

4.0 DRAINAGE AND STORMWATER MANAGEMENT

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. This Synthesis is provided as advice to road maintainers for consideration when developing their own Salt Management Plan. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of individual road agencies. Syntheses of Best Practices have been produced on Salt Management Plans, Training, Road and Bridge Design, Drainage and Stormwater Management, Pavements and Salt Management, Vegetation Management, Design and Operation of Road Maintenance Yards, Snow Storage and Disposal Sites and, Winter Maintenance Equipment and Technologies. For more detailed information, please refer to TAC's Salt Management Guide – 1999.

INTRODUCTION

Salt-laden runoff can have impacts on the natural environment. The nature and extent of these impacts are site specific, and may be temporary or can persist for long periods of time. In some areas, the concentration of chloride in the groundwater and stream baseflow may reach levels sufficient to impair the potability of groundwater or alter aquatic habitat. This Synthesis of Best Practices establishes Guiding Principles to aid in the design of drainage works for existing or new roadways, and provides a framework to identify the specific practices that can be implemented to minimize potential impacts of salt on the surrounding environment.

This Chapter of the Synthesis of Best Practices does not specifically address the impacts of salt-laden runoff and salt spray on vegetation. The Synthesis of Best Practices for Vegetation Management provides information on this aspect of snow and ice control chemicals. It also does not deal with other contaminants in roadway runoff.

RELATIONSHIP TO SALT MANAGEMENT

Much of the salt that is placed on a road during snow and ice control operations eventually runs off with the roadway drainage. This drainage enters the environment through three primary pathways. The first is through overland drainage or stormsewer systems ultimately discharging to nearby surface water. The second is infiltration into the ground potentially entering groundwater.

The third is through spray caused by traffic and wind, potentially affecting adjacent vegetation and agricultural crops.

If any of these pathways introduce high salt concentrations to salt vulnerable areas, then adverse impacts may occur.

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Proper drainage planning and design can reduce the potential impacts on salt vulnerable areas by isolating the drainage from vulnerable areas.

This Synthesis of Best Practices, when used in combination with other policies and guidelines for drainage design, will assist in the responsible selection of drainage management measures. Regardless of the policy framework, the following guiding principles exist for creating an overall management plan that also minimizes salt related impacts:

1. Roadway safety is the priority. Drainage design must ensure that roadway runoff is efficiently and safely removed from the travel surface.
2. Drainage design must comprehensively consider all drainage related impacts in the formulation of a responsible, effective management strategy.
3. The most significant, potential, long-term impact of salt-laden runoff is impairment of domestic groundwater supply.
4. Drainage design must endeavor to protect the natural environment.
5. Drainage design must be practical and must not impose undue maintenance requirements.

SALT MANAGEMENT PRACTICES

The main purpose of any road drainage system is to safely convey runoff downstream to either a natural or man-made drainage system. Management measures should be implemented to ensure that this is done with minimal impact to the infiltration characteristics, water quality, erosion potential, and flood risk of the receiving drainage system. At the onset of any drainage design, sufficient information should be collected to characterize the existing drainage system surrounding and downstream of the roadway.

IMPACT IDENTIFICATION

A detailed surface water assessment should be completed to identify all potential impacts to natural features as a result of the roadway. The requirements of the assessment will be defined by the policy framework in the area where the drainage design is being completed. As a minimum, the assessment should include a review of the impacts of salt-laden surface water on potable water taken from groundwater sources, sensitive aquatic habitat, agricultural lands, wetlands, and wildlife.

Each of these features is described below. Guidelines have been provided to establish the relative importance

of each feature as defined by low, medium or high potential for impact. Specific site characteristics may require that other features be considered as well. The impact potential identified for all significant features will assist in the selection of suitable mitigative measures.

Ground Water

The suitability of groundwater for potable use and irrigation can be significantly impaired by the infiltration of salt captured by roadway runoff. To determine the potential for impact from salt-laden runoff on groundwater, the following questions must be addressed:

- Are there domestic wells near the roadway?
- If there are wells, do they draw from a surficial aquifer?
- Are the surficial soils permeable (sands and loams)?

The degree of potential impact on groundwater can be determined based on the responses to these questions:

- High: The answer is 'yes' to all three questions.
- Medium: The answer is 'yes' to the first question and 'yes' to either the second or third question.
- Low: All other cases.

Aquatic Habitat

Salt-laden runoff can potentially impact aquatic habitat in two ways: sudden pulses of chlorides during spring runoff, and continuous levels of chloride present in the groundwater discharging to the receiving stream. Although both types of impacts are a concern, the literature generally points to sudden pulses as the greater concern. With either type of impact, the existing literature is not clear on "how much is too much". The following provides a guideline for assessing the potential impact:

- High: The receiving watercourse has a permanent baseflow, and the catchment area of the road represents more than 10 percent of the catchment area of the stream.
- Medium: The receiving watercourse has a permanent baseflow, and the catchment area of the road represents less than 10 percent of the catchment area of the stream.
- Low: All other cases (i.e. receiving watercourses with no permanent baseflow).

Agricultural Land

Salt-laden runoff can impact crops in cases where there is the potential for water to pond on agricultural lands. This situation can arise where there is poor positive drainage or an outlet has been blocked by ice or debris. Guidelines for assessing potential impacts are as follows:

- High: Agricultural land is adjacent to the road, and off road drainage has a high likelihood of ponding or blockage.
- Medium: Agricultural land is adjacent to the road, and off road drainage has a low to moderate potential for ponding or blockage.
- Low: Agricultural land is either outside the road runoff influence zone, or there is no agricultural land adjacent to the road.

Wetlands

Swamps, peat bogs, marshes, and other types of wetlands can be impacted where runoff is directed to natural roadside vegetation features. In these cases the runoff may enter the wetland as sheet flow or via a roadside ditch. With very high and prolonged chloride loading, there is the possibility that changes in local plant composition may occur, with the possibility of a reduction in the overall value and diversity of the wetland. Small, perched wetlands that intercept the shallow water table or that are primarily surface water dependant may be most susceptible to chloride loading effects due to their small size and a reduced dilution potential. Large wetlands with extensive catchment areas and high dilution potential are likely more tolerant of chloride loading. Potential impacts may be classified as follows for wetlands located adjacent to the roadway:

- High: No clear flow path evident through the wetland and/or small perched roadside wetlands present (<5 ha in size).

- Medium: Poorly defined channel evident through the wetland and/or moderate sized wetland with better dilution potential (5 -20 ha in size).
- Low: Clearly defined channel evident through the wetland and/or large wetland with good dilution potential (>20 ha in size).

Wildlife

Ponded runoff can serve as a salt source for wildlife. The attraction of the wildlife to the saltwater can be a safety hazard. Potential impacts may be classified as follows:

- High: Roadway located in an area where large mammals (such as elk, big horned sheep, white-tailed deer and moose) are present and where roadside ponding is a current problem or has a high potential based on design limitations and topography.
- Medium: Roadway located as above but roadside ponding is not a current problem or has only a moderate potential based on design limitations and topography.
- Low: Roadway located as above but there is no existing or future roadside ponding problem, or large mammals are limited or absent in the area.

Impact Identification Summary

The potential impacts of salt on each of the categories can be summarized in a table similar to the following example. This table represents a starting point for identifying appropriate drainage management practices that can be used to minimize the impacts of salt on the adjacent environment:

| <i>Features That May Be Impacted</i> | | | | | |
|--------------------------------------|-------------|-----------------|-------------|----------|----------|
| Impact Potential | Groundwater | Aquatic Habitat | Agriculture | Wetlands | Wildlife |
| Not Applicable | | | ■ | | |
| Low | | | | | ■ |
| Medium | | | | ■ | |
| High | ■ | ■ | | | |

**IDENTIFICATION OF ALTERNATIVE
MANAGEMENT PRACTICES**

The minimization of salt related impacts should be one objective of any management strategy formulated for roadway drainage systems. Unfortunately, the range of potential impacts from salt-laden runoff offers considerable challenges to the designer. There are a number of practices that can aid in the management of runoff, however each practice may mitigate some types of impacts while accentuating others. For example, promoting rapid conveyance of runoff to a receiving watercourse will reduce the potential for impairment of potable groundwater

while increasing potential impacts on aquatic environment.

Eight alternative management practices can be considered. In most cases, these practices will be required to achieve other drainage objectives. For some sites, combinations of these measures may be required to effectively minimize impacts related to salt rich surface drainage. This is not a comprehensive list of measures available to the designer. Local drainage policies in different parts of the country may identify additional measures that could be implemented effectively to mitigate drainage impacts.

| Management Practice | Purpose |
|--|--|
| 1 Sheet Flow | Runoff conveyed across grass buffer strips or embankments. |
| 2 V-ditch | Runoff conveyed by roadside ditch to receiving watercourse. |
| 3 Storm Sewer | Runoff conveyed away from sensitive areas using storm sewer system (negligible infiltration potential). |
| 4 Flat Bottom (Trapezoidal) Ditch | Runoff conveyed by roadside ditch with flat bottom ditch. |
| 5 Flat Bottom (Trapezoidal) Ditch with Storage | Runoff conveyed by flat bottom ditch which includes on-line storage to trap sediment and reduce velocities and runoff rates. |
| 6 Dry Basin (Pond) | Runoff directed to stormwater management basin designed to reduce runoff rates and promote sedimentation. |
| 7 Wet Basin (Pond) | Runoff directed to stormwater management basin designed to reduce runoff rates, promote sedimentation and enlarge biological uptake. |
| 8 Buffer Strip and Containment Berm | Berm designed to contain runoff within buffer strip, with positive outlet provided to prevent flooding and sustained water levels. |

The following table illustrates the merits of each management practice in addressing the potential impacts that can result from salt-laden runoff. As the table illustrates the practices which benefit groundwater impacts are typically consistent with those that benefit agriculture, wetlands, and wildlife. However, most of these practices have the potential to negatively impact aquatic resources. This table, in conjunction with the ranking summary table prepared at the end of the impact identification process, will help to determine which impacts can be successfully mitigated through the use of specific drainage measures.

In most cases conflicts will not arise, and the selection of suitable management practices for minimization of salt impacts will be relatively simple. The measures will typically be selected as part of the overall management strategy formulated to achieve other drainage and stormwater management objectives. In cases where objectives are conflicting, the practitioner must review each site on its own merits and set priorities such that the overall impacts are minimized.

| Management Practice | Characteristics | Feature that May be Impacted | | | | |
|-----------------------------------|---|--|-----------------|-------------|----------|----------|
| | | Ground-water | Aquatic Habitat | Agriculture | Wetlands | Wildlife |
| Sheet Flow | Disperses runoff | - | + | 0 | 0 | 0 |
| V-Ditch | Channels runoff | + | - | + | + | + |
| Storm Sewer | Channels runoff with little opportunity for infiltration | + | - | + | + | + |
| Flat Bottom Ditch | Channels runoff Some attenuation of flow rate Some sediment trapping Some potential for infiltration | 0 | - | + | + | 0 |
| Flat Bottom Ditch with Storage | Channels runoff Attenuates flow rate Some sediment trapping Some potential for infiltration | - | + | + | + | - |
| Dry Basin (Pond) | Attenuates flow rate Sediment trapping Potential for infiltration | - | + | 0 | 0 | 0 |
| Wet Basin (Pond) | Attenuates flow rate Sediment trapping Potential for infiltration | - | + | 0 | 0 | - |
| Buffer Strip and Containment Berm | Contains and disperses runoff | - | + | 0 | + | - |
| Legend: | | <p>+The identified management measure may reduce the level of impact from salt-laden runoff (i.e. The level of impact potential for a feature may be decreased from high to medium, medium to low, etc.).</p> <p>- The identified management measure may increase the level of impact from salt-laden runoff (i.e. The level of impact potential for a feature may be increased from low to medium, medium to high, etc.).</p> <p>0 The identified management measure will have minimal effect on the level of impact potential.</p> | | | | |

DESIGN REQUIREMENTS OF PREFERRED MANAGEMENT PRACTICES

The policy framework in the area where the design is being completed will define specific design characteristics of the recommended stormwater management measures. In most cases, stormwater management objectives other than salt management will dictate the design requirements.

In addition to local policy frameworks, design information for these measures can be found in numerous technical documents relating to stormwater management.

SALT VULNERABLE AREAS

Drainage designers need to consider the environmental setting into which their drainage system will be placed. Salt vulnerable areas need to be identified and the potential for salt impacted drainage to affect these vulnerable areas must be assessed. Special design modifications to traditional stormwater management measures may be warranted to protect these salt vulnerable areas. Measures may include clay or geosynthetic liners in conveyance ditches and ponds, infiltration ponds where appropriate, or use of storm sewers to transport drainage past vulnerable areas.

TRAINING

Since roadway drainage depends primarily on design and not on operations, typical salt management training programs would pay little attention to drainage issues except to teach the concept and importance of proper design.

Training for drainage designers should include design options for managing the adverse effects of snow and ice control chemicals.

MONITORING AND RECORD KEEPING

It is not practical to monitor all runoff from roadways for chloride levels. However, road authorities should consider monitoring salt vulnerable areas. One municipality worked with their local conservation authority to add chloride monitors to their stream monitoring network. They measured the chloride concentration in the watercourses as they entered the municipality and again as they left the municipality to track fluctuations. There are many complications with such a monitoring program. These include:

- At what frequency will samples be collected?
- Will the sampling be continuous?

- Will the data be communicated back to a central location automatically?
- The sampling stations will likely need power and telephone capability for communicating the data.
- Sampling locations must be protected from vandalism, flooding and ice impacts.
- If conductivity is being used as the measure, then it will need to be correlated to chloride levels.
- Data analysis will have to take into account any confounding data such as chlorides entering the environment from other sources (e.g. private uses, water softeners, landfills etc.)

Records should be kept on the chloride or conductivity levels and snow and ice control events to determine how the levels fluctuate around an event. The analyst will want to be able to draw conclusions on whether or not the applications of best salt management practices are having an effect on the chloride levels in the aquatic environment. It will be important to determine whether or not drops in chloride levels can be attributed to improved practices and not just different weather conditions.

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