Oregon Department of Transportation

Winter Maintenance Strategy

April 2018

ODOT Maintenance and Operations Branch

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Attachments:

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ODOT Winter Maintenance Strategy

Introduction

This winter maintenance strategy includes phasing in the use of salt in some key areas, defining principles to guide further expansion, consideration of environmental best practices, and annual reporting.

Since the 1990's ODOT has been using a liquid chemical deicer to improve road conditions during winter storms. The product is effective in a wide range of temperatures and in most types of Oregon storms, reduces the impact chloride based deicers can have on vehicles and some infrastructure, and can be stored in large tanks at relatively low cost. ODOT has done a good job maintaining roads in winter with the tools we have. However, gaps in the toolbox have been evident. What once may have been considered extreme in terms of winter weather (e.g., freezing rain), has become more common and more widespread; driver expectation seems to be changing with increased expectations for the highway to remain open, and to be able to drive at speed, during inclement weather.

The winter of 2016-2017 was significant. Widespread snow and ice storms occurred simultaneously across much of Oregon. While drivers expect highways to remain open even during storms, particularly interstates and freeways, several significant routes closed for extended periods due to packed snow and ice. In such widespread events, resources must be prioritized. ODOT prioritizes limited resources to match highway function. The attached *ODOT Winter Level of Service Standards* (Attachment A) describes this prioritization.

ODOT strives to keep interstates and freeways open and to improve mobility by returning to speed as quickly as possible after a storm. While a solid deicer is not always appropriate, in certain situations solid salt can help remove packed snow and ice where a liquid is not recommended.

The July 2017 *Keep Oregon Moving* legislation (HB 2017) directed the Oregon Transportation Commission to develop a winter maintenance strategy that includes the use of rock salt or similar solid deicer. Prior to the passing of this legislation, ODOT had begun to explore the limited use of salt in a couple of locations. The strategy presented here includes and builds on ODOT's years of experience gained from recent use as well as best practices learned from ODOT's participation in organizations such as the Pacific Northwest Snowfighters[1] and Clear Roads[2]. This strategy integrates our snow and ice tools and states our goal to find a balance between providing a safe roadway and minimizing impacts on the environment, the infrastructure and travelers' vehicles. This strategy is built on the notion of learning by phasing in the use of salt and construction of storage sheds, utilizing technology and innovations to collect and review data, and continually evolving our processes and procedures.

ODOT began a pilot project using salt on two sections of highway in the 2012-13 winter (Interstate 5 on Siskiyou Pass at the California border, and U.S. 95 connecting Nevada and Idaho through southeastern

[1] The Pacific Northwest Snowfighters is a consortium of Pacific Northwest states that developed and implements standards for rigorous testing of deicing products to ensure they are effective and safe for human health and the environment.

[2] Clear Roads is a pooled fund technical advisory committee dedicated to funding sound winter maintenance research to identify cost-effective techniques, technologies and equipment to save agencies money, improve safety and increase efficiency.

Oregon). We know salt is an effective deicer. In this pilot, we evaluated how and when to use salt in a limited way to improve highway conditions. Our goal was to limit its use and potential impacts to the environment, infrastructure and vehicles, while also reducing fatal and serious crashes.

As we slowly expand the use of salt to other critical routes, our strategy will continue to be to use salt in a limited way to gain the greatest safety benefit and the least impact to the environment, infrastructure and vehicles.

Deicers are critical to preventing snow and ice from bonding to the pavement and allowing plows to do the removal work. Using a liquid deicer is not always adequate to prevent snow and ice from bonding to the pavement, nor is it appropriate or recommended in certain storms such as freezing rain. Having a solid deicer in the toolbox helps ODOT improve pavement conditions in situations where a liquid is not effective or recommended.

Chemical deicers are just one of several tools in the winter maintenance toolbox. ODOT intends to continue to use abrasives (sanding material) when appropriate and ODOT continues to evaluate equipment and make modifications that improve plowing effectiveness. ODOT has recently added (see photos below) towplows, belly (or underbody) plows and dual wing plows, and is testing new plow blade designs. Effective plowing can reduce the amount of winter chemicals needed. ODOT provides general guidance on winter maintenance activities in the *ODOT Maintenance Guide Snow and Ice chapter* (Attachment B).

ODOT tow plow

ODOT dual wing plow

Because driver behavior and preparedness plays a role in reducing winter crashes, ODOT supports driver education and produces travel information tools. ODOT's TripCheck provides real-time information on road conditions and forecasted events to help travelers plan their trip and be prepared. ODOT is adding to our Road Weather Information System network that provides localized road weather and cameras and also is testing the first weather-triggered variable speed limit signs on Interstate 84 in eastern Oregon (see photos below). The variable speed sign is triggered by certain weather events or visibility restrictions such as heavy fog, reducing the posted speed limit and warning travelers of inclement conditions and the need to travel cautiously. Further, ODOT is staying apprised of national research that aims to better understand how to affect driver behavior and the role it plays in preventing crashes. ODOT recently was awarded for its public service campaign to reduce distracted driving.

Interstate variable speed limit signs eastern Oregon

Phased approach

ODOT's winter maintenance strategy defines an adaptive, phased approach implemented over time and based on lessons learned and advances in technology/equipment/materials.

In 2012, ODOT implemented a pilot project on Interstate 5 at the California border, and on U.S. 95 in southeastern Oregon. In these locations ODOT achieved a reduction in crashes and an increase in mobility based on fewer chain restrictions and highway closures. Findings were reported in the attached *Final Annual Report- November 2017: ODOT Winter Salt Pilot Project, November 2012- April 2017* (Attachment C).

ODOT implemented a second phase pilot study in the winter of 2017-18, where salt was used on interstates in eastern and southern Oregon. This phase constructed new salt storage facilities, added new equipment, and retrofitted existing equipment. Learning best communication and coordination practices across districts and switching between using sand and salt are just some of the learning curves of this phase.

Phase 2 also included allowances for the use of salt, if and when necessary and available, on the remaining interstate and freeway locations in the state. Until adequate quantities of salt are able to be stored nearby, limited areas may be treated with salt when necessary and appropriate in these other interstate and freeway sections, or as further expansion occurs.

This phased approach will continue to inform the future expansion of salt and allow ODOT to continue to learn, adapt and train appropriately. ODOT will continue to evaluate high level of service locations that experience frequent severe winter storm events, significant mobility constraints or crashes to determine if they may benefit from the use of salt and determine how much storage might be necessary to appropriately serve a given area. ODOT is committed to using salt responsibly, limiting its use to locations and situations where current tools are ineffective, inappropriate, or not cost effective. Salt is just one tool in our winter maintenance toolbox. As we learn more about salt storage, equipment, use, and staffing needs, this phased approach will be adapted to best meet highway safety and mobility concerns.

As we consider future phases in the years ahead, we will use the following guiding principles.

Guiding Principles

ODOT does not plan to use salt on all state highways or in every storm. ODOT intends to balance safety and environmental considerations:

- Focus first on interstate and freeway locations
- Consider heavy freight corridors
- Reduce fatal and serious crashes
- Focus on highway segments with a history of snow and ice conditions
- Minimize environmental impacts, including not using it on Cascade or Coast range passes, or on coastal highways

Environmental best practices

ODOT is committed to promoting smart use of salt and deicer materials to minimize impacts to the environment, critical infrastructure, and travelers' vehicles. Providing training on proper storage and handling procedures and how to minimize salt use are the best ways to accomplish these goals.

Before implementing the first phase pilot, ODOT developed best management practices based on national and worldwide research and lessons shared at consortiums, conferences, and engagement with other state DOTs at Clear Roads. These practices are reviewed and updated based on lessons learned. They include environmental BMPs for salt purchasing, storage, handling, disposal, and application rate guidance for different conditions (Attachment D). ODOT will continue to monitor and evaluate storage and handling practices to ensure these practices are optimal. ODOT will also track quantities of deicer materials used on state highways. As we learn more about salt storage and handling methods and ways to reduce salt use, we will continue to evolve the program, implement best practices, and train ODOT staff and managers. ODOT will continue to coordinate with natural resource regulatory agencies and report annually on the winter maintenance program.

Monitoring for environmental impacts

ODOT monitored roadside soils and streams during the initial phase. Sample locations showed little or no increase in associated chloride levels during the pilot. Since salt quantities applied to the highway were minimal, it was expected that elevated chlorides wouldn't be evident or would only occur in those areas where application rates were high or where salt was concentrated due to environmental factors (such as drainage patterns). This was generally true; monitoring conducted at one small stream (Carter

Creek on the I-5 Siskiyou Pass MP 3-6) indicated elevated chlorides where it appears highway runoff is concentrated to one area.

Limited or controlled application of various highway salt products is a relatively new development in highway management. It is well understood that the historical practice of applying large quantities of salt to clear snow and ice from the highway damages the environment. What is not well understood is the environmental risk posed and potential gain made by using lower application rates. There is little value in doing more monitoring to confirm that salt impacts do occur. What is needed is more information on when, where, and why salt impacts occur when using current salt application methods.

ODOT will continue to seek research opportunities to learn about how best to identify and minimize salt impacts. ODOT is currently working with the U.S. Geological Survey (USGS) to complete an important research project on Carter Creek and the surrounding area to determine the factors contributing to higher chloride content in the stream. This monitoring was initiated by ODOT in phase one of the pilot and is now being carried out by the USGS through this research project. The project will further develop a computer model that can evaluate when and where adjacent streams are at risk of exceeding water quality standards due to highway salt use. ODOT will use the study's findings to determine if certain key environmental factors (e.g., precipitation events, streamflow, highway runoff) can be used to determine when and where ODOT salt practices are most likely to pose risks to the environment. In this way the research will identify the best way to assess impacts as we move forward. It may be that in-stream monitoring is not the best approach to evaluate potential highway runoff impacts. A second phase of this research project is planned to examine potential salt impacts to groundwater.

This research is being carried out with involvement from DEQ and ODFW. ODOT will continue to coordinate with both DEQ and ODFW to monitor and review the best way to protect the environment from chlorides and address impacts to water quality, fish and wildlife.

Infrastructure concerns

As part of the phase 1 pilot, ODOT sealed all the bridge decks on U.S. 95 and I-5. The bridge deck seals effectively prevented further chloride contamination, but several bridges with previous chloride-contamination required structural overlays to be installed after only 12 years of service due to salt applications in the 1980s and magnesium chloride use since the 1990s. Based on this experience all bridges exposed to rock salt will require effective deck protective treatments. ODOT bridge engineers will continue routine deck sealing and reconstruction where needed and implement a monitoring plan to evaluate chloride migration and sealant timing practices.

We also tested continuous reinforced concrete on I-5 for impacts from salt during phase 1. While data was inconclusive over this short period of time, salt-related deterioration was evident in the concrete pavement. ODOT is working with Oregon State University to perform a data review and provide alternatives for sealing concrete surfaces.

Annual reporting

As we continue to learn and phase in our new approaches, data will be key to our decision making and the development of this strategy. ODOT will prepare an annual report with the following items:

- Implementation status of the phases;
- Material application and rates, including the amount used;

- Measure of delays to traffic and freight by reporting data on the number of closures, holds, chain restrictions;
- Fatal, serious and all crashes;
- Research status/findings on best practices from around the country as well as from our work;
- Lessons learned and recommendations; and
- Comments or concerns from DEQ and ODFW.

Attachment A:

Winter Level of Service Standards for State Highways (description and map)

Winter Level of Service Standards for State Highways

Oregon Department of Transportation, January 2007

Specific levels of service described below apply to routes defined by collaboration and communication with and among Highway Division staff. Each district has a map that identifies level of service for each route. Where level of service standards change along a defined route is typically based on topographic, climactic, or population factors, for example, base of mountains, edge of large metropolitan center, etc.

ODOT is not staffed, equipped, or funded to maintain the highways at the levels of service indicated on the map for other than routine events. Also, certain weather conditions and types of storms (such as freezing rain) create situations where winter chemicals are not effective and should not be used or should be discontinued. For other than routine events and ruing these situations, road conditions and roadway treatment and actions will fall below the targets shown on the map.

The level of service standards are intended to provide guidance to maintenance staff conducting winter maintenance operations. The overarching goal of these levels of service is to enhance the ability of the safe driver to travel during most winter conditions and to reduce the affect most winter conditions have on driving.

Refer to the Maintenance Guide for additional guidance on sanding, deicing, and other winter maintenance procedures.

Level of Service	Description of Roadway Treatment and Actions	Expected Road Conditions
LOS A	1. Snow should be removed continually during all shifts. 2. Staffing with *overtime is expected*. 3. As appropriate, pre-treat roadway with deicing chemicals before forecast a snow, ice, or frost event. 4. As appropriate, apply deicing chemicals to roadway if snow or ice is accumulating to try to keep it from compacting and bonding to the pavement. 5. If compact snow, ice, or frost forms on the roadway, sand and/or chemicals should be applied as appropriate to try to provide traction and assist in the breakup and removal of the snow, ice, or frost.	• Snow and ice buildup may be encountered during the storm and for a few hours after the storm. • Bare pavement attained as soon as possible. • Travel delays are minimal and infrequently experienced. • Chains/traction tires may be required for short periods during a storm. • Highways are open. [1]
LOS B	1. Snow should be removed continually during all shifts. 2. Staffing with *overtime may be used*. 3. As appropriate, pre-treat *known* problem areas with deicing chemicals before a forecast snow, ice, or frost event. This may include grades, curves, bridges, ramps, and other known problem areas. 4. As appropriate, apply limited applications of deicing chemicals to roadway if snow or ice is accumulating to try to keep it from compacting and bonding to the pavement. 5. If compact snow, ice, or frost forms on the roadway, sand and/or chemicals should be applied as appropriate to try to provide traction and assist in the breakup and removal of the snow, ice, or frost.	• Snow and ice buildup may be encountered druing the storm and for several hours after the storm. • Travelers may experience some delays with roads having patches of ice, slush, or packed snow. • Chains/traction tires may be required during and for several hours following a storm, particularly for vehicles over 10,000 GVW and vehicles towing (Condition B). • Highways are open. [1]
LOS C	1. Snow should be removed during regularly scheduled shifts. 2. Staffing with *overtime should be minimized.* 3. As appropriate, pre-treat *known* problem areas with deicing chemicals before a forecast snow, ice, or frost event. This may include grades, curves, bridges, ramps, and other known problem areas. 4. Accumulated snow pack should be groomed. 5. Chemical deicers may be used on a limited basis to remove ice or snow pack in known problem areas. 6. Snow pack and ice should be sanded at known problem areas which may include grades, curves, bridges, or ramps to enhance traction.	• Snow and ice buildup encountered regularly both during and following a storm. • Travelers likely to experience delays with roads having ice packed snow. • Travelers may encounter bare wheel tracks. • Chains/traction tire requirements occur regularly for vehicles over 10,000 GVW and vehicles towing (Condition B) and occasionally for all vehicles (Condition C). • Short term highway closures may occur during a storm, closures are limited in duration and highways are reopened as soon as possible.

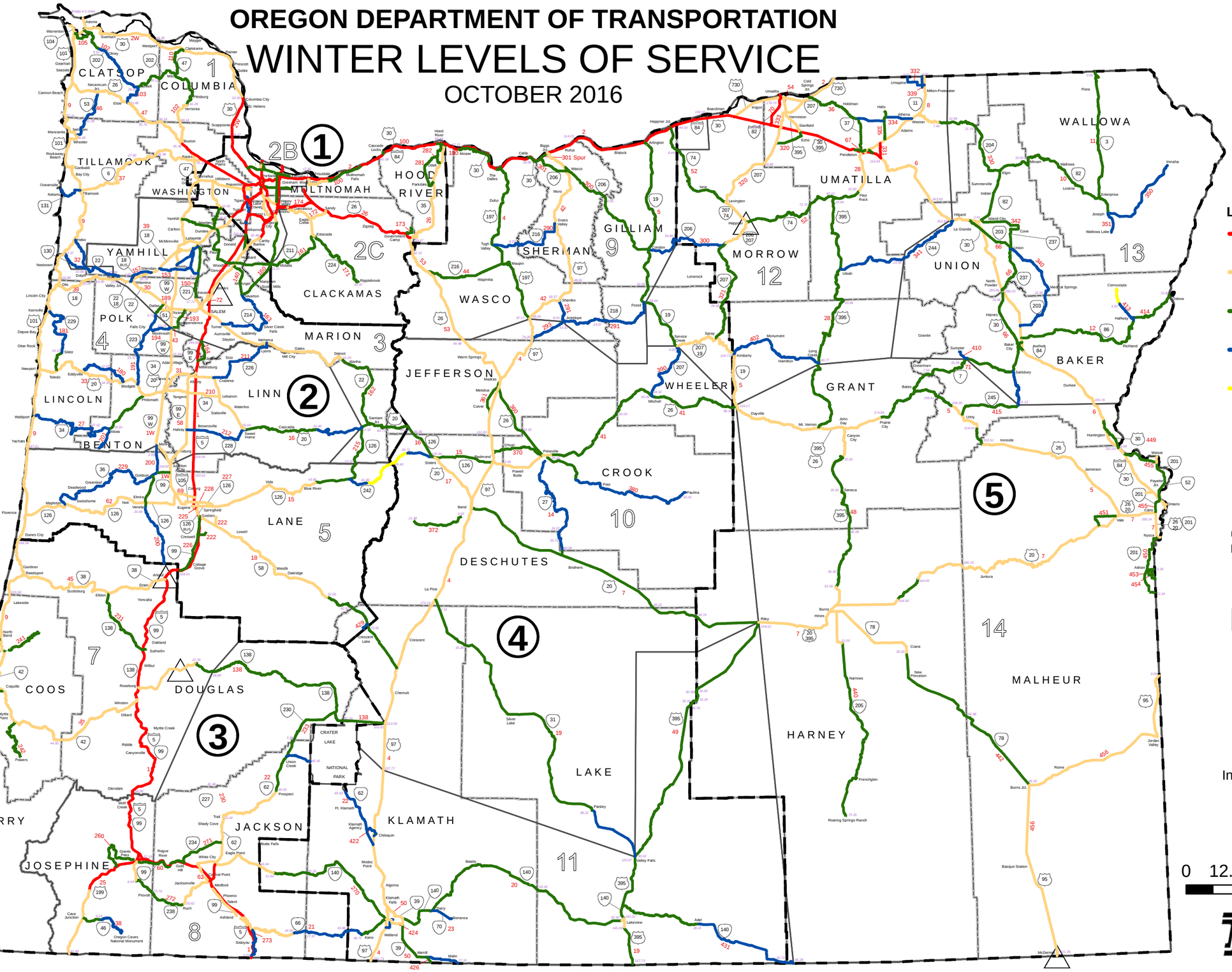
[1] Highway closures should generally not occur for routine winter storms on highways with this level of service. However, closures frequently occur from vehicle crashes caused by driver error and human behaviors beyond the control of ODOT. The department will clear accident scenes and reopen highways as quickly as possible.

LOS D	1. Snow should be removed during regularly scheduled shifts. 2. Generally *overtime should not be used.* 3. Chemical deicers generally are not used to either pre-treat or to remove ice or snow pack. 4. Snow pack and ice should be sanded at known problem areas which may include grades, curves, bridges, or ramps to enhance traction.	• Snow and ice buildup encountered regularly both during and following a storm. • Travelers likely to experience delays, slow speeds, and short-term closures. • Travelers may encounter bare wheel tracks. • Chains/traction tires required routinely for all vehicles (Condition C). • Highway closures may occur during a storm.
LOS E	1. Limited snow and ice removal effort. 2. Staffing with overtime will not be used. 3. Highways should be closed when conditions dictate.	• Closed seasonally or routinely due to road conditions. • Heavy snow and ice buildup encountered regularly both during and following a storm. • Chains/traction tires required routinely for all vehicles (Condition C).

OREGON DEPARTMENT OF TRANSPORTATION

WINTER LEVELS OF SERVICE

OCTOBER 2016



GIS Project #. 23-64
Oregon Department of Transportation
Geographic Information Services Unit

Attachment B:

ODOT Maintenance Guide: Snow and Ice Activities

Activities 170 through 179
Snow and Ice
General Instructions

This section includes activities involved in controlling and removing snow and ice on the State Highway system. Work involved with designated Winter Recreation Parking Locations (Sno-Park) is discussed in the Other Direct Maintenance Activities section of this Guide.

Perform work to maintain those areas at the level allowed by, and consistent with the policies set forth in:

- Chapter 5 of this Guide – Planning, Budgeting, and Reporting Maintenance Activities
- *Role of Maintenance*, Section 3 – Maintenance and Operational Activity Priorities
- Performance Budget and
- *Desired Conditions of Maintenance Features on State Highways.*

Plan and implement methods to control erosion, sediment and pollutants or contaminants, including those discussed in the Control of Erosion, Sedimentation, and Pollutants or Contaminants section of this Guide and the *ODOT Routine Road Maintenance Water Quality and Habitat Guide Best Management Practices.*

As appropriate, implement and maintain devices and processes including those described in the *Field Manual for Erosion and Sediment Control.*

Plan, implement, and maintain traffic control as addressed in the *Oregon Temporary Traffic Control Handbook*

For mobility requirements, maintenance activities (conducted by internal staff or their contractors) and their impacts to traffic must be considered prior to starting work.

Before beginning any type of excavation work in areas where utility or other non-ODOT facilities could be buried, contact the Oregon Utility Notification Center (OUNC) 1-800-322-2344 so the facility owners can mark the location of their facilities.

Activities 171 and 176 involve use of products as pre-wetting, anti-icing, or deicing agents. Only use those products that have been approved by the State Maintenance and Operations Engineer. The Transportation Maintenance Manager must perform or ensure several things about those products, including:

- Post, or otherwise have easily available, a Material Safety Data Sheet (MSDS) for each product located at each storage location.
- Maintain a copy of the bill of lading for each shipment at the storage location.
- Store and use each product in a manner that preserves its integrity, prevents unacceptable leakage or spillage, and that complies with recommendations of the manufacturer.

- Inspect and sample each product as described in the ODOT *Winter Maintenance Chemical Sample Protocol.* This involves:
  - Visually inspect each shipment. Address any apparent problems, including visible contaminants, abnormal odor or color, etc. Seek assistance from the Office of Maintenance and Operations.
  - Sample each shipment using sampling procedures and containers furnished by the Office of Maintenance and Operations.
  - Send the samples to the. Office of Maintenance and Operations where they will be tested

- Record information about use of each product in a format, such as a sanding log discussed in Activity 171, to allow approximate locations and quantities of use to be determined.

ODOT may share information about the use and test results of the products to the Oregon Department of Environmental Quality and others.

Winter Operations Plan

The District Manager, with each Transportation Maintenance Manager in the District, should develop the District's Winter Operations Plan and update the plan by November 1 of each year. The District's Winter Operations Plan may include, but is not limited to:

- Level of service goals for each highway.
- Names and telephone numbers to contact each maintenance employee, Transportation Maintenance Manager, the District Manager, and other personnel or managers that would be involved in winter operations or that may need to be notified in the event of an incident or emergency. (To maintain the security of private information, do not include home phone numbers or addresses in copies provided to individuals or agencies outside of ODOT.)
- Available equipment and location of sanding material, anti-icing or deicing products, etc.
- Procedure to accomplish repairs to winter maintenance equipment.
- Work needed prior to winter, such as installing snow poles, "Snow Zone" signs, etc.
- Probable shift assignments of maintenance personnel.
- Need for training regarding winter maintenance activities or situations.
- Assignment of priorities, by highway and location, for maintenance activities, including routes used by school buses. This could involve cooperative maintenance by or for adjacent maintenance areas or Districts.
- Identification of "Snow Zones" and the procedure to install and remove signing to indicate travel conditions and/or need for traction tires or chains. This should address the travel conditions identified in OAR Chapter 734 Division 017 and ODOT's ability to conditionally close a roadway.
- Names and contact telephone numbers of personnel from adjacent Districts or other public agencies that could be involved in or affected by winter situations.
- Procedure to respond to an incident or emergency, including needed notification of managers or others.

- Procedure to close a highway or limit its use.
- Names and contact telephone numbers of contractors or equipment suppliers that may furnish equipment, operated or unoperated, if needed.

Although a copy of the District's Winter Operations Plan may be furnished to the Region Manager and State Maintenance and Operations Engineer, each District is preparing its Winter Operations Plan for its own use in:

- Understanding the needs of winter maintenance in the District and for each of its highways.
- Identifying resources available to perform the work and respond to maintenance needs.
- Identifying priorities of performing activities or responding to situations.
- Identifying resources that could be available from other sources if needed.
- Identifying points of contact with other public agencies in the area that may be involved.
- Identifying procedures to respond to incidents or emergencies and to close highways if needed.

The District Manager should furnish the names, contact telephone numbers, ODOT radio call sign, and similar information to the Transportation Operations Center (TOC), so the TOC can contact appropriate persons to respond to situations.

The District Manager generally only needs to furnish the telephone number of the TOC to law enforcement agencies, local governments, and others. The TOC can then contact the appropriate Transportation Maintenance Manager, District Manager, or other designated contact person.

Prior to the onset of winter conditions, the District Manager and Transportation Maintenance Manager should, among other things:

- Identify the snowplow, sander, anti-icing or deicing product applicator, or other attachment to be attached to or mounted on specified vehicles.
- If blowing snow may be a problem, maintain roadside vegetation to minimize drifting and maintain or repair snow fence as appropriate.
- Ensure that drainage facilities are ready for increased flows from rainfall and runoff.
- Install snow poles as appropriate.
- Ensure that specialized winter equipment, such as snow blowers, are in good working order.
- Ensure that adequate supplies of sanding material or other anti-icing or deicing material are available when needed.
- Contact the ODOT Construction Project Manager for each active construction project on the State Highway system in the maintenance area to confirm that the project will be in suitable condition to allow snow and ice control work.
- Ensure that needed communications, including radios, will be available for use.
- Ensure that normal repair parts are available for use.

- Maintain or install "Snow Zone" signs.
- Ensure that employees receive needed training on winter maintenance.

Ensure that information on current road and weather conditions is properly and timely reported to the Transportation Operations Center for posting on ODOT's TripCheck website.

Do not perform work for another public agency or a private entity unless ODOT has entered into an agreement to perform the work or the work has been properly approved. As appropriate, record all costs incurred and assure that ODOT bills the responsible party for those costs.

Refer to the Emergency Operations and Incident Response section of this Guide for discussion on crashes, disabled vehicles, and other incidents that may be encountered while performing winter work.

Use of Chains on ODOT Vehicles

Studded tires are not used on ODOT vehicles. Normally tire chains are used on ODOT vehicles when chains or traction tires are required. However, ODOT vehicles are exempt from the chain requirement when used in the course of snow and ice control. Some vehicles, such as the 4x4 Autocar, may provide adequate traction without chains even though other vehicles require chains for the same situation. The driver of ODOT vehicles is responsible to decide when to use tire chains on vehicles during snow and ice conditions.

Generally, it is good judgment to use tire chains when:

- You have a problem in starting, stopping, or turning on ice or snow.
- Operating around stalled vehicles on a steep grade or superelevation.
- Operating during breakup of a snowpack.

When in doubt about whether to use tire chains, it is probably better to choose to use tire chains.

Use of Rotobeams or Other Overhead Warning Lights

Operate the vehicle's rotobeam or other overhead warning lights when actively plowing snow or applying sand or anti-icing or deicing product. Turn on the rotobeam or warning lights in advance of starting the plowing or application work to adequately warn other vehicles.

Rotobeams or other warning lights are not normally used for routine patrol work.

Also see discussion in the Safety section of this Guide about other use of the rotobeam or other warning lights.

Closure of a Highway or Restriction on Use

Refer to the Oregon Administrative Rule 734-020-0150 for authority delegated of the Chief Engineer, Region Manager, District Manager, and Assistant District Manager to conditionally close a highway or to restrict its use by specific vehicles or types of vehicles.

The Region Manager also has delegated authority, in consultation with the Motor Carrier Transportation Division Manager, to establish criteria for and post limits on weight or length restrictions for highway traffic. The authority is included in the Oregon Administrative Rules Chapter 734, Divisions 050 and 070.

Activity 170
Snow Removal/Snow Pole Maintenance

Description

Activity 170 involves removal of snow, ice, or slush from the roadway and shoulders, by plowing, blading, or blowing, to the extent practicable, to allow and maintain movement of traffic. It also includes installing, maintaining, and removing snow poles.

General Information

Refer to discussion in the General Instructions sections, preceding activity 170 in this section of the *Maintenance Guide* for additional information including environmental and traffic control recommendations and other important considerations.

Refer to Activity 174 for winter road patrol.

Refer to Activity 171 for application of sand.

Refer to Activity 176 for application of anti-icing or deicing products.

Refer to Activity 301 for work done in a designated Winter Recreation Parking Location (Sno-Parks).

Refer to Activity 137 for snow removal in rest area parking lots, etc., that are outside of the normal vehicle path through the location.

Refer to Activity F03 for snow removal at building locations.

Except as funded differently in the performance budget or as precluded by more critical work or situations, control and remove snow and ice on the State Highway system as described in the District Winter Operations Plan and ODOT *Desired Conditions of Maintenance Features on State Highways*.

Install snow poles, as appropriate, in areas of heavy snowfall to help identify the edges of the roadway. Generally, install them before the first major snowfall and remove in the spring.
Snow poles may be:

- Attached to delineators or guardrail posts such that the attachment does not impair the function of the delineator or guardrail.
- Installed as freestanding installations. Install at the same distance from edge of pavement as delineators are installed in the area.

As conditions indicate, ensure that proper signing is installed and removed on "Snow Zone" signs to indicate conditions and/or the need for traction tires or chains.

Identify, and mark as needed, the location of guardrail and other features in or adjacent to the roadway that may be damaged by snow removal work.

If blowing snow creates unacceptable drifting, it may be possible to control or maintain vegetation, under the appropriate activity in the Roadside and Vegetation Activities section, such that drifting is reduced. Consider installing snow fence in locations with continual drifting problems.

Operate a vehicle's rotobeam or other overhead warning lights when actively plowing snow. Turn on the rotobeam or warning lights in advance of starting the plowing operation to adequately warn other vehicles. Generally do not use the rotobeam or other warning lights for routine patrol work. Also refer to discussion in the Safety section of this Guide.

Special Instructions

Take extra care when removing snow at crossings of railroads or other rail facilities. Assure that the snowplow blade is raised adequately to not damage the rail facilities. After clearing the rail area, check the rail area for damage and manually remove snow and other material to clear the rail area and not hinder the rail operation.

At bridges and other roadway structures, ensure that snow removal operations do not damage or have not damaged the expansion joints in the structure deck. The Transportation Maintenance Manager should develop a listing of structures that have expansion joints at an angle to the roadway that is similar to that of a snowplow. Operators of snowplow equipment should take extra care, by slightly raising the snowplow or other means, to avoid potential damage to the snowplow and the structure at those locations.

Where a structure crosses a pedestrian or bicycle facility or another roadway, take extra care to avoid damage, injury, or other difficulty by:

- Reducing speed.
- Checking to ensure that removed snow has not been unacceptably thrown onto the other facility, remove any unacceptable amount that has been thrown there.

Extra care or special handling of snow may be needed at designated locations, including on some bridges, within cities, etc.

Avoid or otherwise control operations that would throw snow onto adjacent parked vehicles, traffic, pedestrian walkways, or buildings.

As appropriate and where needed, modify snow removal operations to minimize the amount of snow and other included materials that may be placed directly in waterways and other environmentally sensitive areas by the snow removal operation.

Where the snow removal operation places a berm of snow across another roadway or driveways, remove that berm as practical soon after to minimize inconvenience to users of those facilities. This may require additional equipment to remove that berm on heavily used adjacent facilities.

Before operating a snow blower in parking lots or similar areas, attempt to determine if vehicles or other objects may be located in the work area and need to be avoided, protected, or removed.

Ensure that overhead and other warning lights on snow removal vehicles are clean and operating at all times during this work. Use the vehicle headlights at all times during the snow removal operation.

Plan snow removal work such that traffic is controlled by the snow removal vehicles or that traffic can utilize a lane where snow has been already removed. When possible, operate snow removal vehicles in tandem on multilane roadways to remove snow from all lanes in the same operation.

If an operating snow blower will encroach on a travel lane or if another operation will impact the movement of traffic, protect and direct traffic as addressed in the *Oregon Temporary Traffic Control* Handbook.

Equipment

Use equipment identified in the District's Winter Operations Plan or as suitable for the work and situation.

Materials

Generally, no material is needed for the snow removal operation.

Installation or maintenance of snow poles may involve:

- Snow poles.
- Reflective bands.
- Attachment devices.

Work Method

For snow removal operations:

1. Plan snow removal activities as specified in the District's Winter Operations Plan.
2. Identify and implement appropriate methods to control traffic, if needed.
3. Identify concerns about impacts of snow removal on adjacent streams, waterways, etc. or over railroads or railroad tracks, on structures, and in urban areas and implement appropriate methods to control impacts.
4. Perform snow removal.
5. Remove snow berms from entrances to adjoining roadways, driveways, mailbox turnouts, etc.
6. Remove traffic control as appropriate.

For installation, maintenance, or removal of snow poles:

1. Implement appropriate traffic control.
2. Perform the needed activity.
3. Remove traffic control.
4. Dispose of waste material in an appropriate location.

Measurement of Accomplishment and Expenditure Account Type
Measurement is number of worker hours involved. Expenditure account type is Section EA; use a sub job appropriate for the crew performing the work.

Use a sub job within the 800 series if the work involves bicycle path facilities. These sub jobs are assigned by the Maintenance Management System (MMS) Unit based on the type of work performed.

- Charge all work to Activity 170.

Activity 171
Sanding

Description

Activity 171 involves applying abrasives, including cinders, universally accepted by road authorities for sanding operations, either alone or mixed with pre-wetting agents, to roadway surfaces to assist with traction.

General Instructions

Refer to discussion in the General Instructions section, preceding activity 170 in this section of the *Maintenance Guide* for additional information including environmental and traffic control recommendations and other important considerations.

Perform sanding to maintain the level of service described in the District's Winter Operations Plan and the *Desired Conditions of Maintenance Features on State Highways*. Also refer to the guidelines discussed below.

Appropriately monitor roadway and weather conditions and apply abrasives, according to the guidelines discussed below.

Refer to Activity 174 for performing winter road patrol.

Refer to Activity 176 for applying anti-icing and deicing products.

Generally, do not perform sanding in areas designated as a Winter Recreation Parking Location (Sno-Park).

As needed, calibrate the sander or other application device to ensure proper application rates for abrasives. Also calibrate the application rate for pre-wetting agents that are applied with the abrasives. As appropriate, post information about speed, tachometer reading, and sander adjustment in the sander vehicle as needed to achieve needed application rates.

If pre-wetting agent will be applied to the sanding material in the sander, ensure that each operator knows the proper application method and rate or amount of application.

For each pre-wetting agent used, follow instructions included in the General Instructions section preceding Activity 170 in this section of this Guide, including:

- Sample each shipment.
- Post a copy of the MSDS and the bill of lading for each product and shipment.
- Record information about use of each agent, such as in the sanding log.

Ensure that all lights on the sander vehicle are operating properly and are not obscured by debris. Operate the vehicle's rotobeam or warning lights when applying sand. Turn on the rotobeam or warning lights in advance of starting the sand application to warn other vehicles. Generally do not use the rotobeam or other warning lights for routine

patrol work. Also refer to discussion in the Safety section of this Guide on the use of rotobeams and warning lights.

Take appropriate precautions, while applying abrasives, to prevent damage to oncoming or following traffic, vehicles adjacent to the roadway, etc. or injury to pedestrians or bicyclists.

As appropriate, modify the sanding operation to minimize impact to waterways and other environmentally sensitive areas.

ODOT should minimize the use of sanding material as sanding materials are handled five times including grinding, stock piling, loading, applying, and cleaning up. Sanding material (aggregate, cinder, or other material):

- Is costly.
- Is becoming less available.
- Can be a hazard on bare pavement and may damage vehicles.
- Can cause environmental damage.
- Is costly to clean up and may impair drainage and drainage facilities.
- May have other undesirable effects.

Anti-icing and deicing products also have concerns, including those discussed in Activity 176.

The District Manager, Transportation Maintenance Manager, and other involved maintenance personnel should use good judgment to effectively, but minimally, use sanding materials to meet the District Winter Operations Plan and *Desired Conditions of Maintenance Features on State Highways*, and as discussed in the following general guidelines:

- Do not apply sand if anti-icing or deicing products has been applied and conditions are proper for the product to control icing.
- If an icy condition is imminent and anti-icing/deicing products should not be used, sand may be applied according to the District Winter Operations Plan, consistent with the *Desired Conditions of Maintenance of Features on State Highways* and as described below. Generally, do not apply sand to bare pavement because of the concerns addressed above.
- Apply sand only to help clear a crash scene, including the traffic backup caused by the crash.
- Do not apply sand if the area is in a snow zone where chains are required and most vehicles with adequate tires are not losing traction, except as necessary to remove the chain requirement.
- Generally, do not apply sand while snow is falling or is intermittently falling. Refer to the District Winter Operations Plan and the *Desired Conditions of Maintenance Features on State Highways*.
- Generally, do not apply sand if chains are required on all vehicles, except to treat a specific location addressing an icy condition.

- Generally, do not apply sand if snow or ice is thawing and likely will not re-freeze or otherwise create icy conditions.
- Near environmentally sensitive areas, apply sand according to the management plan for the area.

After use, wash the sander and clean the lights, signs, and warning devices to prevent damage to the equipment and allow needed inspection and maintenance.

Store sanding material in sand sheds or other covered facilities where available to keep it dry before use. It may be appropriate to cover the sanding material or to add appropriate freeze resistance materials, which have been tested and approved by the State Maintenance and Operations Engineer, to the sanding material that is not stored in a covered facility.

Each sanding vehicle must maintain a log, with entries by each operator, listing the times of operation, locations where sand was applied, and information about incidents or crashes related to roadway conditions during the time of operation. This log may also include information about Activities 174 and 176.

Ensure that overhead and other warning lights on each sander vehicle are clean and operating at all times during this work. Use the vehicle headlights at all times during the sanding operation. Also refer to discussion in the Safety section of this Guide on the use of rotobeams and warning lights.

Equipment

Select equipment as identified in the District's Winter Operations Plan or suitable for the work and situation.

Materials

Materials may include:

- Sanding material.
- Pre-wetting agent as appropriate.

Work Method

1. Plan sanding operations as specified in the District Winter Operations Plan.
2. Load sanding material into calibrated sanding equipment. As appropriate, apply pre-wetting agent to sand in the sander or assure that an adequate supply of pre-wetting agent is available on the sander.
3. Apply sand, with pre-wetting agent as appropriate, at desired application rates according to the District Winter Operations Plan.
4. When sanding work is completed, wash vehicle and reload it with sanding material and pre-wetting agent as appropriate.

Measurement of Accomplishment, Expenditure Account, and Charge Activity

Measurement is number of worker hours involved. Expenditure account type is Section EA; use a sub job appropriate for the crew performing the work.

- Charge all work to Activity 171.

Activity 174
Winter Road Patrol (October through April)

Description
Activity 174 involves patrolling the State Highway system, during the months of October through April, to identify adverse conditions or conditions needing maintenance or repair.

General Information
Refer to discussion in the General Instructions section, preceding activity 170 in this section of the *Maintenance Guide* for additional information including environmental and traffic control recommendations and other important considerations.

Refer to Activity 303 for road patrol done during May through September.

Refer to Activity 149 if responding to, or performing work related to, a crash or incident.

Refer to Activity L15 for patrol performed by dedicated Incident Response personnel.

Refer to Activities 170, 171, and 176 for work involving snow removal, sanding, and applying anti-icing or deicing products.

The District Manager and Transportation Maintenance Manager should develop a schedule for patrolling each roadway dependent upon conditions. This may be included in the District's Winter Operations Plan.

As needs are identified, ensure that needed maintenance or repair is performed or scheduled according to the priority of the need.

When patrolling at less than normal traffic speeds for the location or travelling on the roadway shoulder, use appropriate overhead and other warning lights. Also refer to discussion in the Safety section of this Guide on the use of rotobeams and warning lights.

Equipment
Select equipment as identified in the District's Winter Operations Plan and as appropriate for the situation.

Materials
Generally, no materials are needed for this activity.

Work Method

1. Identify the sections of roadway and the frequency of patrols needed for the situation or as described in the District's Winter Operations Plan.
2. As needed, install chains or otherwise equip the patrol vehicle as required for the road and weather conditions.
3. Patrol the roadways as required. Ensure that needed maintenance or repair is accomplished or scheduled based on priority.
4. Implement appropriate traffic control as needed. Implement appropriate methods to control erosion, sediment and pollutants or contaminants as needed.
5. Report crashes, incidents, and other needed information to the Transportation Operations Center.

Measurement of Accomplishment, Expenditure Account, and Charge Activity

Measurement is number of worker hours involved. Expenditure account type is Section EA; use a sub job appropriate for the crew performing the work.

- Charge all work to Activity 174.

Activity 176
Anti-Icing and Deicing

Description

Activity 176 involves applying anti-icing and deicing products to roadway surfaces to reduce the effect to the road of freezing temperatures and presence, or forecast, of moisture, that could result in an icy or frosty road surface.

Anti-icing refers to proactive applications that prevent the formation of ice or frost on the roadway surfaces. Deicing refers to reactive applications to remove the presence of ice or snow on the roadway surfaces. The effective use of these products is dependent on appropriate weather conditions.

General Information

Refer to discussion in the General Instructions section, preceding activity 170 in this section of the *Maintenance Guide* for additional information including environmental and traffic control recommendations and other important considerations.

Refer to Activities 137 and F03 for applying anti-icing and deicing products at rest area or building locations outside the normal vehicle traffic path through the locations.

Refer to Activity 171 for applying sanding material, with or without pre-wetting agents.

Refer to Activity 174 for winter road patrol.

Generally, do not perform this activity in designated Sno-Park areas.

Perform this activity as described in the District's Winter Operations Plan and the *Desired Conditions of Maintenance Features on State Highways*.

Only use anti-icing and deicing products that are approved by the State Maintenance and Operations Engineer. Store and use each product as recommended by the manufacturer or as specified by the State Maintenance and Operations Engineer.

Ensure those personnel involved in planning for and application of anti-icing and deicing products have been adequately trained.

As appropriate, modify this activity to minimize impacts to waterways and other environmentally sensitive areas.

For each anti-icing or deicing product obtained or used, follow instructions included in the General Instructions section preceding Activity 170 in this section of this Guide, including:

- Sample each shipment
- Post a copy of the Material Safety Data Sheet (MSDS) and the bill of lading for each product and shipment
- Record information about use of each product, such as in the log described below

Each vehicle that applies anti-icing or deicing products must maintain a log, with entries by each operator, listing the times of operation, locations where each anti-icing or deicing product was applied, and information about incidents or crashes related to roadway conditions during the time of operation. This log may also include information about Activities 171 and 174.

Use anti-icing or deicing products according the level of service defined in the District Winter Operations Plan and the *Desired Conditions of Maintenance Features on State Highways*. The District Manager, Transportation Maintenance Manager, and other involved maintenance personnel should use good judgment to effectively use anti-icing and deicing products.

- If icy conditions are imminent, refer to the District Winter Operations Plan on areas to anti-ice.
- If icy conditions exist, refer to the District Winter Operations Plan and the *Desired Conditions of Maintenance Features on State Highways* on areas to apply products.
- If applying deicing product only in an intermittent manner, take care to avoid, wherever possible, potential ice conditions at the juncture between locations of application and no application, particularly on curves and longitudinal grades.
- When snow is on the roadway, refer to the District Winter Operations Plan and the *Desired Conditions of Maintenance Features on State Highways* on areas to apply products.
- Near environmentally sensitive areas, apply anti-icing/deicing products according to the management plan for the area

Temporary Protection and Direction of Traffic

Ensure that overhead and other warning lights on each application vehicle are clean and operating at all times during this work. Operate the vehicle's rotobeam or other warning lights when applying anti-icing or deicing products. Turn on the rotobeam or other warning lights in advance of starting the application work to adequately warn other vehicles. Generally do not use the rotobeam or warning lights for routine patrol work. Also refer to discussion in the Safety section of this Guide on the use of rotobeams and warning lights.

Equipment
Select equipment as identified in the District Winter Operations Plan and as suitable for the work and applying the anti-icing or deicing products.

Materials
Materials include anti-icing or deicing products.

Work Method
1. Plan the application of anti-icing and deicing products as specified in the District Winter Operations Plan.
2. Load anti-icing or deicing material into calibrated application equipment.
3. Apply anti-icing or deicing products at desired application rates according to the District Winter Operations Plan.
4. When application work is completed, wash vehicle and reload it with supply of anti-icing or deicing product as appropriate.

Measurement of Accomplishment, Expenditure Account, and Charge Activity
Measurement is number of worker hours involved. Expenditure account type is Section EA; use a sub job appropriate for the crew performing the work.

- Charge all work to Activity 176.

Activity 179
Other Snow and Ice Maintenance

Description
Activity 179 involves performing other snow and ice maintenance, including installing, repairing, and maintaining snow fences, that is not included under another activity.

General Information
Refer to discussion in the General Instructions section, preceding activity 170 in this section of the *Maintenance Guide* for additional information including environmental and traffic control recommendations and other important considerations.

Perform this activity as described in the District's Winter Operations Plan or as the need is identified.

Refer to discussion about drifting snow in the General Instructions section preceding Activity 170 in this section of this Guide.

Refer to the *Oregon Standard Drawings* or the manufacturer's instructions for installation details for snow fence and other devices.

Equipment
Select equipment suitable for the work and situation.

Materials
Use materials needed for the work.

Work Method
1. As appropriate, plan the work as specified in the District's Winter Operations Plan.
2. Identify the needed work and obtain needed materials.
3. Implement appropriate traffic control as needed.
4. Implement appropriate methods to control erosion and sediment as needed.
5. Perform the needed work.
6. Remove traffic control.
7. Dispose of waste material at an appropriate location.

Measurement of Accomplishment, Expenditure Account, and Charge Activity
Measurement is number of worker hours involved. Expenditure account type is Section EA; use a sub job appropriate for the crew performing the work.

- Charge all work to Activity 179.

Attachment C:

ODOT 2017 Final Annual Salt Pilot Report

Oregon Department of Transportation

Final Annual Report - November 2017

Prepared by the ODOT Maintenance & Operations Branch

Table of Contents

EXECUTIVE SUMMARY

This annual report documents the final year of the Oregon Department of Transportation's (ODOT) five-year salt pilot project and provides final conclusions. The project areas included I-5 from mileposts 0-11, and the full 121 mile extent of US 95. The goal of this pilot project was two-fold: evaluate the effectiveness of solid salt in improving winter road conditions in a cost effective manner and ODOT's ability to minimize adverse impacts by developing and following appropriate Best Management Practices (BMPs).

Final conclusions include:

- Solid salt is an effective deicer that fills a gap in ODOT's winter maintenance tool box.
- BMPs related to the application, storage and handling of salt were successfully implemented.
- Elevated chloride levels were observed through monitoring efforts, but more investigation is needed to determine factors influencing those levels and the degree of risk they pose to the environment.
- Although impacts to concrete from chloride based deicer use were evident, it was not clear as to whether salt use during the pilot was a contributing factor. ODOT will continue monitoring efforts in order to better understand how deicing chemicals interact with the infrastructure and how to best mitigate effects.

INTRODUCTION

ODOT strives to keep Oregon's highways safe for the motorist and to keep traffic moving efficiently regardless of weather conditions. Additionally, corridor management between adjoining states (including consistent road conditions and chain restrictions during winter) is necessary to meet driver expectations. Meeting these expectations is always a priority, however winter storm intensity can occasionally surpass ODOT's ability to provide the level of service (LOS) to which the public is accustomed.

ODOT currently relies on a proactive approach of applying corrosion inhibited liquid deicing products in order to prevent snow and ice from bonding to the surface of the pavement. This practice provides more efficient snow removal during and after a storm subsides. Abrasives can also be applied to improve traction on packed snow and ice. Once pack conditions develop, applying liquid deicer becomes less effective. In the absence of a solid deicer, and depending on the severity or type of storm, pack conditions can remain for long periods of time before the snow and ice can be effectively plowed. Relying solely on liquid deicer can become cost prohibitive in attempting to improve LOS in certain conditions.

Nationwide, solid salt has long been used as a cost-effective winter maintenance tool to break up packed snow and ice. It is also well known that excessive use and uncovered storage of large quantities of solid salt can lead to environmental impacts requiring costly mitigation. Several western states are now successfully applying solid salt at application rates well below those that have historically been applied. Lower application rates means less impacts to the environment, infrastructure and less corrosion impacts to vehicles. Greater environmental awareness has dictated change in the industry, which has led to improved practices with respect to BMPs for storage, handling and application.

ODOT has completed a five-year pilot project that evaluated the use of solid salt as an effective tool to improve winter driving conditions. The pilot evaluated the benefits and impacts of using solid salt in addition to typical winter management practices (e.g. plowing and applying abrasives and corrosion-inhibited liquid deicer).

The goal of this pilot project was two-fold; evaluate the effectiveness of solid salt in improving winter road conditions in a cost effective manner and assess ODOT's ability to minimize adverse impacts by developing and following appropriate BMPs.

Annual reports have been provided each year in November; this is the fifth and final report.

BACKGROUND

The pilot was implemented during the 2012-2013 winter season, and concluded in April of 2017, in two distinct locations: in District 14 on U.S. 95 between Nevada and Idaho (approximately 121 miles) and on the Siskiyou Pass, located in District 8 on I-5 from the California border to milepost 11 (see Appendix A).

ODOT evaluated many factors to determine where and how to implement a salt pilot project including:

- Level of Service (LOS) goals
- Driver expectations (transition between states and highway sections)
- Localized weather conditions: type of winter storm and severity
- Geography and susceptibility to salt and chloride leaching into groundwater or sensitive areas
- Infrastructure concerns: bridge structures and pavement type

BMPs were developed for purchase, application, storage and equipment washing, and protecting infrastructure from corrosion. BMPs were based on national and international best practices.
Due to concerns regarding environmental impacts caused by salt use, ODOT collected and analyzed soil and water samples and observed roadside vegetation in the pilot areas to evaluate potential adverse environmental effects that may be attributed to the use of solid salt.

In an effort to balance LOS and environmental concerns, each District developed a management plan (prior to beginning salt applications) that focused on area-specific concerns, based on environmental BMPs and industry knowledge regarding highway winter maintenance tools and their appropriate use.

ODOT took an adaptive management approach to the pilot project, meaning that as new information or technology was discovered the pilot was modified as appropriate to ensure best practices continue to be implemented.

Throughout the pilot, ODOT collected data on key criterion areas: product effectiveness, cost, infrastructure impacts and environmental impacts.

DATA COLLECTION in KEY CRITERION AREAS

Product Effectiveness

Each District has developed a Salt Management Plan that outlines District goals and operational guidelines for the use of various winter maintenance tools. Side by side comparisons of different deicer products did not occur. Throughout the pilot, crews took note of road conditions and the results of using salt.

ODOT uses LOS goals as a method of measuring highway performance and as a treatment prioritization tool for state and local road authorities. The Siskiyou Pass is considered LOS A, meaning ODOT maintenance crews pre-treat the roadway with deicer, remove snow continuously, and use deicer to assist in the breakup and removal of accumulating snow, ice or frost. US 95 is LOS B, meaning snow may be encountered during and for a short period after the storm. Deicer will be used to pre-treat known trouble spots, and applied on a limited basis to known trouble spots where snow or ice is accumulating.

While the liquid deicer that ODOT has been exclusively applying for over a decade is very effective when applied pro-actively before the storm in order to prevent frozen precipitation from bonding to the pavement, it is generally considered to be cost prohibitive to employ during the storm, or after snow pack

or ice has formed a bond with the pavement. Throughout the pilot, solid salt was not only found to be cost effective, but filled a gap in ODOT's chemical deicer "toolbox" that liquid deicer could not fill.

Based on anecdotal feedback provided by maintenance managers and operators, maintenance crews were able to use solid salt to achieve and maintain bare pavement faster and for a longer periods of time, especially during those weather events where liquid deicer would not have been cost effective to use. Many times, the use of salt prevented the formation or build-up of snow pack or ice all together. When snowpack did develop, crews were able to regain bare and wet pavement within 2-3 hours.

The use of salt did not directly correlate to a reduction in use of other winter maintenance materials in a predictable way. When using a toolbox approach, solid salt, liquid deicer and abrasives are used in a manner that achieves the desired management objectives and LOS goals. These materials complement each other, filling specific roles during different types of weather events, different periods of the day, and different phases of the storm (before, during and after) and should be employed at the right time, the right place and in the right amount. Winter severity has a direct effect on the type and amount of material that is used year to year.

District 8

Overall, the Ashland maintenance section experienced a very busy and active winter. The Siskiyou Summit received an above average amount of snow during the 2016-2017 winter. Multiple storms brought moderate to heavy snow fall accumulations and extended periods of cold temperatures. The District was able to meet LOS goals during all of snow and ice events, and continues to receive support and praise from emergency response partners and the freight industry.

District 14

The Jordan Valley and Basque maintenance sections experienced a relatively severe winter. Many agreed it was the worst winter they had ever experienced. Both sections responded to 27 storms, and included a variety of challenging conditions; snow fall rates of 2-3 inches or more per hour, freezing rain and freezing fog. Although there were times (mostly at night) where snow pack developed on the pavement, crews were able to achieve bare and wet pavement within 2-3 hours after the salt was applied using recommended rates. Salt was generally only applied during the daytime when the pavement temperatures were within salt's practical/effective working temperature range. There were multiple occasions where salt was successfully used to keep the pavement bare and wet during snow storms. At night, snow pack was maintained with abrasives. Highway closures and delays were generally a result of trucks not obeying chain laws or from closures requested by Nevada or Idaho. Based on ODOT dispatch data, a noticeable increase of crashes was observed; however many were not weather related. Official crash data for the 2016-2017 reporting year has not yet been evaluated to determine the cause of this increase.

Crash Data and Mobility Indicators

In addition to tracking the number of crashes occurring in the pilot locations, ODOT is also tracking mobility indicators consisting of the number of times chain restrictions are implemented, the number of temporary holds, number of highway closures, and hazards. Improved driving conditions often result in fewer crashes and improved mobility. Many factors can influence highway safety including driver behavior and expectations, objects on the highway, weather conditions, and pavement condition. ODOT strives to provide adequate driving conditions to improve motorist safety. ODOT determined reviewing and reporting crash data might provide some insight into salt's effects on safety.

Although ODOT tracks crash (and/or collision) data it can be difficult to directly correlate crashes to pavement condition because other factors are often at play. Information in this section includes crashes reported during the winter season (November 1-April 30) with no assumption or description of cause. Due to the complexities of defining the cause of crashes, weather-related crashes have not been isolated from other crashes. Minor crashes where the driver did not require assistance or the driver was attended

by local law enforcement may occur without the knowledge of ODOT. Data reviewed includes that from ODOT dispatch records and official crash data from the ODOT Crash Unit. For both data sets, fewer crashes have occurred on average in both pilot locations since implementing solid salt use.

Animal-Vehicle Collisions

The Oregon Department of Fish and Wildlife expressed concern that the use of solid salt might attract large animals to the roadside, which may lead to increased animal-vehicle collisions. ODOT tracks reported animal-related crashes and hazards. Based on a cursory review of reported animal strikes for the years prior to the start of the pilot (November – April, 2009-2012), on average, 15 animal strikes occurred on I-5 and 37 on US 95. Since the start of the salt pilot (November – April, 2012-2017), each year ODOT recorded an average of 17 animal strikes on I-5 and 29 on US 95. A summary of annual animal-vehicle collisions is provided as Table 1.

Table 1: Animal Vehicle Collisions

Number of Collisions	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
I-5	19	8	17	21	25	14	10	13
US 95	42	35	35	37	26	21	18	44

Based on the data collected before and during the pilot, there does not appear to be a correlation between the use of salt and number of animal-vehicle strikes that occur in either of the pilot areas. It is recommended that ODOT continue to review animal strike data, but discontinue annual animal strike reporting. If an apparent upward and consistent trend in strike data is observed in areas where solid salt is being applied, ODOT will include data as part of any reporting that occurs in future salt pilot phases.

District 8

Tables 2a and 2b below reflect data from dispatch records during the winter (November through April). Data shown in parenthesis is official crash data from the ODOT Crash Analysis & Reporting Unit, which only count crashes involving injury or damages greater than $1,500 (as required by Oregon law). Due to rigorous data quality assurance review, motor vehicle crash data from the ODOT Crash Analysis & Reporting Unit is not as readily available as is dispatch data, as indicated by DNA (data not available.) Both numbers are important highway safety indicators.

Table 2a: District 8 – Crash Data and Mobility Indicators prior to Salt pilot

Number of Events	2009-10	2010-11	2011-12	Average
Chain restriction	32	57	57	48
Temporary holds[1]	9	9	18	12
Closures	0	0	0	0
Crashes	115 (33)	153 (31)	77 (22)	115 (28)
Hazards	36	33	7	25

[1] Temporary holds occur when the highway needs to be cleared for a short duration, such as to safely remove a semi-truck blocking multiple lanes.

Table 2b: District 8 – Crash Data and Mobility Indicators During Salt pilot

Number of Events	2012-13	2013-14	2014-15	2015-16	2016-17	Total Pilot Average	% Change[1]
Chain restriction	29	Single axle: 0 Full chain: 2	0	14	11	11	-77%
Temporary holds[2]	8	0	0	2	12	4	-66%
Closures	1	0	0	1	1	.6	0%
Crashes	80 (24)	27 (21)	16 (22)	59 (30)	89 (DNA)	54 (DNA)	-53%(DNA)
Hazards[3]	37	19	5	9	35	21	-16%

District 14

Table 3a shows events in the pilot area during the three winter seasons (November through April) prior to salt use. Table 3b shows events in the pilot area throughout the duration of the pilot. Data in parenthesis is official data from the ODOT Crash Unit. DNA indicates years where event data is not available.

Table 3a: District 14 – Crash Data and Mobility Indicators Prior to Salt Pilot

Number of Events	2009-10	2010-11	2011-12	Average
Chain restriction	DNA	DNA	DNA	DNA
Temporary holds[2]	DNA	DNA	DNA	DNA
Closures	DNA	DNA	DNA	DNA
Crashes	64 (20)	150 (45)	13 (14)	76 (26.3)
Hazards[3]	DNA	DNA	DNA	DNA

Table 3b: District 14 - Safety and Mobility Indicators During Salt Pilot

Number of Events	2012-13	2013-14	2014-15	2015-16	2016-17	Total Pilot Average	% Change[1]
Chain restriction	1	0	1	0	11	3	DNA
Temporary holds[2]	0	0	0	0	0	0	DNA
Closures	0	0	0	0	2	1	DNA
Crashes	60 (20)	28 (21)	33 (19)	79 (29)	128 (DNA)	66 (DNA)	-13% (DNA)
Hazards[3]	DNA	DNA	DNA	DNA	DNA	DNA	DNA

[1] Percent (%) change compares pre-pilot average to the averages observed during the pilot.
[2] Temporary holds occur when the highway needs to be cleared for a short duration, such as to safely remove a semi-truck blocking multiple lanes.
[3] Hazards are defined as vehicles that have not crashed, but are stopped in a location that creates a traffic hazard.

Winter Maintenance Materials

The volumes and procurement costs for winter maintenance materials in the pilot areas are provided in Tables 4 and 5. These volumes and costs do not reflect what was applied; rather only what was purchased during the 2016-2017 reporting year.

Table 4: District 8 – Winter Maintenance Materials Procurement Summary

Volume/Cost	2012-13	2013-14	2014-15	2015-16	2016-17
Sand (cubic yards)	7,573	1,968	1,060	4,174	8,373
Cost of sand	$113,595	$27,269	$14,628	$66,784	$90,428
Liquid Deicer MgCl2 (gallons)	311,661	108,498	112,873	166,852	221,839
Cost of Liquid Deicer	$333,478	$118,035	$121,902	$193,548	$237,367
Solid Deicer NaCl (tons)	254	116	71	596	693
Cost of NaCl	$31,250	$12,296	$7,517	$64,389	$75,537
Total Cost	*$478,323*	*$157,600*	*$144,047*	*$324,721*	*$403,332*

Table 5: District 14 – Winter Maintenance Materials Procurement Summary

Volume/Cost	2012-13	2013-14	2014-15	2015-16	2016-17
Sand (cubic yards)	3,087	1,401	843	976	1,175
Cost of sand	$52,783	$40,345	$24,093	$28,310	$54,947
Liquid Deicer MgCl2 (gallons)	42,605	48,897	108,498	141,895	42,770
Cost of Liquid Deicer	$15,015	$38,468	$118,035	$108,559	$35,499
Solid Deicer NaCl (tons)	68	84	116	189	415
Cost of NaCl	$5,553	$6,698	$12,180	$15,187	$56,835
Total Cost	*$73,351*	*$85,511*	*$154,308*	*$152,056*	*$147,281*

Infrastructure

Salt is known to pose a potential risk to certain materials used to construct bridges and highways; mainly steel bridge components and reinforcing steel in concrete pavements. Due to the typically long service life of reinforced concrete structures (50+ years for well-built concrete pavement and longer for bridges), ODOT bridge and pavement engineers have a particular interest in understanding how salt affects the service life of the infrastructure. Replacing the bridge or pavements under live traffic has significant cost, safety, and user delay consequences. Six main areas of concern were identified:

- Increased chloride penetration into decks
- Corrosion and failure of deck joints
- Deterioration of deck drainage systems
- Accelerated deterioration of safety and structural elements
- The need to monitor decks and other bridge components
- Corrosion of rebar in continuously reinforced concrete pavement (CRCP)

During the course of the pilot, ODOT closely monitored the conditions of bridge components and CRCP for any signs of deterioration. Monitoring consisted of visual inspections as well as invasive core sampling. BMPs suggested bridge mitigation plans be developed and chloride levels be monitored. Mitigation plans were developed and implemented.

Bridges

Prior to the start of the pilot (2012), bridge structures in the pilot areas (five on I-5 and six on US 95) were visually inspected and core samples were collected from the concrete deck and tested for chlorides. Chloride levels in the concrete were found to be high in several of the bridges. In order to prevent further chloride intrusion into the concrete, the bridge decks located in the pilot areas were sealed or resurfaced. Every spring, the ODOT Bridge Section visually inspected pilot area bridges to assess and document any changes in the condition. Concrete core sampling was generally avoided, with exceptions, since the procedure requires drilling through deck seals, which creates potential chloride intrusion pathways.

In 2017, the Bridge Section updated both the chloride sampling methods (improved from powder sampling to coring) and the methods of analysis for chloride test results during the period of the salt pilot. Generally, the protective measures taken at the beginning of the salt pilot prevented additional chloride intrusion beyond existing background levels, and additional damage was not visually observed. Possible exceptions included the decks of Bridges 09259 and 09259A, which were core sampled near the end of the salt pilot. Based on the results of these cores and comparison of core results with powder sample results taken before the salt pilot, Bridges 09259 and 09259A are in need of deck replacement. It is unclear whether the rock salt pilot added to the already significant chloride content of these decks.

The Bridge Section was recently made aware that maintenance personnel purchased rock salt and applied it to Bridges 09260A, 09259, and 09259A prior to 1980. Bridge Section records show that structural overlays were required for Bridges 09260A, 09259, and 09259A during the 1980s after only 11-13 years of service. Based on this anecdotal information, the Bridge Section is recommending that all bridges exposed to rock salt receive effective deck sealing or other effective deck protective treatments.

Pavements

Chloride profiles of the CRCP pavements were conducted as a baseline in 2013 and again in 2016 to assess the intrusion of chloride from salt or magnesium chloride ($MgCl_2$) through the solid concrete. The data is inconclusive, with no rise in chloride levels over the 3-year period of the concrete below 1 inch depth. This result is anticipated, since chloride penetration into the concrete happens slowly and noticeable changes over a 3-year period would be unlikely. Above about 1 inch depth, the chloride levels appear to vary, depending on if deicer ($MgCl_2$ or salt) has been recently applied. Note that the baseline chloride profiles were taken in fall during a season of $MgCl_2$ use, whereas the 2016 samples were taken in the summer. Oregon State University is under contract with ODOT to perform a data review and provide a summary of alternatives for sealing the surface. These tasks were not complete at the time of the drafting of this report.

Environmental Concerns

Vegetation

ODOT maintenance staff routinely patrol the highway and report vegetation concerns to the Vegetation Management Program Coordinator. Many natural, biological, and inorganic factors can affect vegetation. Vegetation concerns observed by or reported to ODOT staff are evaluated for cause and mitigated as appropriate.

Although negative effects to vegetation were not observed during the pilot, it is recommended that visual monitoring continue in any areas where salt is used. The effects from salt use are cumulative, and will take time for salt levels to accumulate.

Soil and Water Quality

ODOT implemented a soil and water quality monitoring plan for the duration of the five-year salt pilot project. The plan focused on collecting grab samples of soil and water from the salt pilot areas and then analyzing these samples for chemical parameters known to be affected by sodium (Na) and chloride (Cl) ions found in road salt (NaCl).

ODOT collected water grab samples during reporting years 2013-2016. Water grab samples were collected by ODOT in the summer to evaluate whether chlorides were accumulating in soils or water. ODOT also collaborated with DEQ to monitor the same stream sample locations during the winter using continuous in-stream conductivity meters. Conductivity was correlated with chloride concentration using proven methods.

Results

To date, ODOT has collected four sets of annual grab samples. 'Grab' samples consist of a sample collected at a single spot during a single point in time. While grab samples do provide a good measure of chemical parameters, the down side is that a single grab sample site may generate a wide range of values due to slight variations in sample material collected or due to a myriad of uncontrolled environmental or human influences that could occur at the site. For this reason, many grab samples are typically needed over time before chemical trends can be identified and substantiated. A summary of the water quality sampling results for chlorides are provided in Table 6. Soil monitoring results are not summarized here, due to the wide variations in results which have been deemed to be inconclusive in terms of identifying any apparent trends in chloride concentrations. It is worthy of noting that the US 95 soil sampling locations are showing a trend of increasing chloride concentrations, but the data has been deemed to not be statistically significant and additional sampling may be warranted.

Table 6: Water Quality Grab Sampling Results

ODOT District	Sampling Location	Chlorides (mg/l)			
		2013	2014	2015	2016
8	*Wall Creek*	21	25	28.1	18.9
	Carter Creek	100	120	147	65.9
	Slide Creek (Control)	-	-	-	0.64
14	*Crooked Creek #1*	17	18	17.7	17.1
	Crooked Creek #2	14	17	19	13

After four years of data collection, it is difficult to confirm data trends that indicate environmental impacts are occurring specifically due to ODOT salt use over the past five years. This is for several reasons:

- Many salt chemical impacts accumulate slowly in the environment over time. In addition, where and how much salt applied per highway has varied throughout the pilot. Considering these factors, it is not surprising that strong trends in chemical impacts are not yet apparent.
- Many of the chemicals monitored for this salt pilot occur naturally, so it is not immediately obvious if measured chemical concentrations are natural or due to salt use.
- ODOT has used salt and other chemical deicers (MgCl2) in the past in both salt pilot areas. Salt and related chemicals that ODOT is monitoring could be coming from sources other than ODOT highway salt applications. Salt is commonly used to melt snow in parking lots (private and public) and cars can potentially track salt over long distances.

While the above factors may mask salt pilot impacts initially, it is expected that enough data will be generated over time to identify chemical trends in the environment. Soil and water laboratory analysis results that have been collected to date are provided in the Chemical Monitoring Summary (Appendix B). Water quality findings and developments in 2017 included:

- Annual grab sampling data found chloride levels in Wall Creek and Carter Creek that are higher compared to the Slide Cree control on Slide Creek. It is likely that ODOT salt use is contributing to the increase.
- Data collected using grab sampling techniques has been found to be highly variable and not capable of accurately assessing salt impacts on an annual basis.
- Continuous instream monitoring conducted during both the 2014-2015 and 2015-2016 winters by the DEQ and ODOT on Siskiyou Pass indicated spikes in conductivity occurred that exceeded both the acute and chronic water quality criteria for chloride. Conductivity was used as a surrogate for chloride; levels were found to exceed chloride water quality criteria in Carter Creek on several occasions each winter sampling period (full details from the DEQ report are available – Contact Bill Meyers, Rogue Basin Coordinator, Department of Environmental Quality, 221 Stewart Avenue, Medford Oregon, 97501, meyers.bill@deq.state.or.us, 541-776-6272).
- Funding was secured for an ODOT/USGS research project aimed at utilizing a computer modeling program to assess environmental risks associated with ODOT salt operations.

Due to these findings and developments, ODOT made a decision not to collect summer grab samples in 2017. Instead, new monitoring objective and strategies were considered that would provide more useful data overall as ODOT salt activities expand.

Implementation and Adherence to Best Management Practices

ODOT developed BMPs are documented in a Highway Division Operational Notice. BMPs are divided into four categories: product specifications, material management, application, and bridge protection.

Product Specifications

Statewide BMPs for winter maintenance chemical deicers require that ODOT use only those products included on the Pacific Northwest Snowfighters (PNS) qualified products list (QPL). This includes salt purchased for use in the pilot sections. District 14 contracts with the deicer vendor Dustbusters to obtain Qwiksalt manufactured by Compass Minerals (formerly North American Salt); District 8 has an agreement with the California Department of Transportation (Cal Trans) to purchase salt stored at their facility in Hilt, which contains Cargill Dry Salt, manufactured by Cargill. Both products are on the PNS QPL.

Material Management

Storage and wash facilities were constructed specifically to minimize salt migration associated with salt storage, salt handling activities and the washing of salt application equipment. All crews were able to generally adhere to the Salt BMPs as described in the Operational Notice. Below are photos of storage and wash facilities in the pilot sections.

District 8 does not store salt in Oregon, but uses the facility just over the California/Oregon border owned and managed by CalTrans. The structure is not large enough to contain equipment during loading, and therefore care is taken to minimize material spillage while loading and any spilled material is swept up and returned to the salt pile. District 8 has an agreement to wash salt equipment at the Jackson County shop in White City. The Jackson County wash facility is connected to the city's municipal water system and meets all washing BMPs.

District 14 has constructed salt storage buildings and equipment washing facilities at the Basque and Jordan Valley maintenance yards. The District 14 storage areas meet all ODOT storage BMPs. The Basque wash area discharges to a lined evaporation pond. The Jordan Valley wash area is connected to municipal sanitary sewer under agreement with the city. Washing facilities meet all washing BMPs.

It is recommended that ODOT continue to follow and refine the Salt Management BMPs for current and all future salt storage and wash facility locations.

Photographs of Salt Storage Facilities

District 8 – CalTrans Hilt Storage | District 14 - Basque Yard | District 14 – Jordan Valley Yard

Photographs of Equipment Washing Facilities in the Pilot Sections

District 8 – Jackson County | District 14 - Basque Yard | District 14 – Jordan Valley Yard

Winter Maintenance Material Application

Application volumes are tracked by equipment operators using handwritten logs. ODOT operators and managers make efforts to ensure the logs are complete and accurate. Application information is provided by the districts is provided as Tables 7 and 8.

The BMP for application is that salt use should be minimized; salt is not intended to replace liquid magnesium chloride as a winter maintenance tool. Current ODOT guidelines recommend minimizing the use of salt to that amount needed to manage winter roads when used appropriately in conjunction with other tools. Further, a rate of 150-300 pounds per lane mile is recommended depending on current conditions, forecast conditions, microclimate factors, and district LOS goals. This application rate range is comparable to rates in neighboring states and low compared to mid-west and eastern states.

No Salt Area: District 14 has identified drinking water in the town of Jordan Valley as a resource requiring additional protection. This is a slow speed section that is very close to the maintenance station. The section will be maintained without the use of salt.

Table 7: District 8 Salt Application Summary

Salt Application	2012-13	2013-14	2014-15	2015-16	2016-17
Salt applied (tons)	254	116	71	596	693
Total area treated (lane miles)	2,065	866	688	4,572	6,095
Number of storm events salt was utilized	8	7	9	25	13
Highest rate (pounds/lane mile)	436	300	300	300	300
Lowest rate (pounds/lane mile)	84	150	150	100	100
Average rate (pounds/lane mile)	246	268	206	260	227

Table 8: District 14 Salt Application Summary

Salt Application	2012-13	2013-14	2014-15	2015-16	2016-17
Salt applied (tons)	68	84	68	305	415
Total area treated (lane miles)	713	802	633	2,764	4,310
Number of storm events salt was utilized	4	11	12	38	27
Highest rate (pounds/lane mile)	300	240	225	230	230
Lowest rate (pounds/lane mile)	150	150	186	216	150
Average rate (pounds/lane mile)	190	209	215	220	192

Lessons Learned

As part of this pilot, managers and operators were afforded the opportunity to learn how to use salt in order to meet management objectives under a variety of weather conditions. ODOT best management practices require that the least amount of salt should be used to meet management objectives, given weather and road conditions. Although managers were able to generally keep application rates within the recommended 150 - 300 pounds per lane mile, it is recommended that more detailed application guidance be developed in order to refine how ODOT applies all winter maintenance materials. The guide should assist managers and operators to apply winter maintenance materials at the right time, right place, and in the right amount.

Although it is standard practice to calibrate solid salt application equipment prior to the start of each winter season, the process and guidance was not standardized. In order to accurately track material usage on a large fleet of equipment equipped with a wide variety of electronically controlled spreaders, standard calibration procedures must be used to ensure discharge rates match the application rates selected by the operator. It is recommended that ODOT develop standard calibration guidance for all equipment that applies salt.

CONCLUSIONS & FUTURE SALT USE

ODOT determined through this pilot that salt can be used effectively in a toolbox approach to winter maintenance. ODOT was able to implement BMPs and to use salt at relatively low application rates compared to historic road salt use nationwide. Salt was effective in maintaining roads, achieving little to no packed snow and ice, reduced crashes, and improved mobility. In high use areas (e.g., Siskiyou pass) it was determined that the use of chloride based deicers likely contributes to stream chloride concentrations.

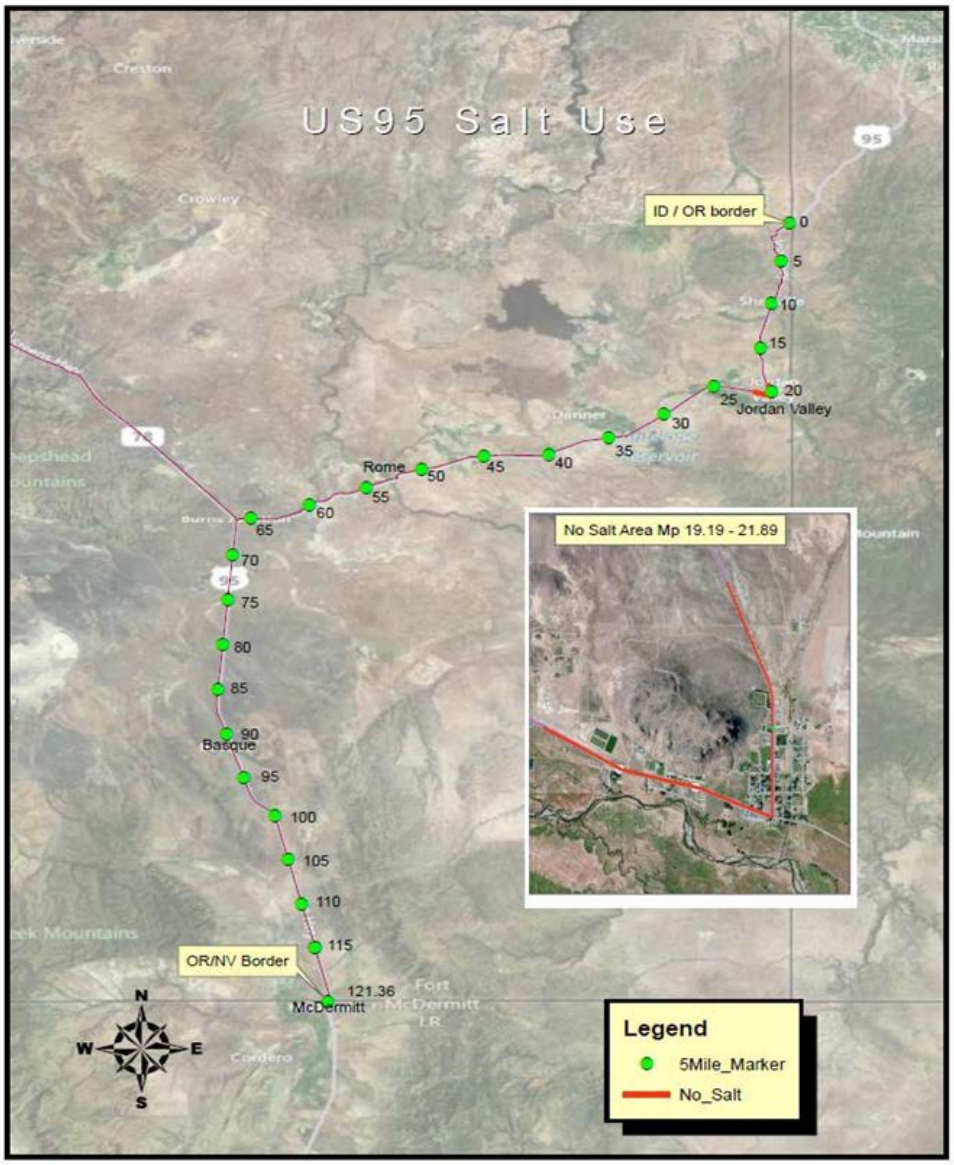
ODOT will continue to evaluate ways to minimize the use of chloride based deicers while balancing the needs of the highway system in moving people, goods, and services in a safe and cost effective way.

With the passing of HB 2017, ODOT is developing and implementing a winter maintenance strategy that includes the use of rock salt. Prior to the passage of HB 2017, ODOT had plans in place to expand the use of salt to interstate locations in eastern Oregon on I-84 and on I-5 north of the Siskiyou pass.

The continued use of rock salt is an important component in keeping our highest level of service roads open during, or soon after inclement winter weather. ODOT will continue to work to balance traveler demands, cost, and protecting the environment and infrastructure by minimizing the use of salt and implementing effective best management practices. Salt will be used where and when it is critically needed when other tools are ineffective or not recommended.

Appendix A

Salt Pilot Location Maps



US-95 Pilot location: MP 0-121

I-5 Pilot Section: MP 0-11

Appendix B

ODOT Chemical Monitoring Summary

November, 2017

Chemical Monitoring Summary for the ODOT Winter Salt Pilot Project

Background

ODOT conducted a five-year pilot to investigate the benefits and risks associated with using solid salt to better manage Oregon's highways in winter conditions. This report provides a summary of the chemical monitoring data collected by ODOT during this investigation.

Salt applied to highways can result in increased concentrations of sodium (Na) and chloride (Cl) in surrounding soils, surface waters, and groundwater. High concentrations of these elements can have negative impacts on people and the environment.

As part of the Salt pilot investigation, ODOT conducted soil and water sampling within the Salt pilot test area to monitor levels of sodium, chloride, and other salt associated chemicals. The sampling was conducted to determine if and how ODOT's use of highway rock salt was impacting the environment.

Pilot Study Areas

Phase One salt applications occurred on ODOT highways in two locations:

- Siskiyou Pass, I-5 from the California border to MP 11 in Oregon (Jackson County).
- US95 from the Nevada border to the Idaho border, total of 121 miles (Malheur County).

Pollutants of Concern

The United States Environmental Protection Agency (EPA) has set a health-based advisory for sodium (Na) in public drinking water at 20 milligrams per liter (mg/l) for individuals on a 500 mg/day restricted sodium diet. A taste threshold has been set at 30-60 mg/l of sodium. Over this concentration the majority of consumers notice an adverse taste in drinking water.

National Secondary Drinking Water regulations set the maximum chloride (Cl) concentration level at 250 mg/l. Secondary drinking water standards may cause cosmetic or aesthetic effects but do not present an unreasonable risk to health. In Oregon, secondary standards are enforceable in public water supplies.

In April 2014, the Oregon Department of Environmental Quality (DEQ) established in stream water quality criterion for chloride to protect aquatic life. The criterion for acute health impacts was set at 860 mg/l. The criterion for chronic health impacts was set at 230 mg/l. Concentrations of sodium chloride (NaCl) in highway runoff have been measured at levels over 19,000 mg/l in areas where winter highway salt use is heavy and historical.

High salt levels in soil can damage both plants and soil organisms. High salt concentration in soil can impede plant uptake of water. High sodium (Na) levels can change soil structure, resulting in reduced infiltration, reduced hydraulic conductivity, and surface soil crusting. Correlating elevated chemical concentrations and associated soil impacts directly to roadway salt use can be very difficult. This is because salt dissolves readily in water and will move quickly through most soils. Also, many native soils naturally contain high levels of chemicals typically associated with road salt use. Heavy metals have been identified as pollutants associated with the use of road salt. This is because heavy metals are a common contaminant found in road salt, but heavy metals are also a common pollutant associated with vehicles

and highways. Heavy metals can also occur at high levels naturally in some native soils. Metals become much more mobile when exposed to high salt concentrations. This means long term salt use can result in heavy metal migration into nearby water and soils.

Other chemical parameters that are indicative of high salt concentrations include: conductivity, alkalinity, and pH levels. Changes seen in these parameters can indicate road salt is accumulating in soils adjacent to the highway and build up is negatively impacting the environment.

Chemical Testing

ODOT collected soil and water samples along the highway right-of-way and from nearby streams within salt pilot areas in an effort to determine if and how salt applications were impacting the environment.

Grab soil samples were collected where soils were likely to be exposed to snow melt or highway runoff. These samples were collected adjacent to the highway at a minimum of three locations per pilot area. Where possible, soil samples were collected at two distances from the highway; 3 feet and 10 feet from edge of pavement. In addition, two soil samples were collected at each sample site, one at surface and one at 12 inches deep. The exact sample distance from the highway and the soil collection depth were modified slightly when rocky soils or other circumstances made soil collection difficult or impossible.

Grab surface water samples were collected from two streams in each pilot area. Streams were selected by considering size and location and when and where salt impacts were likely to occur. Summertime stream flow was also used as a criterion since samples were collected during the summer months. Research has shown that in some situations instream chloride levels become more concentrated during the summer season due to low flow conditions.

ODOT salt pilot monitoring included analysis of the following chemical parameters:

Surface Water -

- Total Metals
- Dissolved Metals
- Chloride
- pH
- Conductivity
- Total Suspended Solids
- Alkalinity
- Hardness as CaCo3

Soils -

- Total Metals
- Available Cations (Calcium, Magnesium, Potassium, Sodium concentration)
- Soluble Chloride
- Conductivity
- pH

Metals –

Arsenic, Aluminum, Barium, Cadmium, Chromium, Copper, Lead, Magnesium, Mercury, Nickel, Sodium, Selenium, Silver, Zinc

Sample Locations

Siskiyou Pass:

Soil samples – A total of 13 grab soil samples were collected annually at 7 sample locations in close proximity to the highway (I-5). Samples included both surface soils and soils at approx.1 foot depth.

Samples were collected from:

- The Highway 273 junction (~ MP 6)
- The Wall Creek crossing/pull out (south bound) (~ MP 7.5)
- The Neil Creek crossing/pull out (north bound) (~ MP 9)

One soil sample was collected in a location outside of the salt application test area

- Highway 273 (adjacent to the Carter Creek water sample location)

Surface water samples – Two grab water samples were collected, one from the North Fork of Carter Creek @ Hwy 273 (approx. ½ mile downstream from I-5), and one from Wall Creek @ Hwy 273 (approximately 1 mile downstream from I-5). These sample sites were selected at the recommendation of Oregon Department of Environmental Quality (DEQ).

Highway 95:

Soil samples - A total of 18 grab soil samples were collected annually at 9 sample locations in close proximity to the highway (Highway 95). Samples included both surface soils and soils at approx. 1 foot depth.

Samples were collected from:

- The Crooked River crossing (~ MP58)
- The Highway 78 junction (northbound and southbound ~ MP68)
- Ditch at MP70
- Hwy 95 approximately ½-mile south of the ODOT Basque Maintenance Yard (~ MP94 northbound).

Two samples were collected in locations expected to be outside the influence of salt application

- the western edge of the City of Jordan Valley (~ MP23)
- MP70 Control

Surface Water samples – Water samples were collected from Crooked Creek at two locations where Highway 95 crosses the creek; one at approximately MP58, and one at approximately MP76. Both samples were collected roughly 25 yards downstream of the highway.

Control Sites Added (2016)
Two control sample sites outside the influence of salt application were added in 2016:

- Hwy 95 - MP 94 southbound - 200 yards west and uphill of the highway (soil)
- Siskiyou Pass – Slide Creek – 500 ft. west and upstream of I-5. (soil and water)
  (This site was also used as a control site for DEQ's Siskiyou Summit Salt Study.)

Sample Data

See Tables 1 and 2. Note terms used on the data tables: "near" and "far" refer to approximately 3 and 10 feet from edge of pavement, "shallow" and "deep" refer to samples collected at surface and approximately 12 inches below surface.

Interpreting Data to Date

Four years of consecutive grab samples were collected during the Salt pilot (samples were not collected in 2017 – see below). As noted in past reports, salt grab samples were highly variable due to natural environmental factors. This has made it difficult to determine if chemical concentration trends observed are significant or not. Of the parameters analyzed, chloride seemed to be the primary analyte indicating that salt impacts may be occurring. Elevated chloride levels were consistently observed in water samples collected from Carter Creek on Siskiyou Pass. This correlated with the DEQ Siskiyou Summit Salt Study findings that indicated highway salt operations are having direct impacts on instream chloride levels during storm events (as deicer is applied to the highway).

By in large, grab sample data does not indicate that salt impacts are occurring in the Hwy 95 pilot area at this time. The MP 70 ditch location did show a consistent increase in chloride concentrations, but the increase was not statistically significant considering variable chloride concentration levels found in the Hwy 95 pilot area. More sampling may be warranted in the future.

Although significant trends were difficult to discern due to data variability, it does appear that grab samples detected elevated chloride levels on Siskiyou Pass. It was not apparent if these elevated levels were a direct result of adding rock salt as a tool to ODOT winter highway operations. Chloride contamination is associated with the use of Magnesium Chloride as well as solid road salt (NaCl). ODOT has applied Magnesium Chloride to I-5 on the Siskiyou Pass for approximately fifteen years.

Monitoring Adjustments

ODOT made significant adjustments to its salt pilot monitoring plans in 2017 due to overall salt pilot findings and changes to the Salt pilot program (as noted in the attached Winter Salt pilot Project Annual Report). Primary factors influencing these adjustments were ODOT's decision to expand and extend the salt pilot and DEQ monitoring findings that reinforced that ODOT grab sampling is not capable of accurately assessing short term chloride impacts occurring during highway salt applications (only general trends that occur over time). These two factors resulted in ODOT eliminating grab sample collection planned for summer of 2017.

Adaptive Monitoring

There are no immediate plans to continue annual collection of grab samples in the pilot areas. Salt Piot monitoring has already established ODOT's use of winter highway salt products (rock salt and/or magnesium chloride) may be contributing to observed elevated chloride levels. Grab sampling may be reinstated in the future to investigate salt contaminant build up over time, but for now salt pilot monitoring will be focused as outlined below.

ODOT Phase 2 monitoring will be conducted through an ODOT/USGS research project. This project is investigating correlations between highway salt application quantities and impacts to instream chloride contamination levels. Data will be utilized by a computer modeling tool to calculate the risk of instream chloride exceedances based on salt application levels and numerous environmental factors. Monitoring will focus on the Siskiyou Pass area but findings are expected to be applicable statewide. A second phase of this project is planned to further investigate groundwater impacts and risks.

Monitoring efforts will continue to be adjusted throughout the future phases of the pilot to ensure findings are adequate and useful. Monitoring activities will be modified if warranted by pilot findings or concerns.

Table 1- Soil Monitoring

- Indicates a concentration below the detection limits.

District 8	2012 RBC[1]	SB on ramp				Highway 99 under W				Highway 99 under W			
		Near highway shallow				Near highway shallow				Near highway deep			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	130	180	194	144	29	2500	132	452	-	590	267	67.6
pH (pH units)	Na	7.4	7.2	6.99	7.48	7.5	7.2	7.47	7.50	8.0	6.5	7.06	7.69
Conductivity (umhos/cm)	Na	590	480	121	189	220	6300	125	189	70	1200	70.8	45.0
Total Metals													
Aluminum (mg/kg)	Na	22,000	32,000	15,900	29,200	32,000	27,000	8,610	26,500	27,000	36,000	15,600	27,200
Arsenic (mg/kg)	0.39	2.8	3.5	6.76	5.24	5.3	5.2	-	1.56	5.7	7.7	5.73	2.15
Barium (mg/kg)	15,000	72	130	88	109	140	120	53.2	139	180	230	83.9	71.3
Cadmium (mg/kg)	39	-	1.8	-	-	-	1.8	-	0.240	-	3.2	-	-
Chromium (mg/kg)	120,000	38	25	11.8	30.7	26	120	11.9	26.9	190	44	14.9	15.9
Copper (mg/kg)	3100	36	46	37.4	37.4	35	73	23	42.7	31	58	27.9	23.2
Lead (mg/kg)	30	9.8	10	14.3	16.5	14	8.7	12.5	12.3	5.1	20	13.9	9.23
Mercury (mg/kg)	23	-	-	.0838	0.0292	0.031	0.042	-	0.0159	0.044	0.045	-	0.00995
Nickel (mg/kg)	1500	160	50	22.4	45.7	75	110	40.4	55.6	180	6	23.5	32.6
Selenium (mg/kg)	Na	-	-	-	-	-	-	-	-	3.4	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	64	92	79.7	77.1	61	160	44.9	187	56	120	64.3	54.5
Cations													
Calcium (mg/kg)	Na	13,000	13,000	7,340	10,300	11,000	14,000	5,170	14,700	8,300	8,700	4,430	5,830
Magnesium (mg/kg)	Na	30,000	16,000	6,490	11,200	19,000	22,000	10,100	13,500	18,000	8,500	9,110	11,500
Potassium (mg/kg)	Na	420	830	560	1,240	1,400	910	545	852	2,200	800	813	818
Sodium (mg/kg)	Na	3,000	3,000	495	1,560	2,200	2,900	648	2,580	1,000	1,100	578	1,330

[1] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 8	2012 RBC[2]	99 SB to I-5				99 SB to I-5				Wall Creek Pullout - S			
		Near highway shallow				Near highway deep				Near highway shallow			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	-	64	129	79.8	-	71	119	72.5	-	71	92.3	61.2
pH (pH units)	Na	7.7	6.6	6.8	7.09	7.6	6.7	6.89	7.10	7.2	8.0	6.17	6.76
Conductivity (umhos/cm)	Na	130	140	101	55.8	110	160	49.1	38.4	160	290	238	69.8
Total Metals													
Aluminum (mg/kg)	Na	30,000	38,000	19,500	35,300	32,000	42,000	18,700	35,600	17,000	23,000	8,750	23,000
Arsenic (mg/kg)	0.39	18	4.9	5.79	3.90	6.3	6.1	5.0	2.48	6.5	3.8	-	2.81
Barium (mg/kg)	15,000	140	140	95.3	142	150	170	81.9	173	66	67	59.4	105
Cadmium (mg/kg)	39	0.79	2.8	-	-	-	2.7	-	-	-	1.2	-	-
Chromium (mg/kg)	120,000	16	21	13.9	18.3	16	20	9.56	17.2	24	24	19.2	41.0
Copper (mg/kg)	3100	32	66	34.5	49.7	41	49	33.9	42.5	58	40	35.7	42.2
Lead (mg/kg)	30	18	23	20.3	21.3	24	16	18.4	20.9	25	8	13.7	13.6
Mercury (mg/kg)	23	0.13	0.11	0.143	0.0717	0.080	0.14	0.146	0.114	-	-	-	0.00714
Nickel (mg/kg)	1500	22	-	14.0	23.3	19	-	12.1	18.2	87	96	91.0	121
Selenium (mg/kg)	Na	-	-	-	-	-	-	-	-	-	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	85	98	93.2	84.1	88	91	78.4	77.9	89	73	90.4	81.3
Cations													
Calcium (mg/kg)	Na	9,900	13,000	9,860	11,900	13,000	12,000	10,300	13,400	12,000	14,000	6,460	13,500
Magnesium (mg/kg)	Na	8,900	9,300	6,520	8,840	8,300	8,000	6,350	7,080	17,000	21,000	18,100	22,000
Potassium (mg/kg)	Na	1,100	1,200	851	1,550	1,200	1,100	676	1,160	830	510	565	1,440
Sodium (mg/kg)	Na	840	1,600	316	1,160	840	840	303	1,100	2,300	3,300	989	2,800

[2] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 8	2012 RBC[3]	Wall Creek Pullout – S				Wall Creek Pullout – W				Wall Creek Pullout - W			
		Near highway deep				Far highway shallow				Far highway deep			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	-	170	79.4	59.7	-	64	97.4	76.7	-	63	91.3	61.7
pH (pH units)	Na	7.9	7.8	6.64	6.79	7.6	5.3	7.26	8.04	7.3	5.2	7.57	7.00
Conductivity (umhos/cm)	Na	60	120	112	22.4	260	130	158	204	80	72	100	119
Total Metals													
Aluminum (mg/kg)	Na	14,000	24,000	7,600	15,200	22,000	22,000	5,740	17,400	23,000	21,000	8,040	24,100
Arsenic (mg/kg)	0.39	3.3	15	3.71	4.18	15	8.6	3.57	1.42	22	12	4.91	10.3
Barium (mg/kg)	15,000	98	200	86.8	76.8	310	160	44.8	57.9	440	290	60.5	414
Cadmium (mg/kg)	39	-	1.6	-	-	-	1.9	-	0.144	-	2.1	-	-
Chromium (mg/kg)	120,000	35	87	32.3	31.1	93	56	13	23.0	130	80	21.0	97.6
Copper (mg/kg)	3100	73	71	39.5	47.7	57	92	48.8	58.9	63	89	75.7	67.9
Lead (mg/kg)	30	42	4.2	13	12.0	40	76	30.2	36.1	12	31	25.2	18.5
Mercury (mg/kg)	23	-	0.022	-	0.00454	-	-	-	-	0.032	0.024	-	0.0254
Nickel (mg/kg)	1500	48	91	66.6	30.7	70	97	53.8	106	92	63	29.7	94.5
Selenium (mg/kg)	Na	-	-	-	-	-	-	-	-	-	-	-	0.858
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	110	61	80.6	34.7	100	110	74.3	90.1	87	77	34.5	70.8
Cations													
Calcium (mg/kg)	Na	8,300	8,200	4,090	6,200	12,000	10,000	4,580	11,900	5,000	7,000	7,050	7,510
Magnesium (mg/kg)	Na	11,000	15,000	11,800	8,270	11,000	18,000	11,000	19,700	12,000	12,000	7,450	13,400
Potassium (mg/kg)	Na	2,100	4,100	1,630	3,420	4,600	2,800	662	834	6,400	4,900	1,080	5,750
Sodium (mg/kg)	Na	1,400	1,200	479	344	1,000	2,000	633	2,460	230	1,000	478	741

[3] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 8	2012 RBC[4]	Neil Creek Ditch				Neil Creek Ditch				Carter Creek (control)			
		Near highway shallow				Near highway deep				Control shallow			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	31	120	99.3	59.2	22	100	50	62.3	-	120	117	58.9
pH (pH units)	Na	7.7	6.7	7.17	7.43	7.7	6.1	7.78	7.26	6.9	6.9	6.92	6.65
Conductivity (umhos/cm)	Na	330	230	66.2	76.4	210	82	45.2	38.7	150	72	78.6	106
Total Metals													
Aluminum (mg/kg)	Na	17,000	28,000	11,300	18,700	15,000	26,000	4,670	19,800	19,000	29,000	6,830	30,800
Arsenic (mg/kg)	0.39	7.6	12	4.11	5.13	6.4	11	-	4.01	-	5	-	-
Barium (mg/kg)	15,000	190	120	121	105	110	100	57.5	77.3	46	97	97.2	115
Cadmium (mg/kg)	39	-	-	-	-	0.31	-	-	-	-	-	-	-
Chromium (mg/kg)	120,000	20	34	15.0	23.9	19	43	6.65	24.1	20	12	10.5	17.3
Copper (mg/kg)	3100	38	48	37.0	37.9	33	47	28.3	40.2	27	39	18.0	25.5
Lead (mg/kg)	30	29	12	29.1	14.2	29	9.6	23.1	9.13	16	7.2	5.19	13.2
Mercury (mg/kg)	23	0.068	-	0.0312	0.0430	0.064	0.025	-	0.0110	0.024	0.45	.0416	0.266
Nickel (mg/kg)	1500	40	32	30.3	40.5	50	35	24.8	31.8	59	18	35.8	32.8
Selenium (mg/kg)	Na	-	-	-	-	4.3	-	-	-	2.0	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	150	90	79.2	84.7	100	66	49	62.2	47	68	38.6	61.6
Cations													
Calcium (mg/kg)	Na	10,000	6,400	7,370	9,310	8,200	3,600	5,080	8,050	12,000	10,000	5,600	12,500
Magnesium (mg/kg)	Na	9,200	9,600	8,260	8,820	9,800	7,100	6,390	9,470	12,000	10,000	7,630	10,200
Potassium (mg/kg)	Na	1,100	1,800	710	1,010	920	2,800	275	1,080	580	720	411	792
Sodium (mg/kg)	Na	1,200	770	536	1,060	1,400	200	414	944	2,800	1,900	527	2,040

[4] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 8	2012 RBC[5]	Carter Creek (control)				Slide Creek (control)	
		Control deep				Control shallow	Control deep
		2013	2014	2015	2016	2016	2016
Chloride (mg/kg)	Na	-	170	83.5	64.4	58.4	75.0
pH (pH units)	Na	6.8	7.1	6.99	6.86	6.74	6.81
Conductivity (umhos/cm)	Na	40	65	25.4	23.8	56.0	35.4
Total Metals							
Aluminum (mg/kg)	Na	19,000	29,000	14,900	41,600	11,000	10,600
Arsenic (mg/kg)	0.39	-	4.8	3.50	2.76	1.61	2.06
Barium (mg/kg)	15,000	440	110	124	139	98.5	99.2
Cadmium (mg/kg)	39	-	-	-	-	-	-
Chromium (mg/kg)	120,000	22	17	13.6	67.8	10.3	9.08
Copper (mg/kg)	3100	61	23	30.5	29.8	20.5	19.6
Lead (mg/kg)	30	5.9	10	16.8	14.0	8.16	4.74
Mercury (mg/kg)	23	0.17	0.18	0.0539	0.0760	0.0202	0.0171
Nickel (mg/kg)	1500	17	30	23.2	32.9	12.4	9.53
Selenium (mg/kg)	Na	7.9	-	-	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-
Zinc (mg/kg)	Na	57	63	66.1	58.1	36.1	29.9
Cations							
Calcium (mg/kg)	Na	5100	9500	5,440	7,680	7,520	6,110
Magnesium (mg/kg)	Na	2300	12,000	5,510	7,210	6,250	5,750
Potassium (mg/kg)	Na	1300	860	638	629	3,200	2,730
Sodium (mg/kg)	Na	110	1700	307	517	166	142

[5] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 14	2012 RBC[6]	Junction 78 N				Junction 78 N				Junction 78 S			
		Near highway shallow				Near highway deep				Near highway shallow			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	140	67	75.7	76.8	110	250	69.6	61.7	210	110	229	391
pH (pH units)	Na	8.2	8.1	8.17	7.6	8.7	7.6	8.66	8.32	7.9	7.7	8.1	7.49
Conductivity (umhos/cm)	Na	290	540	419	317	280	1300	301	158	520	910	485	1090
Total Metals													
Aluminum (mg/kg)	Na	23,000	39,000	10,300	36,300	33,000	29,000	9,690	34,300	4900	31,000	6,850	27,700
Arsenic (mg/kg)	0.39	5.2	25	4.41	6.14	7.0	20	6.66	22.1	6.3	27	14.5	13.9
Barium (mg/kg)	15,000	150	410	198	237	210	250	213	152	78	310	134	185
Cadmium (mg/kg)	39	-	-	-	0.280	-	-	-	0.191	-	-	-	0.292
Chromium (mg/kg)	120,000	22	25	10.2	24.7	20	21	9.53	27.2	6.3	21	7.81	21.5
Copper (mg/kg)	3100	32	51	28	44.2	44	39	25.6	59.5	12	40	20.2	41.2
Lead (mg/kg)	30	25	10	7.82	11.4	14	79	10.6	5.51	18	11	35.2	31.3
Mercury (mg/kg)	23	-	-	-	.00742	0.025	-	.0280	.0144	-	-	.0249	.0186
Nickel (mg/kg)	1500	18	31	21.8	35.1	26	24	20.8	76.1	4.9	26	17.8	34.8
Selenium (mg/kg)	Na	-	-	-	0.853	1.4	-	-	.945	2.0	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	100	79	31.9	74.1	69	80	28.1	48.2	100	79	35.4	70.2
Cations													
Calcium (mg/kg)	Na	14,000	36,000	12,700	9,990	28,000	29,000	25,100	48,200	5,200	60,000	28,900	25,000
Magnesium (mg/kg)	Na	7,600	12,000	7,450	10,200	11,000	10,000	8,400	21,300	3,000	12,000	6,970	11,000
Potassium (mg/kg)	Na	4,800	6,700	2,590	6,710	6,000	5,200	2,400	3,380	890	5,400	1,710	4,680
Sodium (mg/kg)	Na	720	2,200	480	1,030	1,000	1,200	752	2,980	600	1900	416	1,540

[6] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 14	2012 RBC[7]	Junction 78 S				Crooked Creek #1				Crooked Creek #1			
		Near highway deep				Near highway shallow				Near highway deep			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	230	170	117	127	120	230	71.9	85.2	140	85	82.4	63.4
pH (pH units)	Na	8.0	8.2	8.35	8.29	8.3	7.5	8.15	7.95	8.9	7.9	8.5	8.35
Conductivity (umhos/cm)	Na	310	66	225	297	190	860	132	446	240	230	85.6	57.1
Total Metals													
Aluminum (mg/kg)	Na	18,000	2,600	7,030	28,400	8,300	18,000	3,560	13,100	12,000	11,000	3,980	9,080
Arsenic (mg/kg)	0.39	8.6	22	15.0	17.8	8.8	23	4.05	14.0	10	15	4.14	11.0
Barium (mg/kg)	15,000	120	190	142	177	83	210	132	242	220	260	178	175
Cadmium (mg/kg)	39	-	-	-	0.245	-	-	-	0.274	-	-	-	0.229
Chromium (mg/kg)	120,000	15	19	7.87	20.6	6.0	16	4.99	15.4	13	14	5.67	11.6
Copper (mg/kg)	3100	28	36	27.4	46.2	11	25	11.7	19.8	19	18	13.3	14.8
Lead (mg/kg)	30	19	20	30.2	18.1	8	16	9.29	19.7	15	20	11.2	13.8
Mercury (mg/kg)	23	-	-	.0238	.0213	-	-	-	.0102	-	0.023	-	.0114
Nickel (mg/kg)	1500	15	22	22.1	40.0	5.1	14	9.46	16.6	12	13	10.8	13.1
Selenium (mg/kg)	Na	-	-	-	1.03	2.2	-	-	-	1.2	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	86	81	22.7	60.6	80	75	28.7	57.5	54	59	34.3	49.2
Cations													
Calcium (mg/kg)	Na	20,000	39,000	32,300	32,200	15,000	29,000	29,200	12,000	13,000	19,000	9,920	8,510
Magnesium (mg/kg)	Na	7,200	9,400	7,670	12,100	4,600	9,700	5,900	9,830	8,200	7,600	6,200	7,090
Potassium (mg/kg)	Na	2,900	4,400	1,450	4,060	3,800	9,600	2,490	8,210	7,300	7,100	2,990	5,990
Sodium (mg/kg)	Na	790	1,400	443	1,630	1,000	1,600	219	810	1,100	680	242	429

[7] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 14	2012 RBC[8]	Crooked Creek #1				Crooked Creek #1				MP 94			
		Far highway shallow *				Far highway deep *				Near highway shallow *			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	110	68	69.9	58.5	290	76	75.8	83.9	150	64	72.8	54.6
pH (pH units)	Na	8.2	7.5	8.15	7.87	8.4	7.8	8.4	8.63	7.7	7.6	8.58	7.82
Conductivity (umhos/cm)	Na	440	310	349	237	720	340	289	147	320	97	234	101
Total Metals													
Aluminum (mg/kg)	Na	19,000	14,000	8130	14,500	19,000	13,000	7180	16,500	19,000	31,000	6870	26,000
Arsenic (mg/kg)	0.39	13	18	11.9	15.1	7.1	18	7.67	12.5	3.3	10	2.27	5.18
Barium (mg/kg)	15,000	230	230	218	232	200	230	179	211	170	250	193	230
Cadmium (mg/kg)	39	-	-	-	0.268	-	-	-	0.244	-	-	-	0.260
Chromium (mg/kg)	120,000	14	18	9.78	16.1	12	16	7.26	16.4	12	21	5.37	17.3
Copper (mg/kg)	3100	22	21	20.0	19.9	18	20	14.8	20.1	23	37	13.8	30.5
Lead (mg/kg)	30	21	19	23.8	18.7	12	46	44.9	21.8	19	13	11.5	14.5
Mercury (mg/kg)	23	0.022	-	-	0.0113	-	-	-	0.0106	0.022	-	-	0.00921
Nickel (mg/kg)	1500	12	13	14.8	16.1	10	13	11.6	17.8	10	22	11.2	21.7
Selenium (mg/kg)	Na	2.2	-	-	-	-	-	-	-	2.2	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	63	66	46.4	58.3	49	61	38.1	56.1	68	83	26.4	70.5
Cations													
Calcium (mg/kg)	Na	20,000	16,000	17,500	14,500	12,000	20,000	16,500	12,700	6,600	7,000	5,060	6,380
Magnesium (mg/kg)	Na	8,600	8,500	8,850	8,770	6,400	8,100	6,490	8,630	4,600	7,400	3,220	6,280
Potassium (mg/kg)	Na	10,000	8,800	6,890	9,270	8,300	7,600	5,710	9,180	4,800	6,200	2,900	5,690
Sodium (mg/kg)	Na	1,500	880	514	879	2,200	1,000	650	1,440	460	760	439	714

[8] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels. shallow/deep* - Heading was mislabeled in the 2014 report and has been corrected.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 14	2012 RBC[9]	MP 94 Near highway deep *				MP 94 Far highway shallow *				MP 94 Far highway deep *			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	170	96	87.6	101	-	95	89.7	48.5	13	140	61.9	54.5
pH (pH units)	Na	8.2	7.9	8.57	7.86	8.1	7.9	8.14	8.52	8.3	8.1	8.78	8.87
Conductivity (umhos/cm)	Na	450	87	253	205	310	280	332	156	140	210	374	74.5
Total Metals													
Aluminum (mg/kg)	Na	20,000	42,000	8700	22,500	20,000	27,000	17400	24,900	24,000	45,000	35,000	31,200
Arsenic (mg/kg)	0.39	4.4	12	3.69	6.10	2.6	10	8.59	4.75	2.5	13	6.77	5.35
Barium (mg/kg)	15,000	150	240	195	226	180	230	199	236	180	230	174	251
Cadmium (mg/kg)	39	-	-	-	0.254	-	-	-	0.272	-	-	-	0.209
Chromium (mg/kg)	120,000	12	27	7.19	14.7	13	20	11.1	16.6	14	29	21.1	19.9
Copper (mg/kg)	3100	23	48	15.7	26.9	26	31	20.8	29.9	28	44	33.9	34.1
Lead (mg/kg)	30	8.2	12	10.8	15.6	33	13	12	11.3	13	14	10.4	11.7
Mercury (mg/kg)	23	-	0.028	-	0.00869	-	-	-	0.0131	-	-	-	0.0111
Nickel (mg/kg)	1500	10	29	13.8	19.8	12	19	16.4	21.0	14	28	28.2	24.7
Selenium (mg/kg)	Na	-	-	-	-	1.9	-	-	-	-	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	59	96	32.4	66.0	62	72	66.6	65.2	62	100	75	72.1
Cations													
Calcium (mg/kg)	Na	11,000	8,600	5,910	8,450	5,300	6,000	11,700	6,310	5,700	7,800	8,920	6,720
Magnesium (mg/kg)	Na	4,400	9,600	3,830	5,670	4,900	6,000	5,030	5,930	5,500	9,100	8,600	7,310
Potassium (mg/kg)	Na	4,200	7,200	3,300	4,950	4,600	4,600	3,660	5,550	5,200	7,000	6,290	5,830
Sodium (mg/kg)	Na	490	750	413	648	530	1,400	397	861	690	2,000	904	1,020

[9] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels. shallow/deep* - Heading was mislabeled in the 2014 report and has been corrected.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 14	2012 RBC[10]	MP 70 Ditch				MP 70 Ditch				MP 70 Control			
		Near highway shallow				Near highway deep				Control shallow			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	14	62	56.2	97.4	21	74	67.2	92.5	-	60	66	51.7
pH (pH units)	Na	9.1	8.6	8.67	8.88	9.1	8.9	9.04	9.36	8.6	8.4	8.07	8.31
Conductivity (umhos/cm)	Na	670	300	582	3,170	620	270	825	705	110	140	161	125
Total Metals													
Aluminum (mg/kg)	Na	28,000	29,000	21,700	22,500	28,000	37,000	36300	30,600	19,000	20,000	17,300	17,800
Arsenic (mg/kg)	0.39	3.0	10	6.23	8.72	2.0	9.1	6.41	12.5	2.9	7.6	4.16	4.29
Barium (mg/kg)	15,000	120	200	168	205	150	190	185	220	200	240	189	214
Cadmium (mg/kg)	39	-	-	-	0.259	-	1.9	-	0.229	-	1.2	-	0.244
Chromium (mg/kg)	120,000	14	20	20.1	17.9	18	26	24.7	21.5	12	15	13.3	13.6
Copper (mg/kg)	3100	30	36	28.3	28.2	35	52	43.3	41.8	22	25	18.0	21.1
Lead (mg/kg)	30	4.5	10	8.71	10.2	6.2	5.9	9.23	10.2	6.8	6.2	7.33	9.20
Mercury (mg/kg)	23	-	-	-	0.0108	-	-	-	0.0203	-	-	-	0.0172
Nickel (mg/kg)	1500	16	24	21.6	20.5	18	11	33.1	28.6	12	5.2	15.6	17.2
Selenium (mg/kg)	Na	6.7	-	-	-	1.2	-	-	-	2.2	-	-	0.808
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	47	75	64.3	67.6	64	83	76.5	73.9	54	57	49.1	55.8
Cations													
Calcium (mg/kg)	Na	14,000	9,700	11,800	10,800	7,900	9,100	10,100	8,610	5,600	6,600	5,990	6,350
Magnesium (mg/kg)	Na	9,000	7,400	6,020	6,110	7,500	11,000	9,770	8,290	4,200	5,700	4,310	4,720
Potassium (mg/kg)	Na	7,300	6,500	4,910	4,910	5,700	8,000	7,270	5,920	4,000	4,900	4,280	4,090
Sodium (mg/kg)	Na	1,600	1,300	1,580	2,820	1,800	2,100	2,770	3,680	980	990	870	847

[10] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 1- Soil Monitoring - continued

- Indicates a concentration below the detection limits

District 14	2012 RBC[11]	MP 70 Control				Jordan Valley				Jordan Valley			
		Control deep				Control shallow				Control deep			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/kg)	Na	-	63	61	55.0	220	74	85.5	65.7	67	66	156	73.4
pH (pH units)	Na	8.8	8.6	8.86	9.27	6.9	7.3	7.53	7.11	7.3	7	7.79	7.40
Conductivity (umhos/cm)	Na	160	160	252	93.8	620	200	760	418	690	240	402	98.3
Total Metals													
Aluminum (mg/kg)	Na	22,000	20,000	18,100	28,400	17,000	42,000	14,700	38,100	36,000	35,000	15,200	39,700
Arsenic (mg/kg)	0.39	7.0	8.7	6.03	4.39	3.2	11	-	4.09	1.2	9.8	-	4.67
Barium (mg/kg)	15,000	200	220	184	195	140	270	270	277	260	330	269	315
Cadmium (mg/kg)	39	-	1.2	-	0.197	-	-	-	0.287	-	-	-	0.293
Chromium (mg/kg)	120,000	14	16	13.0	18.7	14	36	13.1	27.2	24	27	12.7	29.3
Copper (mg/kg)	3100	29	29	19.7	34.8	20	25	16.1	25.3	23	23	15.5	26.1
Lead (mg/kg)	30	7.7	6.8	7.67	9.43	5.3	11	11.6	15.2	8.3	13	11.5	15.5
Mercury (mg/kg)	23	-	-	-	0.0145	0.1618	0.20	.289	0.229	0.12	0.21	.347	0.159
Nickel (mg/kg)	1500	17	5.3	17.7	25.3	18	20	13.8	20.9	14	17	13.0	22.6
Selenium (mg/kg)	Na	2.6	-	-	-	2.0	-	-	1.19	2.3	-	-	-
Silver (mg/kg)	390	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (mg/kg)	Na	51	59	55.4	67.5	74	88	47.4	80.3	74	82	41.3	79.9
Cations													
Calcium (mg/kg)	Na	5,600	5,900	7,450	6,200	7,500	21,000	9,310	12,500	13,000	14,000	11,200	13,400
Magnesium (mg/kg)	Na	6,100	5,500	4,570	7,280	9,300	15,000	7,510	12,400	11,000	11,000	8,110	12,600
Potassium (mg/kg)	Na	5,600	4,900	4,560	6,460	2,600	6,200	5,050	8,540	6,000	6,100	4,330	8,120
Sodium (mg/kg)	Na	860	920	935	1,310	1,400	4,900	459	1,660	2,300	2,400	594	1,440

[11] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

District 14	2012 RBC[12]	MP 94-W (control)	
		Control shallow	Control deep
		2016	2016
Chloride (mg/kg)	Na	45.1	72.4
pH (pH units)	Na	7.51	8.44
Conductivity (umhos/cm)	Na	116	186
Total Metals			
Aluminum (mg/kg)	Na	29,800	29,800
Arsenic (mg/kg)	0.39	4.84	5.33
Barium (mg/kg)	15,000	248	258
Cadmium (mg/kg)	39	.333	0.328
Chromium (mg/kg)	120,000	19.7	19.8
Copper (mg/kg)	3100	32.5	32.9
Lead (mg/kg)	30	12.0	11.9
Mercury (mg/kg)	23	0.0235	0.0292
Nickel (mg/kg)	1500	23.3	24.0
Selenium (mg/kg)	Na	0.926	-
Silver (mg/kg)	390	-	-
Zinc (mg/kg)	Na	73.6	74.3
Cations			
Calcium (mg/kg)	Na	6,910	7,150
Magnesium (mg/kg)	Na	7,150	7,320
Potassium (mg/kg)	Na	7,120	7,500
Sodium (mg/kg)	Na	689	792

[12] Risk-Based Concentration: Determining the level at which a contaminant of concern becomes harmful is a complex process. DEQ has developed guidance to provide a consistent, streamlined decision-making process for evaluating risk posed to human health and the environment. The value in this column is the most restrictive concentration in soil for all exposure pathways and receptor scenarios (typically ingestion, dermal contact, and inhalation in a residential area). Use of the guidance is optional. When cleanup is necessary, responsible parties and DEQ may use other models or approaches to evaluate the site. The numbers are provided as a reference. Contaminants are naturally occurring; regional background levels may be higher than recommended cleanup levels.

Table 2 - Surface Water Monitoring

- Indicates a concentration below the detection limits

	2014 DEQ Aquatic Life Criteria		District 8								
			Wall Creek				Carter Creek				Slide Creek (control)
	Acute	Chronic	2013	2014	2015	2016	2013	2014	2015	2016	2016
Chloride (mg/l)	860	230	21	25	28.1	18.9	100	120	147	65.9	0.648
Alkalinity (mg/l)	Na	20[13]	63	170	176	62.5	97	130	141	123	44.1
Hardness (mg/L as $CaCO_3$)			96	130	119	86.8	230	260	287	183	31.5
pH (pH units)			8.1	7.1	8.34	8.23	8.0	7.6	8.14	7.92	8.19
Conductivity			240	470	449	222	600	730	808	516	82.4
Suspended Solids (mg/l)			3.7	20	-	1.70	-	3.2	-	-	7.70
Total Metals											
Aluminum (mg/l)			-	0.110	-	0.0809	-	-	-	0.0517	0.112
Arsenic (mg/l)			-	-	-	-	-	-	-	-	-
Barium (mg/l)			0.049	0.087	.063	0.0438	0.040	0.052	.0519	0.0348	0.0230
Cadmium (mg/l)			-	-	-	-	-	-	-	-	-
Chromium (mg/l)			-	-	-	0.00158	-	-	-	0.00143	-
Copper (mg/l)			-	-	-	-	-	-	-	-	-
Lead (mg/l)			-	-	-	0.00351	-	-	-	0.00420	.00413
Magnesium (mg/l)			8.8	13	10.5	7.97	18	22	23.8	14.4	2.27
Mercury (mg/l)	0.0024	0.000012	-	-	-	-	-	-	-	-	-
Nickel (mg/l)			-	-	-	-	-	-	-	-	-
Selenium (mg/l)			-	-	-	-	-	-	-	-	-
Silver (mg/l)			-	-	-	-	-	-	-	-	-
Sodium (mg/l)			8.3	51	54.7	8.67	24	39	43.1	24.2	4.22
Zinc (mg/l)			-	-	-	-	-	-	-	-	-
Dissolved Metals											
Aluminum (mg/l)			-	-	-	0.0422	-	-	-	0.0592	0.0458
Arsenic (mg/l)	0.34	0.15	-	-	-	-	-	-	-	-	-
Barium (mg/l)			0.046	0.085	.0608	0.0435	0.039	0.050	.0488	0.0357	0.0213
Cadmium (mg/l)	hardness dependent		-	-	-	-	-	-	-	-	-
Chromium (mg/l)			-	-	-	-	-	-	-	-	-
Copper (mg/l)	hardness dependent		-	-	-	-	-	-	-	-	-
Lead (mg/l)	hardness dependent		-	-	-	0.00265	-	-	-	0.00340	0.00219
Magnesium (mg/l)			9.1	14	10.4	8.31	18	23	23.6	15.0	2.24
Mercury (mg/l)			-	-	-	-	-	-	-	-	-
Nickel (mg/l)	hardness dependent		-	-	-	-	-	-	-	-	-
Selenium (mg/l)	0.01282	0.0046	-	-	-	-	-	-	-	-	-
Silver (mg/l)	hardness dependent	0.0001	-	-	-	-	-	-	-	-	-
Sodium (mg/l)			8.4	50	51.9	8.68	24	37	41.4	24.7	4.21
Zinc (mg/l)	hardness dependent		-	-	-	-	-	-	-	-	-

[13] Criterion shown is the minimum (the concentration may not be below this value in order to protect aquatic life).

Table 2 - Surface Water Monitoring - continued

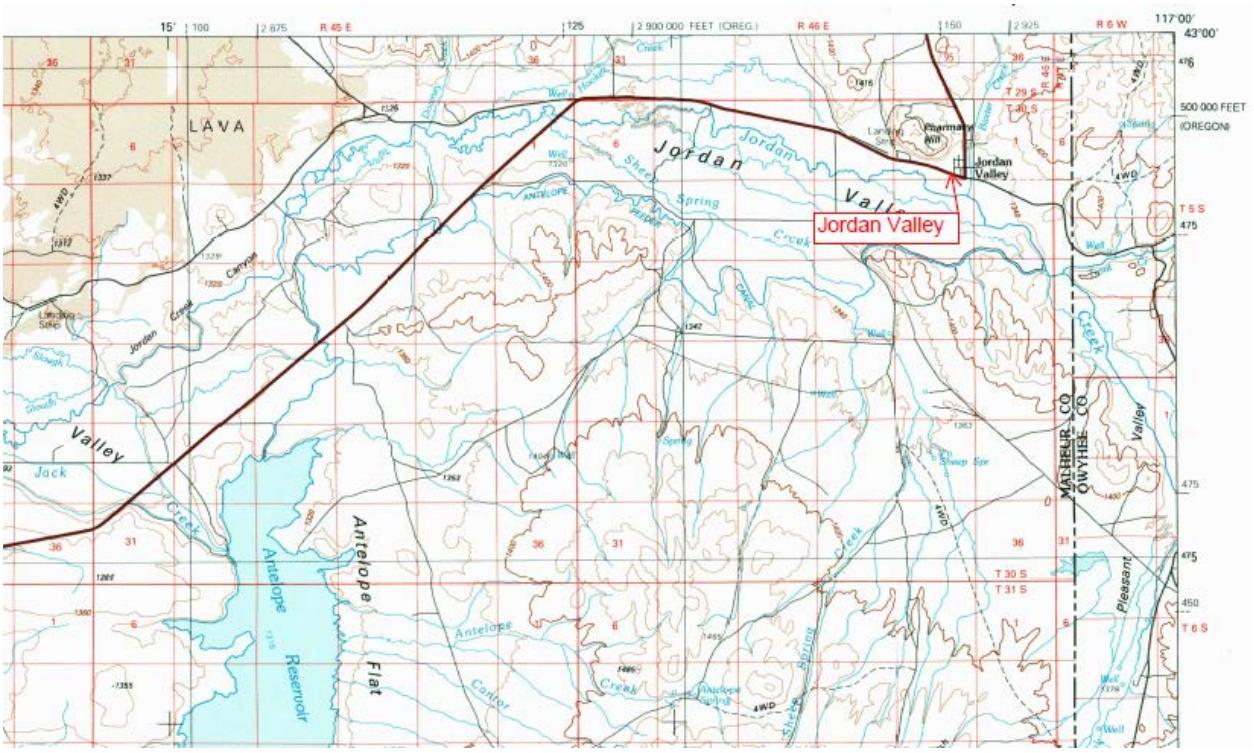
- Indicates a concentration below the detection limits

	2014 DEQ Aquatic Life Criteria		District 14							
			Crooked Creek #1				Crooked Creek #2			
	Acute	Chronic	2013	2014	2015	2016	2013	2014	2015	2016
Chloride (mg/l)	860	230	17	18	17.7	17.1	14	17	19	13.0
Alkalinity (mg/l)	Na	20[14]	140	160	182	141	160	220	261	148
Hardness (mg/L as $CaCO_3$)			60	61	62.2	60.4	63	85	30	58.9
pH (pH units)			8.4	7.8	8.37	8.39	9.3	8.5	8.84	9.08
Conductivity			430	460	475	453	430	520	589	384
Suspended Solids (mg/l)			25	14	11.2	14.1	5.6	4.7	3.110	8.40
Total Metals										
Aluminum (mg/l)			0.22	-	.292	0.183	-	-	-	0.111
Arsenic (mg/l)			0.028	0.3	.0235	.0232	0.037	0.038	.0466	0.0332
Barium (mg/l)			0.006	0.029	.007	.00607	0.0061	0.0094	.0121	.00582
Cadmium (mg/l)			-	0.0093	-	-	-	-	-	-
Chromium (mg/l)			-	-	-	.00271	-	-	-	.00305
Copper (mg/l)			-	-	-	-	-	-	-	-
Lead (mg/l)			-	-	-	-	-	-	-	-
Magnesium (mg/l)			3.9	4.3	4.21	3.62	5.7	7.8	8	4.58
Mercury (mg/l)	0.0024	0.000012	-	-	-	-	-	-	-	-
Nickel (mg/l)			-	-	-	-	-	-	-	-
Selenium (mg/l)			-	-	-	-	-	-	-	-
Silver (mg/l)			-	-	-	-	-	-	-	-
Sodium (mg/l)			68	81	77	72.4	70	91	93.2	61.0
Zinc (mg/l)			-	-	-	-	-	-	-	-
Dissolved Metals										
Aluminum (mg/l)			-	-	-	-	-	-	-	-
Arsenic (mg/l)	0.34	0.15	-	-	.0276	.0206	0.032	0.038	.0504	0.0362
Barium (mg/l)			-	0.029	-	.00354	-	0.0073	.0116	.00663
Cadmium (mg/l)	hardness dependent		-	-	-	-	-	-	-	-
Chromium (mg/l)			-	-	-	.00254	-	-	-	.00313
Copper (mg/l)	hardness dependent		-	-	-	-	-	-	-	-
Lead (mg/l)	hardness dependent		-	-	.00899	.00538	-	-	.00611	.00476
Magnesium (mg/l)			3.8	4.3	4.05	3.61	5.5	8.2	7.9	4.57
Mercury (mg/l)			-	-	-	-	-	-	-	-
Nickel (mg/l)	hardness dependent		-	-	-	-	-	-	-	-
Selenium (mg/l)	0.01282	0.0046	-	-	-	-	-	-	-	-
Silver (mg/l)	hardness dependent	0.0001	-	-	-	-	-	-	-	-
Sodium (mg/l)			70	79	82.2	72.2	71	87	102	61.8
Zinc (mg/l)	hardness dependent		-	-	-	-	-	-	-	-

[14] Criterion shown is the minimum (the concentration may not be below this value in order to protect aquatic life).

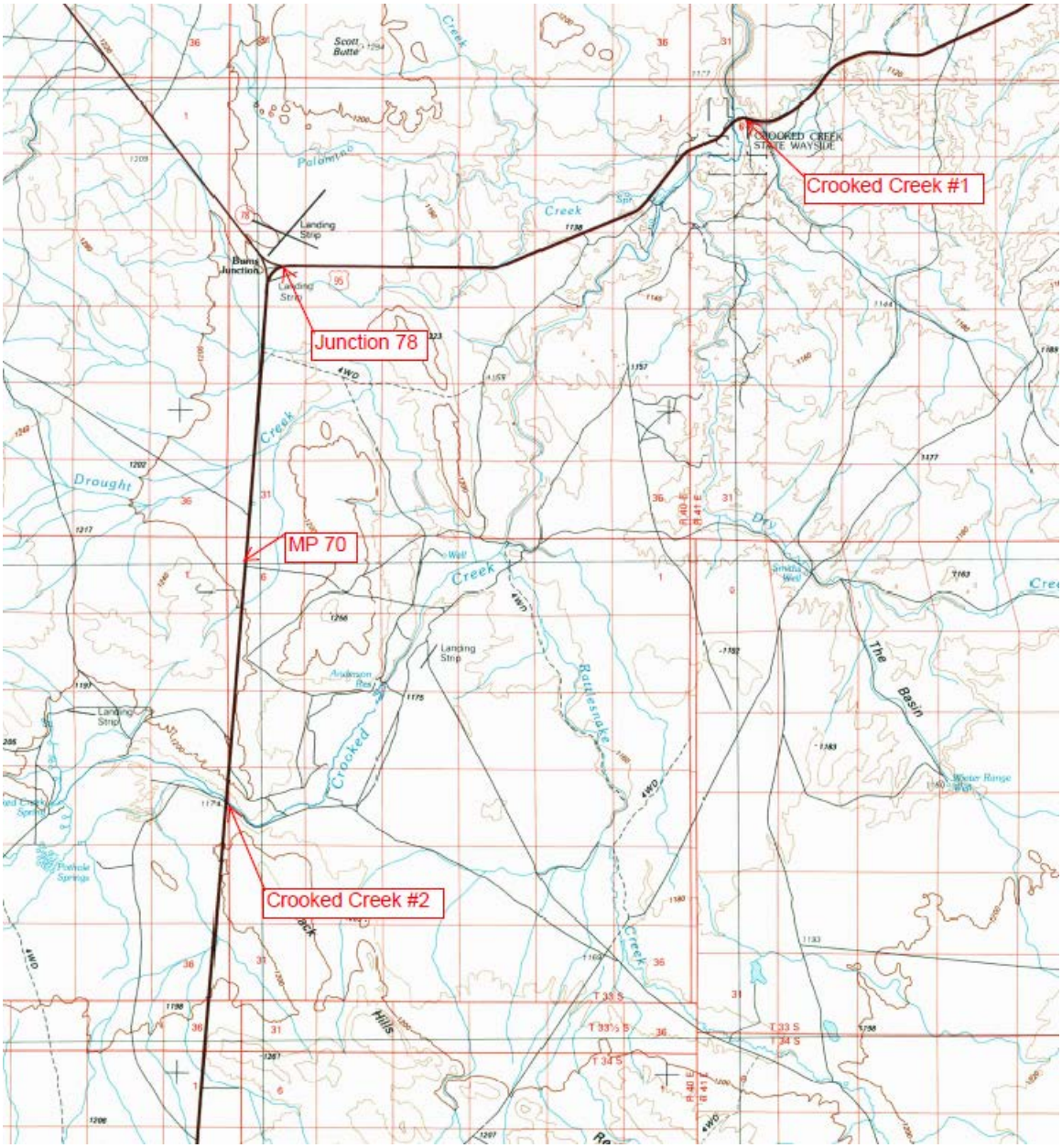
Map Detail:
U.S.Geological Survey
Jordan Valley
Oregon-Idaho
30 X 60 Minute Series

ODOT Salt Pilot – Hwy 95/Jordan Valley – Sample Site Locations



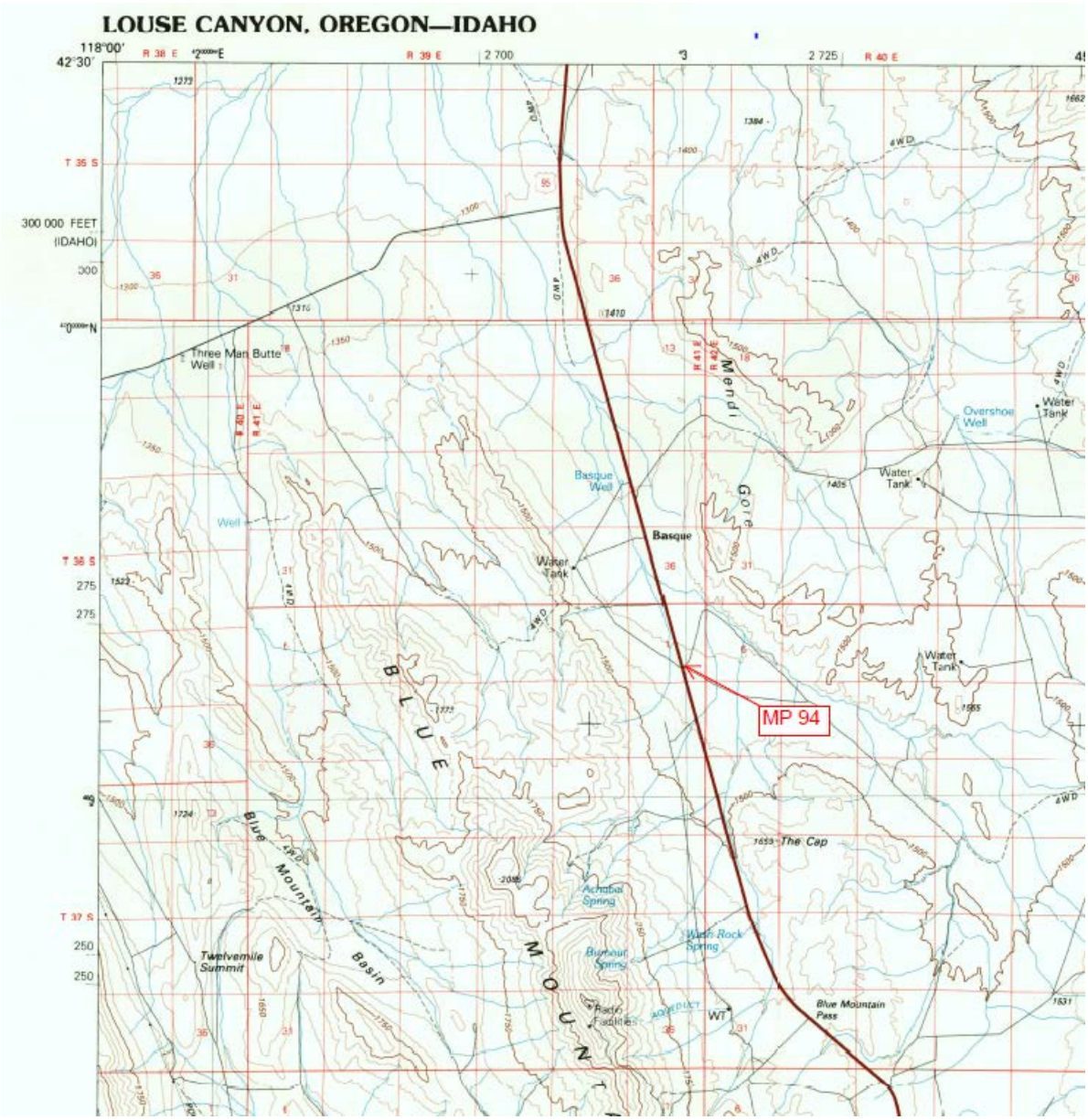
Map Detail:
U.S.Geological Survey
Jordan Valley
Oregon-Idaho
30 X 60 Minute Series

ODOT Salt Pilot – Hwy 95/Jordan Valley – Sample Site Locations



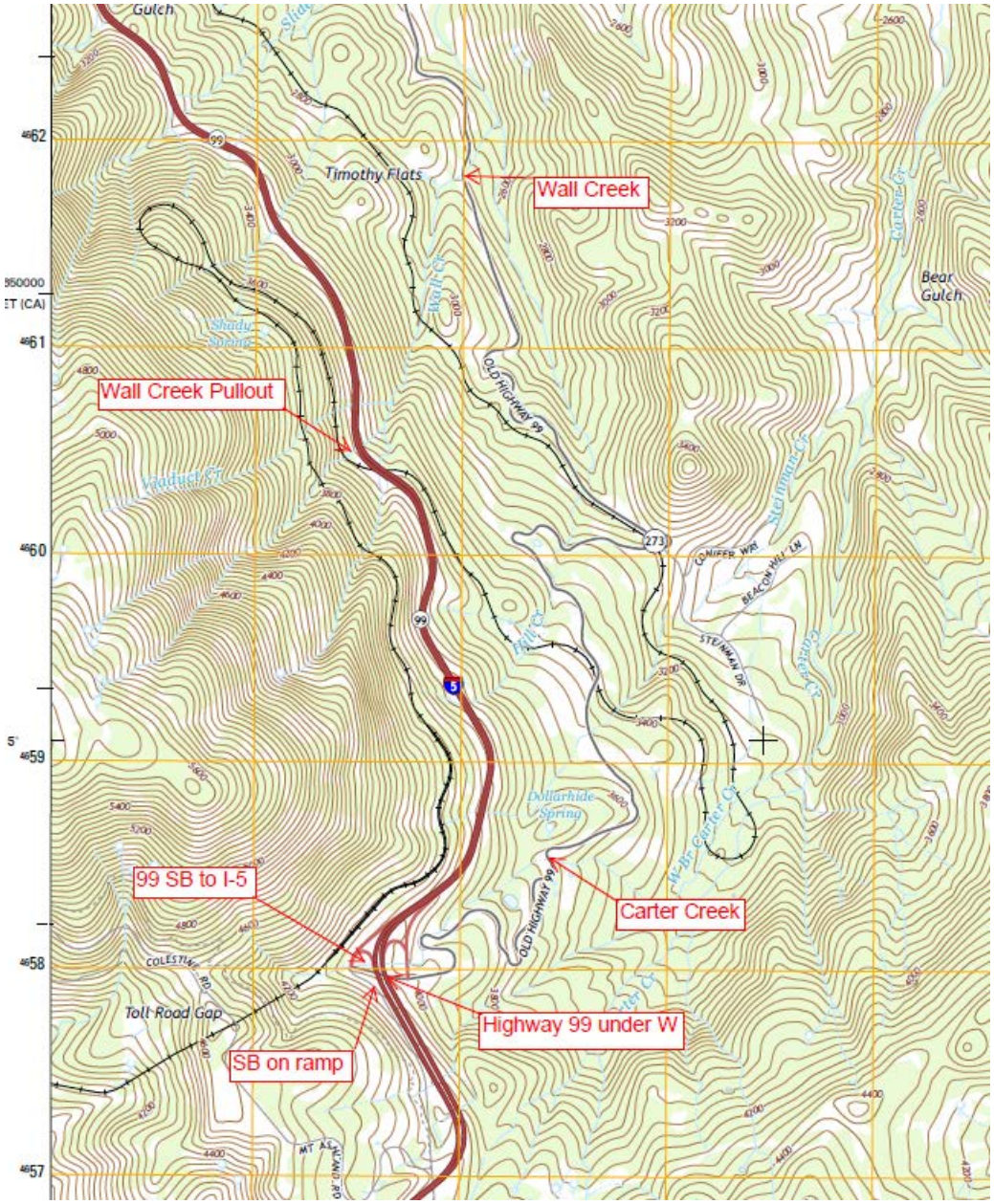
Map Detail:
U.S.Geological Survey
Louse Canyon
Oregon-Idaho
30 X 60 Minute Series

ODOT Salt Pilot – Hwy 95/Jordan Valley – Sample Site Locations



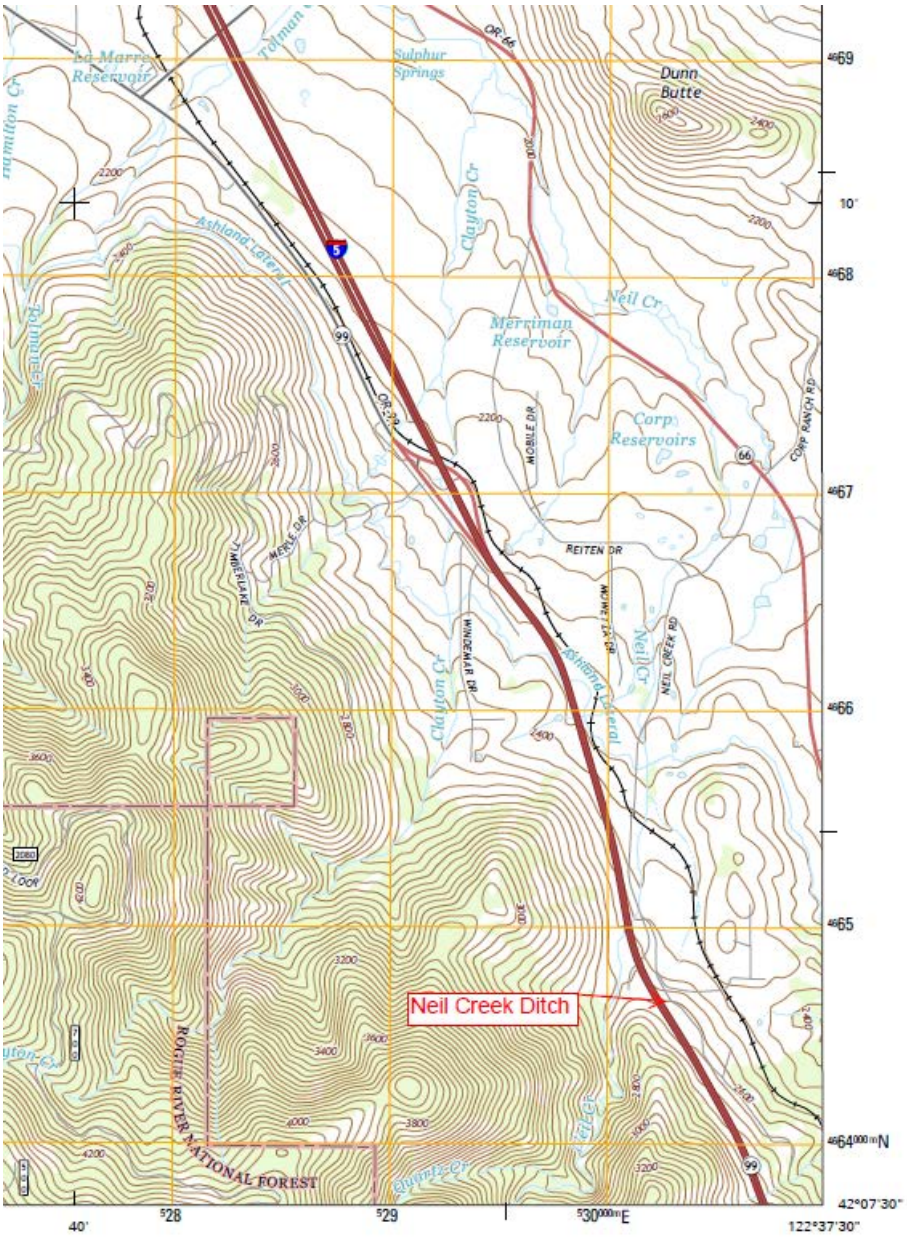
Map Detail:
U.S.Geological Survey
Siskiyou Pass Quadrangle
Oregon-California
7.5-Minute Series

ODOT Salt Pilot – I-5/Siskiyou Pass – Sample Site Locations



Map Detail:
U.S.Geological Survey
Ashland Quadrangle
Oregon-Jackson Co.
7.5-Minute Series

ODOT Salt Pilot – I-5/Siskiyou Pass – Sample Site Locations



Attachment D:

Maintenance Leadership Team Operational Notice

MAI-170-1: Road Salt Pilot and Best Management Practices

Oregon Department of Transportation

Highway Division
Maintenance Leadership Team
Operational Notice

Number	Supersedes	Effective Date	Cancellation Date
MAI 170-1	**10/1/2017**	**10/20/2017**	
Subject		Issuing Body	
Road Salt Pilot Project and Best Management Practices		Maintenance and Operations Engineer	

Purpose

This Notice defines the salt pilot project locations where salt can be used (see attached map Exhibit A) and outlines practices required to minimize environmental and corrosive impacts from using solid NaCl (salt).

Background

Responding to certain types of winter weather events with the liquid deicing chemical currently available to Maintenance Districts may be cost prohibitive, or not appropriate or effective. In an effort to address this gap, ODOT is taking a phased approach to expanding the use of a solid deicing salt. Salt resources are available in areas located within the phase 1 and phase 2 salt pilot areas. Interstate and freeway sections outside of these areas are included in what is referred to as exception areas (see attached map, Exhibit A).

Significant efforts have been made to implement the use of salt in the phase 1 and 2 pilot areas, mainly by making infrastructure and application resources/equipment readily available. Access to salt resources within the exception areas may be extremely limited or absent.

Because salt can be toxic as well as corrosive to vehicles and highway structures, Best Management Practices (BMPs) must be implemented to maximize benefits and minimize potential impacts.

ODOT expectations for highway maintenance activities are described in the ODOT Maintenance Guide. BMPs implemented by ODOT to minimize the impacts maintenance activities can have on fish, fish habitat, and water quality are listed in the ODOT Routine Road Maintenance Water Quality and Habitat Guide Best Management Practices (the Blue Book). Modification to the BMPs in the Blue Book requires concurrence with National Marine Fisheries Service, the Oregon Department of Fish and Wildlife, and ODOT maintenance managers. The Environmental Management System for ODOT Maintenance Yard Policy and Procedure Manual (EMS Manual) is the guiding document for material management at Maintenance Yards. Modifications to the EMS Manual require approval from the EMS Technical Team. Modification to ODOT Policy requires approval from the Maintenance Leadership Team.

Exception Areas

The intent of the exception process is to enable the use of salt in areas that are on interstate and freeway segments either adjacent to the pilot phase 2 locations to accommodate an improved transition, or in extreme events for known trouble spots. An exception process has been developed to assist with determining when it is appropriate to request salt in the exception areas. Areas of particular concern include;

- Known interstate or freeway trouble spots, including ramps and interchanges.
- Interstate freeway areas located between districts where there is a potential for hazardous transition in pavement conditions.
- Maintaining a more consistent level of service between districts, through corridors and high ADT areas.

The manner in which salt would be used to address the operational considerations listed above should be documented in district winter operations plans. The approval to use salt will be granted on a case-by-case basis, and will be documented on a salt exception form (example attached, see Exhibit B). Each decision point addresses the most significant operational considerations and BMPs that must be considered and addressed in order to gain approval.

Definitions

Pacific Northwest Snowfighters (PNS): The PNS Association is a group of technical experts from five western states and British Columbia. The group evaluates and establishes specifications for winter maintenance deicing products that emphasize safety, environmental preservation, infrastructure protection, cost effectiveness, and performance. Oregon is a PNS member state.

Process – Winter Road Salt (NaCl) Best Management Practices

Best Management Practices and goals for anti-icing and deicing are outlined in the Maintenance Guide, Desired Conditions of Maintenance Features on State Highways, and the "Routine Road Maintenance Water Quality and Habitat Guide Best Management Practices, 2009," (Blue Book). The appropriate storage, handling and disposal of deicers are outlined in the "Environmental Management System Manual for ODOT Maintenance Yards, 2009."

Because salt (NaCl) is the most mobile, the most corrosive, and the most likely deicer chemical to negatively impact surface and groundwater resources, the ODOT Maintenance and Operations Branch has developed the following additional Best Management Practices. In the event a BMP cannot be met, document mitigation measures implemented to protect, to the extent practical, the environment, infrastructure, and equipment.

Purchase of Salt Products

The purchase of salt products is limited by ODOT Procurement policies and commitments to regulatory agencies outlined in Blue Book. Commercial road salt can be contaminated with heavy metals or chemical additives.

- **Salt products applied to ODOT highways must be listed on Pacific Northwest Snowfighters Qualified Products List (PNS QPL) to minimize contamination and ensure quality.**

- **Before purchasing salt products from adjoining states or other municipalities, the local manager must verify the product is listed on the PNS QPL.**

- **All salt deliveries, including deliveries to other states or municipalities that ODOT uses must be sampled and the samples sent to the MOB for analysis.**

- **Experimental products and methods must be coordinated through and approved by the MOB.**

- **A quality assurance (QA) program for winter maintenance chemicals must be established.** A QA program tests purchased winter chemical products to ensure the product is not contaminated with potential pollutants. The MOB oversees ODOTs Winter Maintenance QA Program, which includes salt testing.

Application

Environmental and structural impacts of salt increase in risk as application rates increase. The higher the application rate the higher the risk of environmental or structural impacts. Application guidance for deicing chemicals is currently listed in the Maintenance Guide and in the Blue Book. In addition to existing guidance the following BMPs are required for salt:

- **Use salt only in those areas identified in Exhibit A**. Those areas include the phase 1 pilot, phase 2 pilot, and exception areas.
- **Obtain approval by the State Maintenance and Operations Engineer prior to using salt in the areas identified as exception areas** (see attached sample form, Exhibit B).
- **The use of salt must be minimized.** Typical application rates for salt range from 100-300 lbs. per lane mile as a deicer, depending on current and forecasted weather and road conditions. Use the minimum amount necessary to meet management objectives (see attached Application Guidelines, Exhibit C).

  Note: Category 8B salt products are not effective at melting pack at temperatures below 15°F, no matter how much is applied.

- **Products must be used for the intended purpose.** Salt should only be used when standard winter maintenance practices are ineffective or cost prohibitive. Plowing operations should be timed to allow maximum melting (by salt products) before snow is plowed off the road. Liquid chemical should be used proactively for anti-icing prior to snow and ice accumulation.

- **Anti-icing should be used.** Established best practices for snow and ice removal indicate that anti-icing (preventing snow and ice from bonding to the pavement) is the most effective means of snow fighting.

- **Avoid using deicing chemicals to burn off thick layers of pack (e.g., 2" or greater) due to safety risks and the amount of chemical necessary.**

- **Apply deicers only at working temperatures per manufacturer guidelines.**

- **Districts *should* weigh the benefits of salt application in sensitive areas.** As salt sensitive areas are identified, Districts should assess the benefits and risk of salt use. 'No salt' areas will be identified in District Winter Operations Plans.

- **Reduce speed of application whenever practical to maximize efficiency (reduce bounce and scatter, minimize adverse environmental effects).** Ideal application speeds are between 25 and 35 MPH.

- **Salt must be pre-wet with liquid corrosion-inhibited deicer (either as purchased or on the truck) prior to application to minimize bounce and scatter and to activate the product.** Pre-wetting with a corrosion-inhibited liquid deicer provides corrosion inhibition. Pre-wetting rates vary from 10-20 gallons per ton of material.

- **Application equipment must be properly calibrated.** Verify that application rate settings match discharge rates as outlined in the Calibration Guide. Keep a rate chart in the vehicle for spreader settings.

- **Application equipment must be equipped with a properly functioning pavement temperature sensor and gauge.**

- **Accurate application records must be kept.** Automatic data collection will be used if equipped. For all applications paper records will be kept.

Material Management

Best management practices for the storage, handling, and disposal of materials at ODOT Maintenance yards are listed in the EMS Manual.

Salt management guidelines are not currently included in the EMS Manual; however, some of the existing BMPs in the Winter Maintenance, Good Housekeeping, and Drainage sections are applicable. The following BMPs are required in addition to existing EMS guidance.

STORAGE

Concrete will not adequately contain salt without additional measures; a salt crust will form on the outside of untreated concrete walls.

- **Salt must be stored in a structure that prevents the migration of solid or dissolved salt from entering the adjacent soil, surface water, or groundwater.**

- **Salt storage structures *should* be located away from stormwater conveyances and waterbodies.** Where possible based on site constraints, the following setbacks *should* be implemented when siting salt storage buildings:

    - At least 300' from private water wells
    - At least 300' from drywells.
    - At least 300' from waterbodies or wetlands.
    - At least 100' from stormwater conveyances including catch basins and ditches.
    - Outside of the 100-year flood plain.

- Outside of source areas (groundwater and surface water) for public drinking water

- **The structure *should* be aligned to minimize salt migration by wind.**

- **Floors and stem walls of salt storage structures must be constructed of a material that will prevent the migration of dissolved salt into the soil below.**

  Note: salt will migrate through concrete or asphalt that is not properly sealed. Cracks or gaps in walls or floor will also allow salt to migrate.

- **Floors, stem walls and plastic sheeting *must* be visually inspected annually and repaired or resealed as needed to maintain impermeable condition.**

- **Floors must be sloped or curbed to retain salt-contaminated runoff within the structure.**

- **Salt structures must be fully enclosed and protect salt from being carried outside of the structure by wind or water.**

- **Salt structures should be tall and large enough to accommodate the annual anticipated amount of solid product, equipment, loading and unloading.**

- **Approaches *should* be paved and sloped to divert stormwater away from the storage structure.**

- **Salt *should* be stored in a manner that protects the function and integrity of the product.** Product *should* be protected from the weather and other damaging elements (e.g. moisture, wind). Storage areas *should* be high and dry.

- **Trucks containing salt must be parked under cover at the end of the shift.**

HANDLING

- **Equipment Washing *should* be done as soon as practical at the end of each storm. Salt neutralizing products *should* be used.**

- **Washing must occur on a paved surface.**

- **Where practical, chunks of hardened salt *should* be removed from application equipment prior to washing.** Hardened salt *should* be swept up and returned to the storage pile or managed as solid waste (e.g. trash).

- **Water from washing or rinsing equipment used to apply salt must be either directed to a municipal sanitary system or to a closed-loop system.** Examples of a closed loop system include evaporation from an impervious surface, discharge to a lined evaporation pond, or collection in a storage tank. Wash water collection tanks *should* follow the BMPs for liquid winter maintenance chemical storage.

- **Lined evaporation ponds should be checked regularly for damage**. Liners should be repaired or replaced when damaged. Liner is damaged when

condition allows wash water to be released to the subsurface. Repair or replace the liner with similar material. In many cases, rigid plastic liners may be repaired by welding a similar material over the damaged portion or using a waterproof epoxy.

- **If washing or rinsing equipment uses a municipal sanitary system, approval from the municipality must be obtained prior to a significant change in washing or rinsing practices.**

Loading and Unloading

- **Loading and unloading must occur on a paved surface.** The surface should be constructed of a material that will not absorb the product or allow dissolved salt to migrate.

- **Loading and unloading must occur indoors**, with the exception of tow plow combination trucks due to their length and maneuverability restrictions. Loading and unloading of tow plow combination trucks must occur as close to the salt storage shed as feasible.

- **Loading and unloading practices *should* minimize tracking of salt.** Avoid overfilling and overloading trucks. Where appropriate, employ methods to capture solids before entering the storm system.

- **Sweep up solid salt that has escaped the storage area (e.g. tracked from equipment movement) as soon as practical and disposed of appropriately (see below).**

- **Chunks of salt *should* be crushed and blended into the pile.**

DISPOSAL

- **Salt that cannot be applied to the highway *should* be managed as *solid waste* (e.g. trash).**

- **Salt-laden wash water must be directed to a municipal sanitary sewer, picked up and hauled by a licensed pumper, or evaporated from an impermeable surface (e.g., paved area or directed to a lined evaporation pond).**

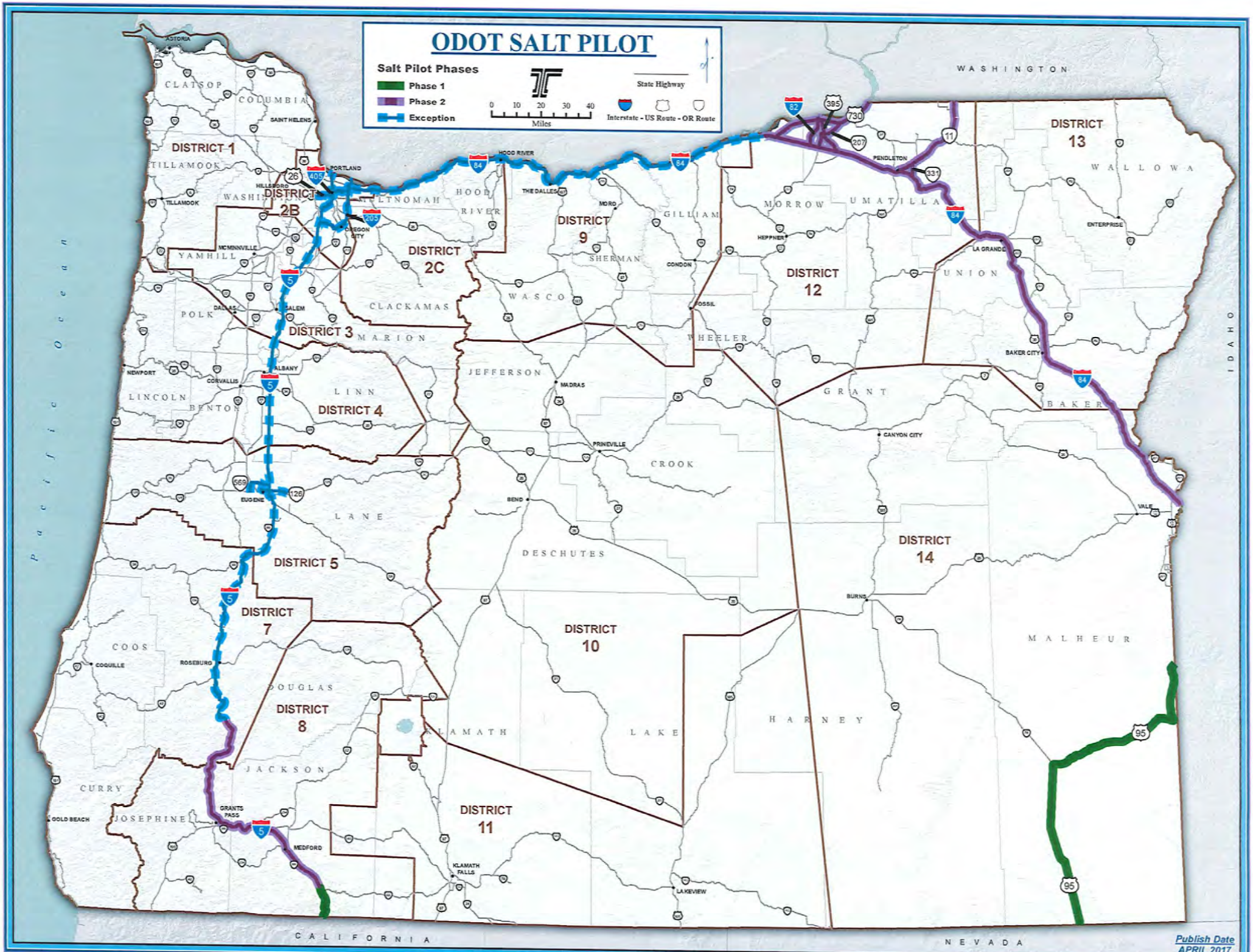
TRAINING

- **Staff involved in salt handling, storage, application, or the direction of those activities, must be appropriately trained.**

Responsibility	Action
State Maintenance and Operations Engineer	• Establish and maintain practices and procedures to prevent or reduce impact on the environment • Evaluate pilot project results annually and make adjustments to pilot program and BMPs as needed • Approve the use of salt in exception areas as appropriate • Modify Ops Notice based on recommendations as appropriate
District Managers	• Establish clear expectations and accountability for work performance, implementation of best management practices, worker protection, environmental stewardship, and sustainability • Request prior approval of salt use in exception areas in writing (see sample form attached; Exhibit B) • Report to MOB at least annually on salt pilot lessons learned, effectiveness (number of applications, triggers for use, weather conditions, road conditions, forecast, storm characteristics), quantities, locations where used • Identify known trouble spots in the exception areas where salt may be used • Adjust/modify winter operation plans as appropriate based on lessons learned and any changes to BMPs • Ensure BMPs are being met or that mitigation measures are implemented, as appropriate • Recommend to MOB changes to best management practices based on experience
Transportation Maintenance Managers (TMM)	• Report on the effectiveness of salt in winter maintenance operations to DM • Implement the Road Salt Pilot Project Best Management Practices • Report to the DM when/if a BMP cannot be met • Follow the Material Management BMPs, and direct crews in following the Material Management BMPs, including storage, handling and disposal of salt • Participate in appropriate training for salt applications and material handling • Ensure appropriate training for crews that will use, handle or direct the use or handling of salt • Ensure that accurate records of salt application rates and locations are completed in a timely manner and kept • Ensure completion of monthly and annual audits of best management practice implementation and effectiveness

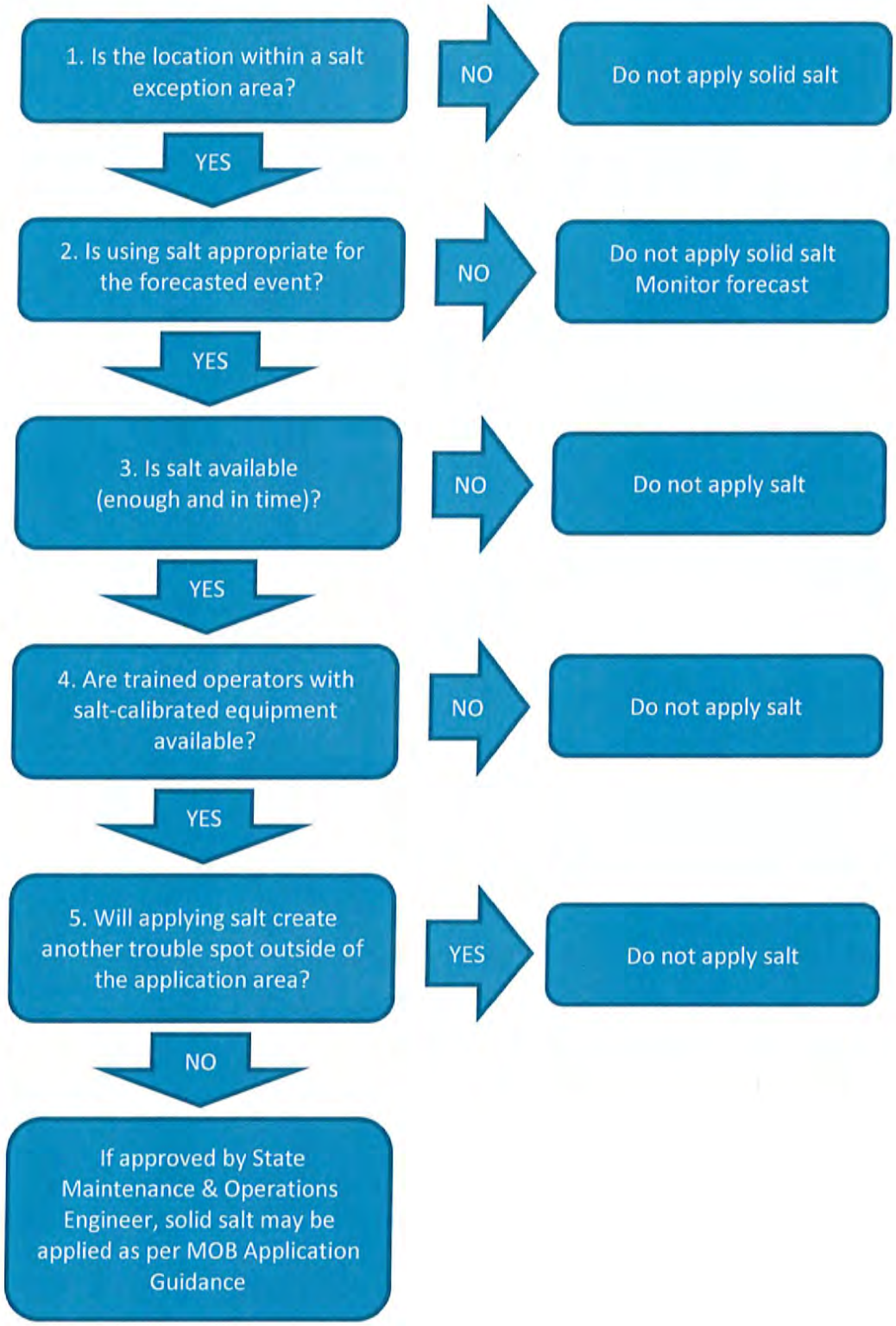
Maintenance and Operations Branch	• Ensure that salt products used by ODOT meets the PNS specifications • Modify and maintain a quality assurance (QA) program that will have the capability to test salt products • Support District Managers, Maintenance Managers, Maintenance Coordinators and crews in implementing salt product BMPs • Coordinate and make available appropriate training for the proper use, handling, storage and disposal of salt products • Based on district reports, evaluate BMP effectiveness and adequacy • Support development of a means to evaluate the effectiveness of salt in closing current operational gaps in winter maintenance

Exhibit A: Salt Pilot Map
Exhibit B: Exception Area Form/Process
Exhibit C: Application Guidelines


ODOT SALT PILOT
Salt Pilot Phases
Phase 1
Phase 2
Exception
0 10 20 30 40
Miles
State Highway
Interstate - US Route - OR Route
DISTRICT 1
DISTRICT 2B
DISTRICT 2C
DISTRICT 3
DISTRICT 4
DISTRICT 5
DISTRICT 7
DISTRICT 8
DISTRICT 9
DISTRICT 10
DISTRICT 11
DISTRICT 12
DISTRICT 13
DISTRICT 14
WASHINGTON
CALIFORNIA
NEVADA
IDAHO
Pacific Ocean
ASTORIA
PORTLAND
SALEM
EUGENE
MEDFORD
GRANTS PASS
KLAMATH FALLS
LAKEVIEW
BEND
PRINEVILLE
MADRAS
THE DALLES
HOOD RIVER
PENDLETON
LA GRANDE
BAKER CITY
ENTERPRISE
BURNS
VALE
CANYON CITY
FOSSIL
HEPPNER
CONDON
MORO
ROSEBURG
COQUILLE
GOLD BEACH
NEWPORT
CORVALLIS
ALBANY
MCMINNVILLE
TILLAMOOK
HILLSBORO
OREGON CITY
DALLAS
CLATSOP
COLUMBIA
SAINT HELENS
MULTNOMAH
HOOD RIVER
WASCO
SHERMAN
GILLIAM
MORROW
UMATILLA
UNION
WALLOWA
BAKER
WHEELER
GRANT
JEFFERSON
CROOK
DESCHUTES
LINN
BENTON
LINCOLN
POLK
YAMHILL
CLACKAMAS
MARION
LANE
DOUGLAS
COOS
CURRY
JOSEPHINE
JACKSON
KLAMATH
LAKE
HARNEY
MALHEUR
Publish Date
APRIL 2017

Oregon Department of Transportation

Solid salt exception process flow chart



Describe the current/forecasted conditions and the approved treatment plan:

1. **Is the location within a designated salt use exception area?**
   A. Are the areas under consideration included in an approved salt application area (highway sections included in the final salt build-out plan?) **Y / N**
   Highways/MPs salt will be applied: _____

GO / NO GO

2. **Is using salt appropriate for the forecasted event?**
   A. Are the forecasted pavement conditions and precipitation types appropriate for the use of salt? **Y / N**
   Explain: _____
   B. Can salt be used efficiently and effectively based on MOB Deicer Application Guidelines? **Y / N**
   Explain: _____
   C. What strategy will be used: proactive **(anti-icing)** or reactive **(deicing)? Circle one or both**
   Explain: _____

GO / NO GO

3. **Is salt available in sufficient quantities to last the duration of the event, and in a location where reloading will be accomplished in an efficient manner? (Consider treating one direction, trouble spots only, full treatment)**
   A. _____ Total lane miles to be treated
   B. _____ Highest anticipated application rate (lbs./LM) based on MOB Deicer Application Guidelines.
   C. _____ Anticipated duration of the storm (hrs.)
   D. _____ Cycle time (hrs.) (time needed to treat all lane miles and reload)

GO / NO GO

(A_____ X B_____) X (C_____ / D_____) = _____ Estimated total lbs. of salt needed for event

4. **Are operators and equipment available? (a no answer for any of these = NO GO)**
   A. Are operators trained on the BMPs associated with the use of solid salt? **Y / N**
   B. Are adequate numbers of spreaders available to achieve desired cycle times? **Y / N**
   C. Have the spreaders been calibrated for solid salt? **Y / N**
   D. Does the application equipment have functional pre-wet systems installed? **Y / N**

GO / NO GO

5. **Have unintended consequences been considered and accounted for (i.e. transition zones)?**
   Explain: _____

GO / NO GO

Manager completing exception request: _____ Date/Time: _____

State Maint. & Ops Engineer approval: _____ Date/Time: _____

Oregon Department of Transportation Deicer Application Guidelines[i]

Anti-Icing (Before the Storm)			
Pavement Temperature at the time of application	Snow	Freezing Fog/Black Ice	Freezing Rain/Sleet
Over 30	15-30 (L)	15-30 (L) or 100-200 (S)	100-200 (S)
26 to 30	20-40 (L)	20-30 (L) or 100-200 (S)	100-200 (S)
21 to 25	30-50 (L)	20-40 (L) or 100-200 (S)	200-300 (S)
15 to 20	40-60 (L)	30-40 (L) or 200-300 (S)	200-400 (S)
Below 15	Not Recommended	Not Recommended	Not Recommended

Deicing (During the Storm)				
Pavement Temperature at the time of application	Light Snow (1" per hour or less)	Moderate - Heavy Snow (More than 1" per hour)	Freezing Fog/Black Ice	Freezing Rain/Sleet
Over 30	15-30 (L) or 100-200 (S)	200-300 (S)	15-30 (L) or 100-200 (S)	200-300 (S)
26 to 30	20-40 (L) or 100-200 (S)	200-300 (S)	20-40 (L) or 100-200 (S)	200-300 (S)
21 to 25	20-40 (L) or 100-200 (S)	200-400 (S)	30-50 (L) or 100-200 (S)	200-400 (S)
15 to 20	40-60 (L) or 200-300 (S)	200-500 (S)	40-60 (L) or 200-300 (S)	200-500 (S)
Below 15	PA	PA	AA	AA

After Storm (Precipitation has Stopped)			
Pavement Temperature at the time of application	Compacted/Bonded Snow	Freezing Fog/Black Ice	Freezing Rain/Sleet
Over 30	200-300 (S)	15-30 (L) or 200-300 (S)	200-300 (S)
26 to 30	200-300 (S)	20-30 (L) or 200-300 (S)	200-300 (S)
21 to 25	200-400 (S)	30-40 (L) or 200-400 (S)	200-400 (S)
15 to 20	200-500 (S)	30-50 (L) or 200-400 (S)	200-400 (S)
Below 15	PA or AA	AA	AA

(L) = Liquid Mag ($MgCl_2$) gallons per lane mile **(S)** = Solid Salt (NaCl) pounds per lane mile

PA = Plow and apply pre-wetted abrasives as needed **AA** = Apply pre-wetted abrasives as needed

Practical Tips/Best Management Practices

1. **These are typical application rate ranges, and can be adjusted based on pavement/environment variables and to meet operational objectives.**
2. **Generally choose a lower application rate when the pavement temperature trend is rising or steady, and a higher application rate when the temperature trend is falling.**
3. **Melting or "burning" all snow or ice from the pavement is not recommended – apply just enough to loosen the bond between the ice/compacted snow so that it can be effectively plowed off.**
4. **Time applications to prevent conditions from deteriorating and avoid the development of packed and bonded snow.**
5. **Plow as much snow and ice as possible (initial or re-application) before applying any deicing chemical. Target depth should be 2 inches or less.**
6. **Cycle times should allow time for product to work prior to plowing and re-application. Higher application rates can be used to accommodate longer cycle times by countering dilution of solution caused by melting and/or precipitation.**
7. **All solids must be pre-wetted with liquid mag ($MgCl_2$) at a rate of 10-20 gallons/ton in order maximize effectiveness.**
8. **The application of liquid deicer is not recommended when snow/ice is too thick to see pavement or if the pavement is wet.**

ODOT Maintenance & Operations Branch – 2017

[1] The following references were used to establish the deicer application rates:

1. *Establishing Effective Salt and Anti-Icing Application Rates*, Clear Roads Research Program, 2014.
2. *Snow and Ice Control: Guidelines for Materials and Methods (Report 526),* National Cooperative Highway Research Program, 2004.
3. *Manual of Practice for an Effective Anti-Icing Program,* Federal Highway Administration, 1996.