No. 13: Implementation Report
- Deliverable No. 14: Project Summary Report
- Deliverable No. 15: Project Poster
- Deliverable No. 16: Final Presentation
- Deliverable No. 17: Project Webinar

RISKS

We anticipate the risks in conducting this project to be low. Identified challenges include finding a plant species suitable for remediation. Additionally, there is unknown potential for issues faced in the field deployment task. The researchers have extensive experience in conducting laboratory, greenhouse, and field research and will draw on this expertise to successfully complete this project, avoid common issues, and trouble shoot needs as they arise. With each task report and discussion of next steps, issues encountered, and potential paths forward will be provided. Additionally, following plant identification, soil sampling, and green house tasks, a meeting with the technical panel will be held to discuss the feasibility of moving into field trials.

IMPLEMENTATION

We anticipate that the remediation method, if found to be feasible, can be deployed across the state and used by other agencies. It is possible that additional field deployment studies, or multiple years of data collection would be necessary to determine remediation potential. If this method is found to be feasible, some changes in operations may be recommended to fully realize the potential on a larger scale. Specifically, mowing protocols would need to be changed to collect and appropriately dispose of clippings. Information regarding suitable plant species would need to be promptly disseminated to nurseries and seed producers.

SCHEDULE

The project would be conducted for a duration of 2 years (24 months).

Table 1: Project Time Schedule

Task	Month																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0 Project Management																								
Kick-Off	X																							
Update Calls				X			X				X			X			X					X		
Close-Out																							X	
1 Identify Potential Plant Species																								
2 Soil Sampling																								
3 Green House Study																								
4 Field Deployment																								
5 Report & Project Close-Out Deliverables																								

BUDGET

The total project budget is $199,927.60. Travel has been identified for the project in Tasks 1 and 4. An overall budget by tasks, meeting, and deliverables is provided in Table 2, a detailed budget by staff member and task is provided in Table 3, and budget by fiscal year is provided in Table 4.

Table 2: Budget by task, meeting, and deliverable

Task, Meeting, and Deliverable Cost Breakout			
Item	**Labor**	**Travel**	**Total**
Task 0 Project Management	$ 29,775.00	$	**$ 29,775.00**
Deliverable: Kick-Off Meeting			
Deliverable: Check-In Conference Calls			
Deliverable: Project Close-Out Meeting			
Task 1 Soil Sampling	$ 29,026.35	$2,500	**$ 31,526.35**
Deliverable: Draft Soil Sampling Results			
Task 2 Identify Potential Plant Species	$ 18,952.35		**$ 18,952.35**
Deliverable: Task Report			
Deliverable: Draft Greenhouse Test Design			
Task 3 Greenhouse Study	$ 36,999.75		**$ 36,999.75**
Deliverable: Report of Findings, Recommendations			
Task 4 Field Deployment	$ 49,023.00	$2,500	**$ 51,523.00**
Task 5 Report & Project Close-Out Deliverables	$ 31,151.15		**$ 31,151.15**
Deliverable: Final Report			
Deliverable: Performance Measures Report			
Deliverable: Implementation Report			
Deliverable: Project Summary Report			
Total:	**$ 194,927.60**	**$5,000**	**$ 199,927.60**

Table 3: Detailed Project Budget

Budget		WTI-MSU Team							Other Direct Expenses			Totals
Task #	Task Title	Laura Fay	Dr. Claire Luby	Research Support (GIS, Stats)	Graduate Student	Editor & Graphics	Business Office	Total Hours/Total Costs	Supplies	Graduate Student Tuition	Travel	Total Costs
0	Project Management	80	80				8					
								$12,120.00		$11,700.00		$23,820.00
1	Identify Potential Plant Species	40	80		200	4						
								$15,161.88				$15,161.88
2	Soil Sampling	100	80	20	200	4						
								$21,721.08	$1,500.00		$2,000	$25,221.08
3	Greenhouse Study	80	80	5	500							
								$28,599.80	$1,000.00			$29,599.80
4	Field Deployment	140	140	20	500							
								$38,518.40	$700.00		$2,000.00	$41,218.40
5	Report & Project Close-Out Deliverables	100	80	5	300	16	8					
								$24,920.92				$24,920.92
	TOTAL HOURS	540	540	50	1,700	24	16	2,870				
TOTAL DIRECT COSTS (includes ben.)		$45,532.80	$33,609.60	$3,750.00	$56,100.00	$1,259.28	$790.40	$141,042.08	$3,200.00	$11,700.00	$4,000.00	$159,942.08
	Indirect Costs at 25%	$11,383.20	$8,402.40	$937.50	$14,025.00	$314.82	$197.60	$35,260.52	$800.00	$2,925.00	$1,000.00	$39,985.52
	Total Project Costs	$56,916.00	$42,012.00	$4,687.50	$70,125.00	$1,574.10	$988.00	$176,302.60	$4,000.00	$14,625.00	$5,000.00	$199,927.60

Table 4: State Fiscal Year (SFY) (7/1 – 6/30) Breakdown

Item	State Fiscal Year (SFY)			Total Cost
	2024	2025	2026	
Salaries		$ 77,987.08	$ 36,017.00	**$ 114,004.08**
Benefits		$ 20,550.00	$ 6,488.00	**$ 27,038.00**
In State Travel	$	$ 2,800.00	$ 1,200.00	**$ 4,000.00**
Out of State Travel	$	$	$	**$**
Expendable Supplies	$	$ 2,240.00	$ 960.00	**$ 3,200.00**
Student Tuition & Fees	$	$ 8,190.00	$ 3,510.00	**$ 11,700.00**
Total Direct Costs	$ -	$ 111,767.08	$ 48,175.00	**$ 159,942.08**
Indirect Cost – 25%	$ -	$ 27,941.77	$ 12,043.75	**$ 39,985.52**
Total Project Cost:	**$ -**	**$ 139,708.85**	**$ 60,218.75**	**$ 199,927.60**

STAFFING

Principal Investigator (PI) Laura Fay with the Western Transportation Institute has reviewed the background, objectives, and desired outcomes of the "Use of Salt-Tolerant Plants to Remediate Deicing Salt Contaminated Soils" project. She and co-PI Claire Luby have developed a Work Plan to assess the feasibility of using salt-tolerant plant species to remediate salt contaminated soils at MDT facilities and in the near road environment. In summary, the primary tasks will include assessing soil salt concentrations, identification of potential plant species, a greenhouse study to determine remediation potential, and field deployment to test remediation of soils.

An overview of Laura Fay and Dr. Claire Luby's academic, professional, and research experiences is provided below.

Laura Fay, Senior Research Scientist/Program Manager - Cold Climate Operations & System

Western Transportation Institute, Montana State University
M.S., Environmental Science & Health, University of Nevada, Reno, 2006
B.S., Earth Sciences, University of California, Santa Cruz, 1999

Laura Fay has served as the Principal Investigator (PI) or co-PI on more than forty projects in her eighteen years with the Western Transportation Institute at Montana State University. She has conducted research in the areas of winter maintenance and operations, specifically conducting laboratory and field testing of deicers. Additionally, Laura's graduate work focused on the cycling of mercury from air-water-soil-plants in both greenhouse and field environments. Laura served nine years on the TRB Winter Maintenance committee and is in her second term as Chair of TRB's AKD30 Low Volume Roads committee.

Laura has dedicated her career to supporting state and local transportation agencies in the identification and implementation of best practices through applied research. A key thrust of her research is the effective use of deicers and deicer impacts to the environment (see Road salts, human safety, and the rising salinity of our fresh waters). Additional work can be viewed here.

Dr. Claire Luby, Assistant Professor, Department of Plant Sciences and Plant Pathology, Montana State University

PhD., Plant Breeding and Plant Genetics, University of Wisconsin-Madison, 2016
M.S., Plant Breeding and Plant Genetics, University of Wisconsin-Madison, 2013
B.S., Biology, Middlebury College, 2010

Claire Luby is an Assistant Professor of Horticulture at Montana State University. Throughout her career, she has directed many greenhouse and field-based research projects on various plant species and has published more than 20 peer reviewed papers on this work. She has been the PI or Co-PI on 15 grant-funded projects. She has experience mentoring graduate and undergraduate students through horticultural research projects.

Table 5 presents the number of person-hours devoted to each task by research team members. It also details the percentages of time that each employee is committed to all projects. The level of effort proposed for the Principal Investigator and professional members of the research team will not be changed without written consent of MDT.

Table 5: Project Staffing

Name of Employee, or Support Classification	Role in Study	Task							Percent of Time vs. Total Project Hours (total hrs./person/total project hrs.)	Percent of Time - Annual Basis (total hours/ person/ 2080 hr.)
		0	1	2	3	4	5	**Total**		
Laura Fay	Principal Investigator	80	40	100	80	140	100	**540**	19%	17%
Claire Luby	Co-PI	80	80	80	80	140	80	**540**	19%	17%
Research Support	GIS,Stats			20	5	20	5	**50**	2%	2%
Graduate Student	Researcher		200	200	500	500	300	**1700**	59%	54%
Accounting	Administration	8					8	**16**	0.6%	0.5%
Editor/Graphics	Technical Editing		4	4			16	**24**	1%	0.8%
TOTAL		**168**	**324**	**404**	**665**	**800**	**509**	**2870**		

FACILITIES

The research team has the resources necessary to successfully complete the research and does not anticipate needing additional equipment or facilities that are not already on hand.

The Western Transportation Institute at Montana State University is housed in the Transportation and Systems Engineering Building on the south side of the Montana State University (MSU) campus, which provides ready access to MSU's library, computing, and other facilities. The 27,000 square feet of office space provides dedicated onsite space for project staff and facilities for archiving and transmitting data.

Research Computing: MSU computing resources and software will be available and sufficient to perform the research tasks described in the Research Plan.

Information Services: The MSU Library system has licenses with the largest databases of published literature and open access to published articles in many peer-reviewed journals. Literature and information gathering is performed through the extensive resources of the MSU Library which subscribes to more than 250 databases and 18,000 journals in print and electronic format. Specific items not accessible through these sources can be located and retrieved by the Interlibrary Loan service, which is affiliated with other research libraries across the United States.

Graphic and Communication Services: Communications staff provide technical editing, layout, graphic design, and web page support. Information Technology staff maintains network servers and individual computers, software, and hardware. Relevant university communication facilities include fully equipped video and conference room facilities. WTI routinely conducts internet-based meetings with clients and staff located around the world. Webinars are hosted to facilitate training and information dissemination and recorded for later access by stakeholders.

Administrative Services: The researchers at WTI are assisted by a highly qualified group of experienced support staff. Administrative staff members assist with budgeting, procurement, contracts, and accounting. The university provides Extended University services for online educational course development and publications and an Institutional Review Board (IRB) to oversee all research engaging humans. In addition, the MSU Academic Technology and Outreach department can provide continuing education units.

MSU Plant Growth Center: The MSU Plant Growth Center is a state-of-the-art heated greenhouse facility with 29 different greenhouses, growth rooms, and growth chambers. Supplemental lighting and heating are available in all spaces. Soil and growing media, water, and fertilizer are available for use. Staff members can assist with preparing and setting up experiments.

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