

REMEDICATION OF DEICER SALT CONTAMINATED SOILS USING NATIVE MONTANA PLANTS

Task 2 Report – Soil Sampling Plan

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Acronym List

DOT	Department of Transportation
EC	Electric conductivity
FHWA	Federal Highway Administration
MDT	Montana Department of Transportation
MSU	Montana State University
MT	Montana
NRCS	Natural Resource Conservation Service
PDF	Portable Document Format
PPE	Personal Protective Equipment
ROW	Right of Way
USDA	United States Department of Agriculture
USU	Utah State University
WTI	Western Transportation Institute
avg.	average
Cl	Chloride
dS/m	deciSiemens per meter
ft	feet
in	inch
μS/cm	microSiemens per centimeter
min.	minimum
mg/L	milligrams per liter

Objective

In this task, salt and salt/sand storage facilities and roadways with a higher concentration of winter salt applications will be identified for soil sampling using the help of MDT staff, data from MDT, and other data sources as are needed. Following analysis of this information, a selection of MDT salt and salt/sand storage facilities and highway road segments will be identified for soil sampling. Methods for soil sampling and analysis are provided. The goal of soil sampling is to get a representative view of chloride concentration in soils, identify a range of concentrations that are present, so that they can be used in the Greenhouse study (Task 4) of this research project. The goal of soil sampling is not to perform a detailed sampling of the DOT facilities but to inform future tests. A meeting will be held with MDT staff and the project panel to discuss the identified locations and decide on which sites will be used for soil sampling. Once soil sampling sites are approved, soil sampling will be conducted.

Soil Sampling Locations

MDT staff identified the following locations where elevated salt concentrations in the soil and or water are present at MDT facilities: Alberton, Ashland, Clinton, Deer Lodge, Hardin, Harlowton, Livingston, Philipsburg, Plains, Stanford, Three Forks, and Wilsall (Figure 1). Sites that are shown as red dots have active issues with chloride contamination, whereas sites shown as yellow dots previously had contamination issues. MDT provided available documents on ground and or surface water monitoring reports from these MDT facilities/locations, and a related report on sediment loading from road sanding in Beaverhead County. The range of reported ground water conductivity measured at or near MDT facilities was 98 - 19,918 $\mu\text{S}/\text{cm}$ (Table 1) which can be compare to groundwater quality standards in Table 2. Note that two facilities have soil chloride data, which ranged of 9 – 67,800 mg/L. Showing the need for additional soil sampling at MDT facilities.

Table 1. Summary of MDT facilities reported groundwater conductivity and soil chloride values.

Location	Reported groundwater conductivity ($\mu\text{S}/\text{cm}$)	Reported soil chloride (mg/L)	Most recent year data reported
Alberton	270-1,870		2024
Ashland	1,603-2,040	15.2-17,257	2022
Clinton	98-3,550		2022
Deer Lodge	362-6,609		2023
Hardin			
Harlowton	3,830-4,470		2023
Livingston	805-3,830		2023
Philipsburg	593-602		2019
Plains	513-921	9-67,800	2023
Stanford	411-3,590		2023
Three Forks	463-1,997		2024
Wilsall	818-19,918		2023

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Table 2. Groundwater quality standards.

Standard	Amount
Class 1 Groundwater (EC)	1,000 $\mu\text{S}/\text{cm}$
Maximum Contaminant Level (Cl)	250 mg/L

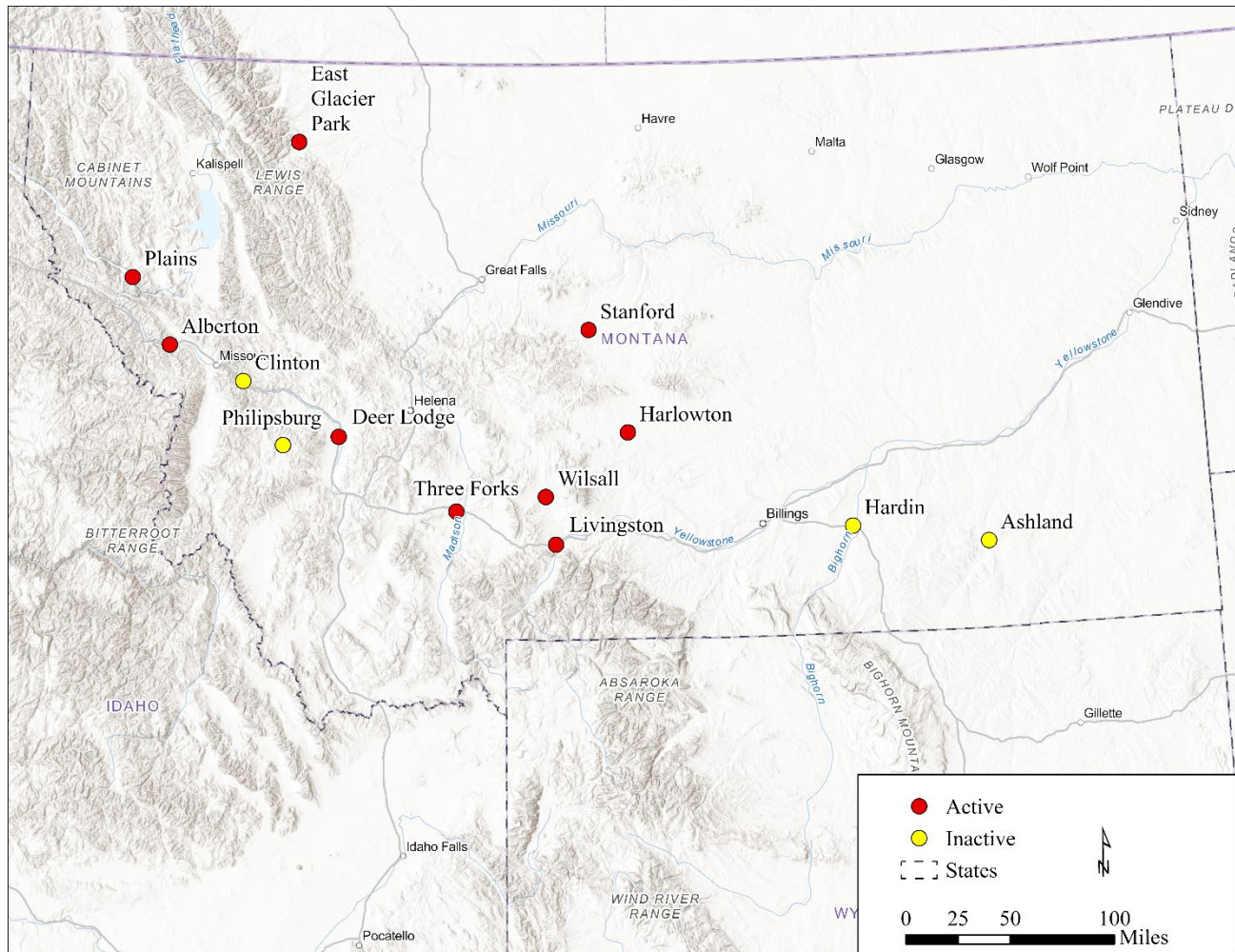


Figure 1. Map of Montana with MDT facilities noted that have active tracking of deicing salt related contamination of soils and or water (red) and inactive (yellow) previously identified as having deicing salt contamination of soils and or water.

To identify highway locations for soils sampling, MDT provided data on road salt use across the state. The locations with the highest road salt use were identified as potential areas where the highway soil sampling may occur.

Proposed MDT Facility Soil Sampling Locations

Based on the information provided by MDT, the following MDT locations have been identified for soil sampling to ensure soil sampling at a variety of sites, on both the western and eastern side of the Rocky Mountains: *Alberton, Deer Lodge, Three Forks, and Wilsall*. Note that the Plains MDT facility was identified early on as an important site but because of the extensive soil sampling and ground water monitoring (reports provided from 2023 and 2024), sufficient information on chloride concentrations at the facilities is already documented and does not warrant additional sampling for validation. We will use existing Plains data to support future task efforts.

Proposed Highway Roadside Soil Sampling Locations

Soil sampling will be done at multiple locations along the highway roadside. Areas identified with high volumes of deicing salt use include highways near Laurel and Billings. These are general locations with road salt use, but to identify specific sampling sites, we will need further input from MDT staff.

Soil Sampling Method

For the sites selected, soil sampling will follow the methods described herein.

Soil Sampling Timing

Soil and water chloride concentration can vary seasonally (Lundmark & Jansson, 2008; Olofsson & Lundmark, 2008). The timing of sampling will be determined by weather and ground thaw conditions. These will be carefully tracked, and the team will be ready to sample in March-April of 2025.

Soil Sample Collection

The following soil sampling protocol has been developed to ensure consistency among samples collected from the various identified locations.

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. 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.

Soil Sampling Method

MDT salt storage facilities will be sampled differently for each site based on local maintenance crew knowledge and existing information from the reports provided by MDT. This may include areas with higher salt levels or with other significance (former salt storage area, snow storage location, etc.).

Soil samples collected from highway roadside will be collected based on the recommendations of local crews, existing information, and site-specific characteristics. In the near-road environment, we will use a systematic grid sampling approach, with measurements parallel along either side of the highway that will extend the sampling out to the tree line (Figure 2).

No more than ten samples will be collected at any MDT salt storage facility or highway location, as we are finding a range of soil salinity rather than mapping soil conditions. Samples will be collected from the top twelve inches of soil depth for roadside and facility sampling. Extensive pictures of each site will be taken to record soil and weather conditions, plant distribution, and sampling locations. Notes about site conditions will be taken to match the pictures. Samples will be stored in 1-gallon sealing plastic bags, labeled with site details, and stored together to be processed in the lab. To expand on sample data, sites where samples were collected will be mapped.

Sampling Equipment

- Soil auger
- Soil sample collection probe
- Shovel
- Mallet/hammer
- 1-gallon sealing plastic bags
- Permanent marker
- Camera
- Notebook
- Pen, pencil

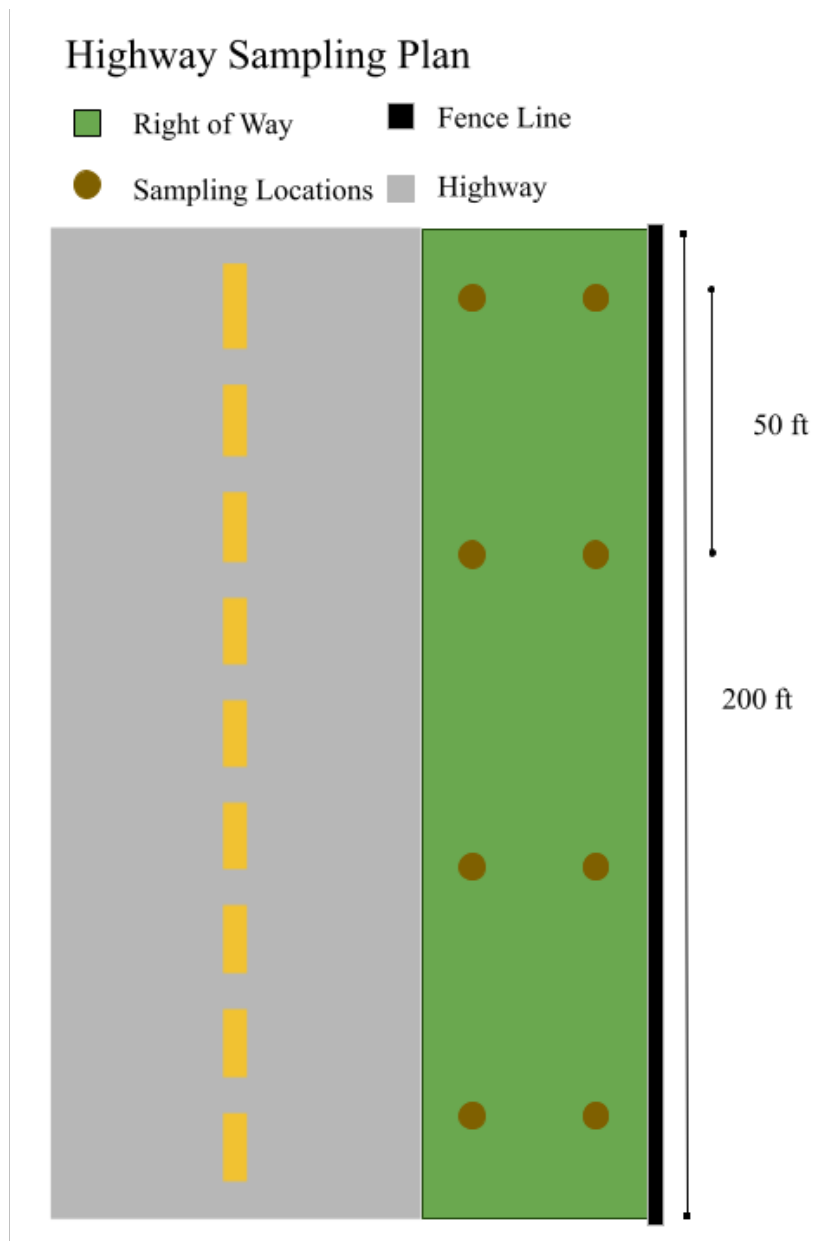


Figure 2. Highway Soil Sampling Plan

Sampling Equipment

- Soil probe
- Gallon zip-lock bags
- Sharpie and pencil
- Gloves
- High visibility vest and hard hat
- Notebook
- Camera

Safety and Communication Protocols

Before visiting any MDT facilities to sample, the appropriate site contact will be notified to ensure everyone's safety at the site during sampling.

Prior to soil sampling along the highway, MDT will be notified, and all required safety protocols will be followed when working in the ROW; including signage and use of personal protective equipment (PPE) (e.g., high visibility vest and hard hats).

Soil samples collected will be brought to MSU for processing to determine chloride concentrations. This data will be used to determine chloride dosing in Task 3 Greenhouse effort.

Soil Chloride Analysis

For the samples collected in the field, 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 blends (rock salt blended with sand (NaCl, solid) (50/50)), and salt along highway roadside 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 soil samples. Both chloride testing methods require sample preparation. This includes pulverizing the soil, passing it through a 40 mesh or 18 mesh sieves respectively, drying it, and dissolving it in 50-100 ml distilled water. This process will be done for each bagged sample to maintain testing uniformity and keep materials clean and safe.

Titration is a standard methodology used to determine chloride concentrations. This protocol involves adding Potassium Chromate to the prepared sample as an indicator. Silver Nitrate is titrated into the sample until color change occurs. Calculations are done to determine the amount of reactant needed to offset the chloride concentration or cause the color change. This method can be resource- and time-intensive and requires expertise to perform.

Another proposed method for determining chloride concentrations is using a chloride ion sensor. It requires a sensor and a connection to a sensor data collection device. After the sensor is

calibrated with the 2 provided equilibrium solutions, it is placed in the solution, and the measured concentration is recorded. This method is much less resource- and time-intensive but has a much higher initial cost and potentially fragile instrumentation.

To ensure accurate results, we will record conductivity with an aqueous EC meter after titration or after using a chloride sensor.

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 will be provided, and a meeting will be held to discuss the findings and the next steps.

Next Steps

The soil sampling will be conducted, followed by testing soil samples for chloride concentration. Preliminary seed studies will continue.

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