

8.0 – SNOW STORAGE AND DISPOSAL

This is one in a series of Syntheses of Best Practices related to the effective management of road salt in winter maintenance operations. This Synthesis is provided as advice for preparing Salt Management Plans. The Synthesis is not intended to be used prescriptively but is to be used in concert with the legislation, manuals, directives and procedures of relevant jurisdictions and individual organizations. Syntheses of Best Practices have been produced on:

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| 1. Salt Management Plans | 8. Snow Storage and Disposal |
| 2. Training | 9. Winter Maintenance Equipment and Technologies |
| 3. Road, Bridge and Facility Design | 10. Salt Use on Private Roads, Parking Lots and Walkways |
| 4. Drainage | 11. Successes in Road Salt Management: Case Studies |
| 5. Pavements and Salt Management | |
| 6. Vegetation Management | |
| 7. Design and Operation of Maintenance Yards | |

For more detailed information, please refer to TAC’s Salt Management Guide - 2013.

INTRODUCTION

Over the course of a winter and multiple plowing operations snow can build up along roadways and in parking lots. Areas with limited space for plowed snow storage may develop large snow banks that can:

- obstruct the line of sight of drivers
- reduce vehicle mobility and available parking
- create a hazard to pedestrians
- form barriers causing drifts to form across pavement, and
- fill snow storage areas thus interfering with future plowing operations.

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In these cases, it becomes necessary to remove accumulated snow by melting it in place or transporting it to a site where it is melted by natural or mechanical means.

This snow can be impacted by:

- salts or other snow and ice control chemicals
- oil, grease and heavy metals from vehicles
- litter and debris, and
- normal dirt, dust and airborne pollutants.

Hauled snow must be handled, stored and disposed of in an appropriate manner that manages these contaminants in a way that protects the environment.

A number of methods have been developed to handle and remove snow. The least expensive way is to handle and dispose of the snow close to where it accumulates (i.e. pushed to the sides of roads, walkways and parking lots).

The simplest of these is to wing back the windrows as needed. This works well in areas where there is ample snow storage capacity. However, in many urban areas, this is not always an option. Some jurisdictions have tried spreading the snow banks back onto the paved areas in the spring and broadcasting salt over it to accelerate the melting process. This practice should be discontinued; as it increases the amount of chlorides released into the environment and can create hazardous conditions.

A number of jurisdictions are using mobile snow melters to melt the accumulated snow at the roadside and dispose of the meltwater through the storm sewer system. This method, although generally considered expensive, has merit in areas where haul distances would be excessive or snow disposal site capacity is limited. The ability of the storm sewer system and discharge site to handle the additional capacity and contaminants are important factors to consider before implementation.

Most hauled snow is taken to a location where it can be received, stored and melted. It is at these locations where the contaminated snow and the resulting meltwater accumulate, and measures need to be taken to minimize potential impacts to the environment.

This Synthesis of Best Practices establishes Guiding Principles to aid in developing appropriate snow

removal, storage and disposal procedures. It also provides an approach to locating, designing and managing snow disposal facilities in a way that minimizes the potential impacts of contaminated snow and salt-laden meltwater on the surrounding environment.

RELATIONSHIP TO SALT MANAGEMENT

The primary purpose of snow storage and disposal sites is to manage snow that would otherwise be a hazard to the public or impair winter maintenance operations. The snow that is stored at snow disposal facilities contains contaminants that are deposited on the ground or carried away with the meltwater as the snow melts. The meltwater and debris must be managed and should not be discharged back into the environment until properly treated. It should be kept in mind that currently there is no practical or economical way of removing the chlorides found in snow. Studies¹ have shown that much of the salt that is applied to pavement is not retained in the snow that is removed to snow disposal facilities. This is because chlorides tend to leave stockpiled snow soon after it is plowed. Only a small percentage of the salt that is applied to a road may be reaching the snow disposal facility. The other contaminants are often a greater issue for on-site management.

Most jurisdictions will have some form of regulation, policy or guideline for the protection of water quality, the protection of the environment, disposal of contaminated waste, possibly snow disposal and design approvals. This Synthesis of Best Practices should be used in combination with these regulations, policies and guidelines. Together they will assist in the responsible development of snow handling, storage and disposal procedures and sites.

When planning, designing and operating a snow disposal site, the following guiding principles should apply.

- Public safety is the priority. Organizations must ensure that the hazards caused by accumulated snow are efficiently and safely addressed.

¹ Environmental Study of Richmond Hill Snow Storage Facility, K. Exall et al, presentation to 1st International Conference in Cold Climates, University of Waterloo, May 2009

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- Snow disposal sites should be located and operated to minimize impacts to the natural environment and control nuisance effects, including noise, dust, litter and visual intrusion on adjacent landowners.
- The actual snow disposal area within the site boundary should be clearly delineated in a way that is easily identifiable under adverse winter conditions, to ensure that the snow is placed in the proper location on the site.
- Meltwater must be managed in compliance with local water quality regulations and in a manner that protects surface and groundwater resources.
- Onsite litter, debris and sediment from the meltwater settling area must be collected and disposed of in accordance with local waste management legislation.
- Emissions (drainage, noise, dust, litter, fumes) must be controlled to prevent offsite environmental impacts.
- The design of snow handling, storage and disposal facilities must be practical and must not impose undue maintenance requirements.

SALT MANAGEMENT PRACTICES

Good planning and background information are important to the success of any long-term infrastructure development, including snow storage and disposal sites. A thorough evaluation of existing and new methods and sites is crucial before any preliminary decisions are made on sites and methods that will be used for storage and disposal.

Good site design and construction will have a positive impact on the site’s longevity, ease of operation, maintenance costs, environmental impacts and public/agency acceptance. The following sections detail the information, criteria and best practices that other jurisdictions have used at each stage of the process to implement a successful snow removal, storage and disposal program.

Planning

With each stage of the process building on the previous one, the initial planning and information gathering are

important. A standard environmental impact assessment approach to site selection should be followed. This involves:

- the determination of the snow disposal needs and ideal site characteristics
- the identification of candidate sites/technologies
- assessment of the potential environmental and operations implications of each site/technology
- evaluation of candidate sites/technologies
- selection of the preferred sites/technologies along with identification of strategies to control unavoidable impacts

Much of the information needed to carry out the planning process may already be available within the organization or with other agencies in your jurisdiction. Figure 1 shows the planning steps and the following discusses each of these steps.



Figure 1 – Site Selection and the Development Process

Needs Assessment

Before developing your snow disposal strategy it is important to understand how much snow you need to handle and the source areas. The needs assessment process involves the following:

- Determine or review the various snow removal locations and the volumes of snow that are typically removed. If possible include estimates for future snow removal locations due to road network expansion and possible use by private companies. Calculations should be based on both historical trends and worst-case scenarios. A five-year average is a good initial estimation of snow disposal requirements. The worst winter will also help to assess contingency or emergency needs. While it is not economical to have fully engineered sites for the worst-case scenario, it is important to plan for these winters.
- Determine the current cost of snow removal, storage and disposal. Include the costs to:
 - load/haul/dump to land sites, water sites (where permitted by regulations) or sewer chutes
 - melt snow (both stationary and mobile systems), and
 - maintain/repair/upgrade existing sites and dispose of waste materials.
- Determine the size of property needed. A snow disposal site must have an area sufficient to accommodate:
 - the anticipated volumes of snow
 - a site access/control facility
 - drive paths for heavy trucks allowing for simultaneous arrivals and departures and one-way circulation for safety and efficiency
 - a parking and re-fuelling area for on-site equipment (bulldozers, blowers, etc.)
 - temporary storage for large debris
 - berms around the perimeter
 - meltwater collection/ retention/ settling ponds
 - maintenance access
 - monitoring stations/sites, and
 - consideration for other uses if included or desirable.

- To address the capacity needs a road authority may wish to consider:
 - establishing one single large site or several smaller sites, and
 - using the vertical capacity of the site by piling the snow in layers, leveling and freezing each layer in succession, or blowing the snow into higher piles (intensive site management is required for these methods to be successful).

CANDIDATE SITE IDENTIFICATION

Once the needs and desirable service areas have been determined, a technology assessment should be done. For many projects these will be straightforward. Land disposal may be the only option. In other cases, snow melters, sewer chutes etc. may have merit and need to be evaluated.

It is unlikely that snow disposal can be adequately handled without land-based snow disposal sites. The following site selection process should be applied to both permanent and temporary sites:

- There will likely be a need for a variety of sites. This could include permanent sites to handle the snow disposal requirements of most years, and some temporary, contingency or emergency sites for the unusually bad years. The temporary sites would only be used in cases where the permanent sites become overloaded. Snow melters are a good way to accommodate the extra disposal capacity required for heavy snowfall winters.
- Many existing sites may have been established with little regard for the potential environmental issues. As well, historical sites may now be surrounded by incompatible land uses due to urban development. It is important to assess existing sites to determine their acceptability and ability to handle snow disposal needs. Unacceptable sites should be decommissioned and the search for additional capacity undertaken. Deficient sites will need to be upgraded to acceptable standards.
- Review public, agency and staff concerns with existing sites and develop a list of potential concerns that should be resolved during the planning and design process.

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- The search for new candidate sites should begin with an environmental scan using GIS and secondary source materials. Many agencies have environmental and land use data that can be compiled onto one constraint map. Such a map provides an excellent visual means for eliminating highly vulnerable areas from further consideration. The land base under consideration can be ranked on the basis of high, medium and low vulnerability. The process should go through a couple of iterations. The first is at a fairly high level and is intended to identify candidate areas where a more detailed site search will take place. This detailed search will be confined to areas with lower environmental risk and will use a finer level of detail. The criteria used in both searches may include:
 - surface water quality and quantity (including potential assimilative capacity)
 - site hydrogeology
 - location of groundwater recharge areas
 - location and nature of salt vulnerable areas including wetlands, sensitive vegetation, agricultural areas, drinking water supplies, shallow ponds etc., and
 - location of sensitive land uses such as residential, institutional and recreational areas.
- Involve the public and government agencies in the site selection process.
- The identification of potential temporary, contingency or emergency sites may focus on smaller more remote sites with natural features supporting the basic siting criteria such as:
 - soils with a low permeability
 - natural slopes with a ponding area
 - discharge to a high volume surface water receiver or sanitary sewer, and
- multiple use sites such as the parking lots of facilities that are not normally used in the winter can make excellent temporary snow disposal areas – particularly if combined with a snow melter.

ASSESSMENT AND EVALUATION

The assessment and evaluation process is iterative with increasing level of detail being used as sites are narrowed down.

Many of the same criteria are used for the evaluation of existing and new snow disposal sites. The following criteria should be considered as part of the assessment and evaluation process.

Snow Hauling Distances

The haul distance is an important criterion to consider when identifying candidate sites. Snow storage and disposal sites should be located as close as possible to the snow removal sites to minimize high snow hauling costs.

A useful approach is to draw concentric circles at 5 km intervals around each major source of snow to be hauled. The goal will be to identify sites that are closer to the sources of snow in order to reduce haul costs and impacts.

This may be less of an issue for temporary sites.

Snow Hauling Routes and Site Access

Snow hauling requires the use of dump or similar trucks and can significantly increase the heavy truck traffic along the routes taken to the snow disposal sites.

Noise and traffic levels and associated complaints may increase along routes through residential areas.

The heavy truck traffic could also significantly reduce the life expectancy of the roads.

The roads leading into and out of the sites and the site access will have to be planned and constructed to accommodate the increase in heavy truck traffic.

Potential haul routes should be plotted so that cycle times and operating costs can be computed. This will also help in assessing the potential community impacts of snow removal operations.

Past and Current Site Land Use

Certain land uses (e.g. wetlands, previously contaminated land and flood prone areas) are incompatible with snow storage and disposal sites and should be avoided.

The use of current and decommissioned solid waste disposal sites must be evaluated carefully. The leachate collection system could easily be overloaded by the addition of meltwater from the stored snow, resulting in the potential release of contaminated leachate.

Sites under electrical transmission lines should be avoided as the lines may interfere with dumping operations and limit the use of loaders, backhoes and snow blowers.

Sites above underground utilities should be avoided. Snow disposal over underground utilities can create significant repair and maintenance problems and the elevated chloride levels may accelerate corrosion.

Surrounding Land Use (Current and Future)

Certain surrounding land uses are incompatible with snow storage and disposal sites. Residential, institutional and year-round recreational land uses should be avoided.

Zoning

The land for the site may have to be acquired and re-zoned to accommodate a snow storage and disposal site. It is likely that any zoning approval will have site plan controls that address noise, dust, light and visual impacts.

The issue of ownership vs long-term leasing may have to be addressed. Because the soils at snow disposal sites can become contaminated, leases may come with a remediation requirement at the end of the term.

Permanent sites allow greater control over surrounding land uses. A temporary site may have to be closed prematurely if it becomes incompatible with future surrounding land use.

Sub-surface Conditions

The underlying soil and rock structures of the site are important features that affect the suitability and design of the site. Preference should be given to sites with low permeable soils with sufficient bearing capacity to handle year-round operation of heavy equipment.

Protection of water quality may be the most important and difficult of issues to address. Consideration should be given to:

- proximity to drinking and irrigation water sources (avoid possible contamination)
- proximity to surface water, downstream effects and the type of aquatic species present (avoid or minimize impacts), and
- meltwater discharge location:
 - When discharging meltwater into a surface water body the receiver must provide enough dilution all year round to protect the aquatic ecosystem. The potential receiver should be evaluated both on its historical flow rate and volume fluctuations and potential for future fluctuations, particularly lower flow periods.
 - Meltwater must not be discharged to salt vulnerable areas. An assessment of the potential impacts should be undertaken.
 - If ultimate discharge is into municipal sanitary system, ensure the treatment system can handle the additional flow and contaminants.
 - Avoid groundwater recharge areas and areas over shallow aquifers.

DESIGN, CONSTRUCTION AND IMPLEMENTATION

The design of snow disposal sites should address the following requirements:

- efficient site operation
- proper base construction
- drainage and meltwater management
- site security, and
- environmental controls.

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Temporary sites, by their nature, would likely not include some of the permanent infrastructure. However, the access, site management and environmental requirements would still apply. The following sub-sections discuss these requirements.

EFFICIENT SITE OPERATION

- Accessibility and onsite vehicle management (large trucks can access the site, maneuver and not get stuck) are important. The logistics of snow delivery, dumping, distribution and truck departures need to be carefully considered. Proper onsite and entrance signage should also be installed and maintained.

Truck Routes

- Roads used by trucks entering and leaving the site may have to be upgraded to handle the increase in heavy truck traffic and to provide room for trucks to wait for their turn to dump.
- Queuing lanes may be needed at the entrance depending on the ability of the site to handle the truck volumes.

Vehicle Management and Snow Loading Areas

- A significant amount of snow dumping occurs at night. Therefore, onsite vehicle management may be needed to avoid accidents and to control pile formation. Poles or moveable concrete barriers could be used to clearly mark the travel areas and actual snow disposal areas.
- To reduce nuisance noise from “vehicle reversing warning beepers” the layout of the site should attempt to minimize the requirements for trucks to back-up.

Access to Electrical Power

- Electrical power may be required at the gate as well as around the site for lighting, buildings, monitoring equipment and maintenance.

Permanent or Temporary onsite building

- An onsite building may be required for security personnel, for staff to monitor truck traffic and

loads and receive payments for private dumping (if permitted).

- Onsite staff comfort during winter months should be considered.

Accessible Monitoring Points and Monitoring Equipment (Year Round)

- For routine data collection.
- For maintenance purposes.

Maintenance Access for Collection, Treatment and Discharge Areas

- Routine clean out and repair of collection and treatment areas using heavy trucks and equipment.
- Periodic rehabilitation of discharge area may require the use of heavy equipment.

BASE CONSTRUCTION

- A good solid base is required to allow heavy trucks and graders to drive repeatedly over the wet ground without getting stuck or creating deep ruts that could divert or hold meltwater.
- The base must remain firm enough to support vehicle loads even after the frost has gone out of the ground.
- The base should have low permeability to protect groundwater resources.
- Where possible, the base for the snow pile should slope downwards to the north to take advantage of the sun melting the pile from south to north. The snow on the high (south) end melts first running under or around the piles to the meltwater collection facility. In this way, contaminants (sand, silt, litter, etc.) will remain up-stream of the pile and meltwater will not continuously flow across the materials previously released from the pile.
- Some agencies have designed the base with “V” ditches under the pile to channel meltwater to the collection pond.

DRAINAGE AND MELTWERter MANAGEMENT

- Site drainage and meltwater should be directed to a meltwater collection pond.
- Site meltwater should be directed away from the snow piles and dumping area to reduce ponding/rutting.
- The meltwater collection pond should be designed with an impermeable base, a forebay to collect litter and settle coarse sediments and a larger secondary area (polishing pond) to settle finer particles. An oil/grit separator should be placed in advance of the forebay to capture any oil and grease in the site drainage.
- Where local regulations permit dilution to meet regulated contaminant levels, uncontaminated site drainage and precipitation may be directed to the collection pond to provide dilution of the impacted meltwater. Otherwise, uncontaminated drainage should be isolated from the meltwater.
- The meltwater collection pond should be designed large enough to handle the expected meltwater volume, other site drainage and the periodic additional load from precipitation events.
- The outlet should be controlled to regulate the release to the receiving water body. The point of discharge should be protected to prevent scour.
- Adequate access to the pond needs to be provided to allow for periodic cleanout of sediments.
- The polishing pond should be designed to encourage complete circulation to avoid salt stratification and the potential for higher releases during wet weather flows.
- All required federal, provincial and municipal approvals, permits and licenses will have to be applied for, obtained and met.

SITE SECURITY AND ENVIRONMENTAL CONTROLS

The sites should be secured to avoid illegal dumping, prevent unauthorized access, by both humans and animals, for safety reasons and permit safe efficient operation of the site. Security and environmental considerations include:

- delineation of the site boundary using perimeter fencing with appropriate signage and a gate with controlled access
- provision of adequate lighting for operations, with the lights focused away from adjacent land uses, and
- providing low permeability berms (with or without trees) around the site to prevent uncontrolled offsite release of meltwater. These berms and additional landscaping can also mitigate noise, litter and visual impacts.

OPERATIONS AND MAINTENANCE

Once a site has been approved and commissioned for use, the following ongoing operational and maintenance issues should be addressed:

- site management
- snow pile and meltwater management, and
- off season (spring, summer and fall) maintenance.

Site Management

- Ensure that a single individual is assigned responsibility for the operation of the site; and is accountable for its operation and environmental performance.
- 24 hour security may be required to control unauthorized access and dumping (even during the off season).
- Vehicle management may be needed.
 - Night-time dumping may require onsite vehicle management to help prevent accidents and ensure dumping occurs in the correct location and follows prescribed safe dumping procedures. All dump trucks should lower the truck box prior to leaving the site to avoid contact with overhead power lines.
 - Hauling operations may have to be monitored periodically to ensure drivers are following the designated haul routes.
 - Increased vehicle management may be required later in the season, to limit the number of trucks onsite, as the site fills up with snow and maneuverability becomes an issue.

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- Discourage “tailgate banging” and, where possible, trucks backing-up to reduce the nuisance noise levels if adjacent to noise sensitive land uses.
- Large debris management.
 - With any snow removal and disposal operation a significant amount of large debris will be collected and dumped along with the snow.
 - Periodic collection and onsite storage of the large debris will be required. An appropriate offsite disposal area will have to be identified to eventually dispose of the large debris.
 - The types of large debris should be monitored and steps taken to avoid collection in the future. Marking or flagging of mailbox and newspaper box locations has proven successful in reducing the number inadvertently hauled away during snow removal operations.
- Litter control.
 - A significant amount of small, lightweight debris is normally collected and dumped along with the snow. This litter is blown around by the wind and can become a problem both on and off site.
 - Staff should collect litter regularly to prevent it from blowing onto adjacent properties.
 - The installation of a net or fence around the perimeter of a snow disposal facility can help contain the litter within the site.
 - Adjusting or re-scheduling garbage collection to avoid snow removal locations and times has helped reduce onsite litter in some jurisdictions.
- that site operations are safe, space is efficiently used and that the pile melts quickly enough to achieve complete melting while the receiving water body has high flow.
 - Minimize handling of the contaminated crust that forms on top of the piles.
 - Spread piles in the spring to increase area, breakup crust and maintain volume of melt water for early spring run.
- Equipment for pile management:
 - The pile can be managed using loaders, dozers or blowers to move, pile and breakup snow.
 - Blowers can be used onsite if it is known that the snow is free of large debris such as wood. If all the snow being delivered to the site was blown into the trucks then it is likely safe to use a blower onsite. Otherwise a bulldozer or loader should be considered.
- Proper and efficient pile melting is important to the smooth operation and long term stability of the site:
 - The snow must be completely melted as early in the spring as possible to allow for maximum dilution in the receiving area.
 - Weather data and long range forecasts can help predict current and future meltwater volumes and discharge rates.
 - Avoid discharging during the summer months when the receiving area cannot dilute it.
 - Meltwater must not become trapped or allowed to pond in the receiving area of the site.
 - Multi-use sites need to be cleared of snow and all debris before the off-winter use begins.
- Efficient flow of meltwater to the collection area must be maintained:
 - Rutting caused by heavy trucks must be kept to a minimum or repaired quickly.
 - Fast flowing, high volume channels of meltwater must not be allowed to develop near the piles to avoid excessive erosion and rutting of the driving and snow pile surface.
 - Sheet flow of meltwater under and near the piles is preferred.

**SNOW PILE AND MELT WATER
MANAGEMENT**

Traditionally snow was dumped and allowed to melt virtually undisturbed. A number of jurisdictions find it necessary to manage the snow piles to control or enhance melting.

- Pile management (dumping location, pile formation, pile melting management, etc.):
 - The snow pile needs to be managed to ensure

Off Season Maintenance

- Once the snow has completely melted any accumulated contaminants left behind will have to be carefully collected and properly disposed of.
- Check for and repair any damage to the access and haul route roads.
- Check for and repair any damage to the site surface and base and check the drainage channels for erosion.
- Summer/fall maintenance should include:
 - grass cutting on berms and around the collection and treatment areas
 - tree trimming
 - equipment check (lighting, monitoring, security, etc.) and general site repairs, and
 - animal control
 - o animals may come onsite to lick the contaminated residual salts
 - o beavers, muskrat, etc. can tunnel in and damage the pond and discharge receiving area, and
 - o ponds should be cleaned out when the capacity is reduced below the volume needed to handle the worst case year.

SALT VULNERABLE AREAS

To the extent possible, snow storage and disposal areas should be planned and located away from salt vulnerable areas. This requires sufficient investigations of potential sites to identify salt vulnerable areas and to factor them into the site selection and evaluation process. The best way to avoid salt vulnerable areas is by including them in the constraint mapping process discussed in the “Candidate Site Identification” section. Where salt vulnerable areas cannot be avoided, special design measures must be taken to prevent salt impacts.

MONITORING

Site monitoring is often the most neglected aspect of the operation. Site staff and users are more often concerned with hauling and dumping the snow (the

most visible cost) then with what happens in the piles and to the meltwater. Staff should monitor:

- what is brought onto the site (inputs)
- what is being discharged from the site (outputs)
- any onsite and downstream contamination and environmental impacts, and
- the operation of the site.

The following sub-section lists items and areas that may require on-going monitoring.

BASELINE CONDITION

- The baseline condition of the site and surrounding areas should be assessed as a benchmark against which future conditions can be compared.
- Test sites and holes drilled for benchmarking the site could be made permanent allowing future comparison data to be collected from the same locations.

SITE INPUTS

- The volume of snow dumped on the site. If the site is used for both public and private snow dumping, separate records for both public and private volumes should be kept including fees collected.
- Regular estimates of the volume of snow left onsite. An estimate of the melt rate may also be needed if there is a timing restriction for discharging into the receiver.

SITE OUTPUTS

- The volume of meltwater being discharged into the receiving area. The volume of flow in the receiving water body should be monitored to ensure it provides sufficient dilution of the discharge.
- The levels of chlorides and other contaminants in the discharge from the meltwater pond.
- The volume and type of large debris collected and sent for disposal.

Environmental Impacts

It must be recognized by all parties involved that snow disposal sites will have an impact on the environment. Most activities should be focused on minimizing or

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mitigating these impacts. Monitoring will aid in the determination of the extent of the impacts and effectiveness of the mitigation measures taken.

- Contaminant levels recorded once the site is operational can be compared to the benchmark levels established prior to the site opening to give a true indication of any environmental impacts.
- Contamination levels may be monitored at various points around the site and surrounding area. Various factors can affect the number and location of monitoring points including:
 - urban vs. rural location
 - intensity of site use
 - size of site, and
 - local requirements and sensitivities.
- Where warranted some or all of the following locations may be monitored:
 - beneath the site (groundwater and soil)
 - above and around the site (where air quality is an issue)
 - in the collected meltwater
 - at the discharge site and in the discharged melt water
 - upstream and downstream of the discharge site (in the receiving area or mixing zone), and
 - in the groundwater down gradient of the discharge site.
- There are numerous potential parameters that can be monitored. Some monitoring may be required due to local, provincial or federal regulations. Some land lease arrangements also require monitoring of specific contaminants. Below is a list of some of the important contaminants from a salt management perspective.
 - chloride
 - sodium
 - pH
 - metals
 - total petroleum hydrocarbons (TPH), and
 - suspended solids.

- Depending on the nature of road operations some road authorities may monitor other parameters such as other snow and ice control chemicals used on the road network.

Monitoring can be expensive and should be directed at addressing specific goals. If after monitoring some parameters it becomes clear that they are not relevant, then they should be discontinued.

Site Operation

- The efficiency and remaining capacity of the meltwater collection and treatment areas will have to be monitored. Over time the collection and treatment ponds will silt-up reducing their capacity and ability to handle the meltwater. Regular removal of the material that has settled out will significantly extend the life of the ponds and maintain their efficiency.
- The stability and condition of the snow storage and driving surface. If the surface deteriorates significantly, a site may become unusable until major repairs are done.
- A site that allows both public and private snow dumping may have to be monitored more closely:
 - Some jurisdictions have had problems with mixed load dumping (snow piled on top of waste fill or construction material). Mixed loads may not appear for some time as melting slowly exposes the foreign material.
 - Methods have been developed using transponders and Weigh In Motion (WIM) sensors that can automatically track private dumping volumes and associated fees.

RECORD KEEPING

Record keeping has become an important element in maintaining a snow disposal site. Snow disposal site records should be kept for:

- dealing with public and private complaints
- litigation and showing due diligence
- showing compliance with regulations and licensing
- providing information to regulatory agencies

- determining fees and payments
- improving general knowledge and understanding of the effectiveness of specific designs, and
- decommissioning and future sale of site.

The following lists items and issues for which records should be kept.

- General site information:
 - number of snow disposal sites and their capacity
 - percentage of snow disposal site with run-off collection and/or treatment system(s), and
 - percentage of snow disposal sites with a monitoring program (groundwater, surface soil, etc.).
- The volume of snow dumped and when it was dumped.
- An estimate of the melt rate:
 - Can use estimate of volume of snow left, flow into meltwater collection and treatment system or discharge volume.
 - A record of basic atmospheric data is useful in helping to determine the melting rates.
- Debris volume and type:
 - Some sites have instituted a lost and found so residents and businesses can retrieve items such as mailboxes, garbage cans, signs, etc.
- Contaminant monitoring records (point data, trends, levels, etc.):
 - Benchmark and contaminate monitoring data may need to be kept on file even after the site has been decommissioned.
 - Monitoring records may be subject to periodic audits and third party reviews and need to be kept.
 - Maintenance and operation records.
 - Regularly review site operations and look for ways to improve efficiency of dumping, pile management and melting.
 - Look for ways to reduce debris and litter by tracking type and source.
 - Good records provide an excellent source of information to aid in training new staff and passing on experience.

DECOMMISSIONING

The form and extent of the site remediation and decontamination will depend upon the level of contamination. The monitoring records in and around the site will help in designing the type and extent of decommissioning required. Local regulations for decommissioning contaminated sites will provide relevant cleanup criteria.

It should be noted that soil underlying retired snow disposal sites may fail local soil clean-up guidelines, particularly the Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC) parameters, and will need to be managed in accordance with local waste management regulations.

TRAINING

A good, thorough, ongoing training program for staff involved in managing the site is critical. It will help ensure the site:

- is operational when needed
- meets or exceeds its life expectancy, and
- minimizes the impact to the environment.

Refer to TAC's Salt Management Syntheses of Best Practices for Training and guidelines on developing training programs with an emphasis on Salt Management. Salt Management training for staff managing snow disposal sites should focus on five key areas or learning goals.

- Understanding how to manage the snow pile to facilitate melting.
- Understanding the measures to be applied to control nuisance effects such as:
 - noise from trucks and equipment
 - visual impacts such as dirty snow piles and vehicle and site lights from night time dumping
 - dust, and
 - litter and debris.
- Understanding how to monitor, and record the chloride, metals, pH, total petroleum hydrocarbons (TPH) and suspended solids in the meltwater discharges.

8.0 – SNOW STORAGE AND DISPOSAL

- Understand how the snow disposal system has to be managed to be cost effective and to reduce environmental and social impacts.
- Understand the importance of proper record keeping and how to complete the required documentation on snow received and quality of meltwater being discharged.

CONCLUSION

Snow storage and disposal sites are used to manage snow that must be removed from roadsides, sidewalks and parking lots in an environmentally responsible way. If these sites are properly located, designed and managed the adverse environmental effects will be controlled. Snow storage and disposal sites should be planned, designed, operated, maintained and decommissioned in accordance with this Synthesis of Best Practices. As well, staff responsible for managing these sites should be properly trained to ensure that the sites are operated in a safe, efficient and environmentally sound manner.

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