



*International **F**ederation of **M**unicipal **E**ngineering*  
*Fédération **I**nternationale des **I**ngénieries **M**unicipales*

# BEST PRACTICE IN WINTER MAINTENANCE



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# Best practices in Winter Maintenance

IFME: International Federation in Municipal Engineering  
[www.ifmeworld.org](http://www.ifmeworld.org)

IFME member countries that experience heavy winters have collaborated to share information and practices in winter road maintenance.

Member countries that have provided sections of the attached report include: Finland, Denmark, Estonia, Iceland, Norway, Sweden, USA and Canada.

Questions answered include background information on the winter conditions of each country, clearing and haulage of snow practices, anti-skid treatments, city planning and future approaches and prospects.

Download a copy of the report here: <http://www.ifmeworld.org/viewdocument/best-practice-in-win>

**Comments and corrections on the report are welcome. Contact [Ville Alatypko](#).**

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## Set of questions

- **General information about the country's winter conditions**
  - How many days with snow cover are there on average in a year?
  - What are the average snowfall and thickness of snow cover in a winter?
  - What is the length of a winter? (When is it counted to have begun and when to have ended?)
  - What kind of winter maintenance policy does the country have?
    - Are, for example, streets closed in severe snow situations?
- **Clearing and haulage of snow**
  - What are the action times and quality requirements of snow removal?
  - How many snow dump sites do you have?
  - Are sites close by used for storage of snow or is all snow hauled to snow dump sites?
  - How many loads have been hauled per winter?
- **Antiskid treatment**
  - What kind of salt and crushed stone are used for antiskid treatment?
  - In what kind of conditions is antiskid treatment (salt or crushed stone) used?
- **City planning**
  - What kind of planning solutions improving winter maintenance have been used in your city?
- **Future prospects**
  - cost efficiency
  - environmental friendliness

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# 1 Best Practices in Winter Maintenance in Finland

## 1.1 General Information about the Country's Winter Conditions

Helsinki, Finland's capital city, is located on the southern coast of Finland and winter conditions vary from snowless to very snowy winters. On average there are 101 days with snow cover per year in Helsinki. In the snowy winter of 2011 – 2012 there were 154 days with snow cover. Thermal winter usually begins towards the end of November and lasts until the latter half of March.

The average depth of snow in Helsinki in the past thirty years is about 40 cm. The average cumulative amount of snowfall is respectively about 100 cm.

Despite the snow, streets are not closed during winters and public transport routes are the first

priority. When required, in certain street sections the pavement on one side can be retained as a space for snow if pedestrian passage has been arranged on the other side. Residential streets are cleared of snow only after streets of public transport.

## 1.2 Clearing and Haulage of Snow

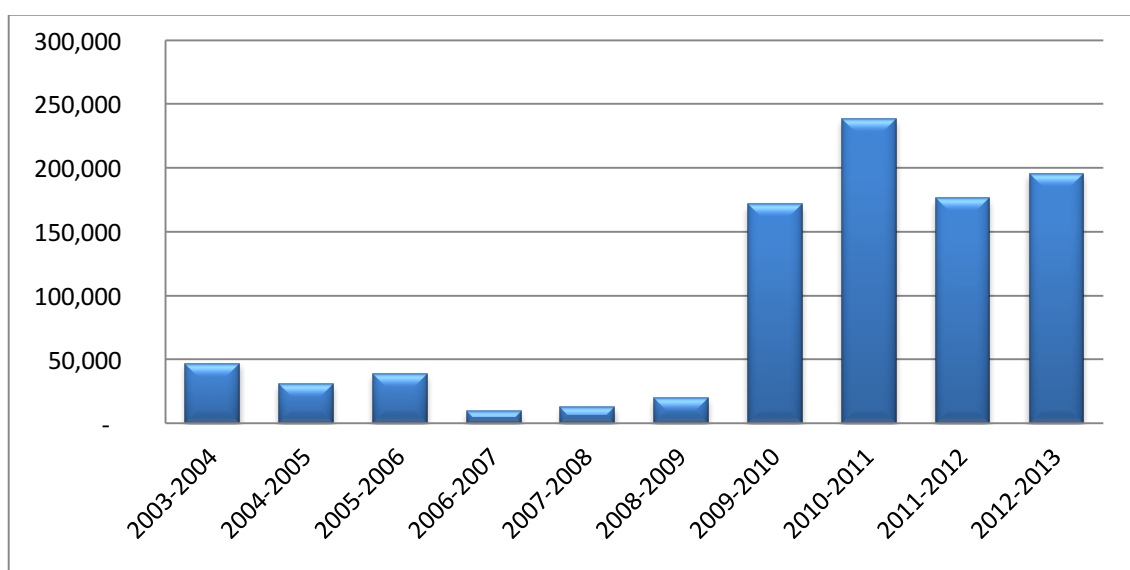
In Helsinki streets have been divided into three maintenance classes based on their urgency. Class I includes the main streets, class II the collector streets and class III the residential streets. There are separate quality requirements and action times for the maintenance classes for the removal of snow, slush and hard ridges of snow as well as for antiskid treatment. The table below presents the action times for clearing in different maintenance classes.

Maintenance class	Action time at daytime	Action time at night-time	Action during continuous snowfall	Action limit (thickness of snow layer / slush)
<b>Class I, carriageways</b>	3 hours	by 7 a.m.	carriageways to be kept trafficable	5 cm / 3 cm
<b>Class I, passageways</b>	4 hours	by 7 a.m.		5 cm / 3 cm
<b>Class II, carriageways</b>	4 hours	by 7 a.m.	carriageways to be kept trafficable	5 cm / 3 cm
<b>Class II, passageways</b>	4 hours	by 10 a.m.		5 cm / 3 cm
<b>Class III, carriageways</b>	3 weekdays	3 weekdays	-	7 cm / 5 cm
<b>Class III, passageways</b>	8 hours	by 12 noon		5 cm / 5cm

Haulage of snow to the snow dump sites is started when the spaces for snow in the streets and nearby places of removal get full. There are eight official snow dump sites in Helsinki. Of these one is a dump site by the sea, two are melting tanks and five land dump sites. At the dump site by the sea the snow is dumped from the pier straight into the sea. In the melting tanks the snow is melted by purified wastewater with a temperature of about 8

degrees centigrade that comes directly from a wastewater purification plant and the melt water is finally led to the sea. The capacity of official snow dump sites is 200 000 loads i.e. 3 000 000 m<sup>3</sup> (load size about 15 m<sup>3</sup>). In snowy winters it is possible to take into use standby dump sites totaling about twenty. In total there is room for approximately 300 000 loads of snow at the official dump sites and standby sites.

Figure 1 presents the number of snow loads hauled to official dump sites in the years 2003 - 2013.



**Figure 1. Hauled snow loads in 2003 - 2013**

Before haulage of snow to the dump sites is started, efforts are made to utilize as much as possible nearby snow piling sites that are e.g. unbuilt lots and park areas where snow can be piled from nearby areas and be left to melt.

### 1.3 Antiskid Treatment

In Helsinki salt treatment is used as antiskid treatment on class I and II carriageways and gritting is used on class III carriageways and passageways. In salt treatment either dampened chloride based salt or diluted salt is used so that the salt amounts can be kept low. Dry salt is not used, neither other than chloride-based deicers. On both carriageways and pavements wet-sieved crushed stone with a grain size of 2-5.6 mm is used as gritting material.

The skidding of carriageways is prevented in very slippery road conditions when black or wet ice occurs. Advance salt treatment is carried out before heavier snowfalls in order that the snow will not form a hard ridge.

Snow surface is gritted in places where it, due to traffic, wears smooth or is in danger of being worn smooth and very slippery as at stops, steep hills and in intersection areas. The base value of gritting is 150 g /m<sup>2</sup>. A carriageway or passageway with newly fallen loose snow, a surface cleared in below zero conditions or slush, does not have to be gritted. Routes reserved for pedestrian use are gritted over their entire lengths and over their available

widths. The slipperiness of zebra crossings must be prevented to suit pedestrian needs.

In Helsinki removal of gritting material and dust binding are also included in winter maintenance. The amount of street dust is actively monitored and on very dusty days special measures are taken to reduce dust. Removal of gritting sand is started immediately when the conditions allow it, usually in mid-April and it takes maximum six weeks. Dust binding is carried out with a ca. 5-10 % CaCl solution.

### 1.4 Preparing for the Winter

In 2011 The City of Helsinki has drawn up a winter maintenance preparation plan that has been implemented and updated in the recent years. The preparation plan is divided into two parts: a) preparing for the winter and b) preparing for an exceptional snow situation.

The first part defines which tasks shall be performed each year before the onset of winter. Performing these tasks on time as an annual continuous process every year ensures quick and smooth start-up of the snow work related to the first snowfall. Tasks included in the normal process of winter maintenance preparation include e.g. inspection of the contractors' winter maintenance plans, starting the monitoring of snow thickness, inspection of the snow dump sites, deciding on wintertime parking arrangements and drawing up a communication plan.

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The second part of the preparation plan includes the procedures and special actions resulting from abundant snowfall. Essential matters include defining the criteria for starting special actions and appointing the management group of special actions. The management group decides on the starting of possible special actions. Since special actions are not part of normal maintenance contracts, starting them also requires additional financing exceeding the approved budget. The resources of contractors are increased by all possible means.

Special actions are primarily focused on ensuring the smooth flow of public transport and functioning of the street network serving public safety in a manner and in the order specifically determined by the management group. Matters to be decided by the management group include e.g. focusing of special actions and the quality level of service, reinforcement of parking arrangements, vehicle removal operation and communication about situations.

## **1.5 City Planning**

### **Parking**

Street side parking is quite common in Finland. Street side parking slows down winter maintenance considerably. The City can move vehicles out of the way of maintenance provided that information about maintenance work has been given at least 48 hours before the work. Helsinki has invested in external communication in order that as many vehicle owners as possible would move their vehicles themselves.

Several big cities have started to build underground parking facilities in their centers, but the reason is rather the condensing urban structure than maintenance related considerations. However, people do not stop street side parking in the condensing urban structure and this exerts more pressure on the usability of parking places in the winter time, as well.

### **Snow storage sites / piling sites**

Finland does not have a generally accepted dimensioning method for the storage of snow. Hence, in practice, each city must resolve its intermediate and final storage sites on its own.

### **Snow logistics as a whole**

In Finland the calculated need for snow storage space has been determined for three different types of winter (light snow cover, average and abundant snow cover). With the balance figure of snow storage space we aim to obtain a realistic estimate by areas of the amount of snow that can be held and not be held in the street environment. If the snow cannot be held safely in the street area, it must be hauled to a snow dump site. Snow balance calculation can be used to assess the functioning of the entire snow logistics in different areas.

In Finland planning solutions improving winter maintenance have hardly been implemented at all. Details of the street environment that obstruct winter maintenance have been clarified. These details include e.g. bollards of traffic areas, narrow cross sections, sharp edges in the street structure etc. These issues can already in some way be taken into consideration in street planning, but not yet sufficiently.

Snow logistics also has an essential influence in reducing street dust. Helsinki has, together with other cities, studied the best practices of winter maintenance to control street dust in an EU-financed research project (REDUST). The project ends in 2013.

## **1.6 Future Prospects**

In Finland the condensing urban structure, environmental and operation reliability requirements and society's economic development are strongly focused on the snow logistics of cities. Snow may no longer be left on the street side for such a long time to wait for haulage away and the final snow storage sites are located increasingly far away. It is for these reasons that snow logistics must be improved and also the economic utilization of snow melting facilities is considered.

New snow treatment methods (regional snow loading by centrifugation, regional intermediate snow storage sites etc.) are gradually taken into use.

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## 2 Best Practices in Winter Maintenance in Iceland

### 2.1 General Information about the Country's Winter Conditions

Reykjavík is the capital city in Iceland. It is located on the south west coast of Iceland. Reykjavík has average 61,3 days of snow, but Akureyri (north of Iceland), the number is 100,3. Winter can vary from middle of October and lasts until late April.

Average of snowfall in Reykjavík is about 10 mm. In Akureyri the thickness is 22 mm.

Like in Finland, despite the snow, streets in Iceland are not closed during winter and public transport routes are the first priority. When required, in certain street sections the pavement on one side can be retained as a space for snow if pedestrian passage has been arranged on the other side. Residential streets are cleared of snow only after streets of public transport.

### 2.2 Clearing and Haulage of Snow

In Reykjavík, streets have been divided into four maintenance classes based on their urgency. Priority 1 includes the main streets, Priority 2 the collector streets, Priority 3 the through streets and Priority 4 are local streets.

There are separate quality requirements and action times for the maintenance priority for the removal of snow, slush and hard ridges of snow as well as for antiskid treatment. - The table below presents the action times for clearing in different maintenance priority.

This schedule for Reykjavík is:

**Priority 1:** Main streets and important connection roads, emergency service. Always.

**Priority 2:** Collector streets and bus routes. Always in the morning, then when needed.

**Priority 3:** Through street. Every other round, but only once per day.

**Priority 4:** Local street. When needed, when snow load is heavy or very icy.

**Priority B:** Parking.

**Priority G:** Sidewalks and bus station.

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Priority	Service time All day	Action time hrs.	Clearing time hrs.	First action / snow thickness cm	Max snow depth cm	Limited view. day
1	04 - 22	0,5	2	2	5	1
2	07 - 22	1,0	3	5	10	1
3	08 - 21	1,5	3	7	12	1
4	08 - 21				15	
B	08 - 17					
G1a	07 - 18	1,0	5/4			
G1	08 - 18	1,0	5/4			
G2	12 - 18	1,0	10/8			
G3	Within 24 hrs.					
G4	Clearing is later.					

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Sidewalks and biking routes are always cleared by certain priority:

**Service 1a:** Biking routes. Cleared from 04:00-07:30

**Service 1b:** Walking paths, priority. Cleared from kl. 04:00-08:00

**Service 2:** Walking path. Cleared from 04:00-12:00

**Service 3:** Sidewalks in local streets. Cleared when all above is cleared.

In Reykjavík, the action starts when the snow is about 2 cm. But that is where the streets have the highest priority. In streets with lower priority, when the snow is about 5 – 7 cm thick.

Cities in Iceland have average about 5 -7 dumpsite places. Almost every town in Iceland is located close to the sea. Usually, first action is to store the snow close by. Some storage

places are approved by the Health department. After the situation has been stabilized the snow is transferred further away and usually the snow is dumped in to the sea.

How many loads have been hauled per winter? This is different. Depends on how much snow there is every year. In South/West corner about 2 – 3 times. Up North this is much more. About 5 – 7 times.

## 2.3 Antiskid Treatment

In Reykjavík salt spreading is used as antiskid treatment on main roads, Priority 1 and Priority 2. For parking, sidewalk and smaller roads in towns, sand is used.

Requirements for salt is: grain distribution, NaCl, Kaliumferrocyanid, solubility in water and water content.

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### Grain distribution:

Thru sieve	Weight%
500 µm will go thru	0 - 10
1 mm will go thru	0 - 30
2 mm will go thru	20 - 65
4 mm will go thru	65 - 100
8 mm will go thru	95 - 100

### Solubility in water:

**Chemical composition:** NaCl  
..... Kaliumferrocyanid

### Water content:

min	97,0 %
min	95,0 % (solid)
min	100 ppm, max 200 ppm
max	4,0 %

No requirements are for appearance, but the salt should be free of foreign objects, grease and smell.

For some years, ursalt has been used on the highway. Ursalt is a salt that has been used in the fish industry. The salt is used three times to make bacalao (salted codfish). After that, it is no longer fit for use. Instead of disposing it, it can be used as an salt for antiskid treatment. The usage of ursalt is still on the experimental stage.

### Grain distribution for sand is 2-8mm.

When the forecast is snow or ice, the administrator gives orders. Within 30 min. action starts and is on and first passage is within 2 hrs.

First actions for antiskid treatment on main roads is salt. But in the condition when the temperature reaches x degrees then usage of salt is not possible.

Parking, sidewalks and local streets, sand is usually used.

The removal of gritting material starts immediately when the conditions allow it, middle of April.

## 2.4 Preparing for the winter

Winter maintenance is divided in to two categories roads vs. sidewalks.

The city of Reykjavík makes a contract with a contractor for winter maintenance on main

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roads and carriageways. The contract is for three years with possibility of extension. The inspectors make sure that all equipment is in order in the beginning of the winter season.

Different contract is made with a contractor for cleaning snow from sidewalks and biking routes. The contract is for one year with possibility of extension. The inspectors make sure that all equipment is in order in the beginning of the winter season.

## 2.5 City Planning

### Parking

Street side parking is quite common in Iceland. This slows down winter maintenance. But vehicles are left alone in the parking spot. Today in big private buildings, underground parking is part of the structure. Also, Reykjavík is the only city in Iceland that has built a underground parking facilities in the city center. This is because there is not too much parking space in the city Center.

When designing streets, the grass between street and sidewalk is thought as a storage for snow.

### Snow storage sites / piling sites

No planned snow storage sites are in Iceland. In Reykjavík the health department has approved their storage sites. The urban structure of street has been taken to consideration. Like sharp edges, structure, parking, etc.

### Snow logistics as a whole

In Iceland the winter can be very different from one year to the next. Storing sites are used if possible. Every city has it own plan for winter maintenance.

## 2.6 Future Prospects

The future in Reykjavík city is to lower cost in winter maintenance. That will be done by better usage of salt, better equipment's, better and more detailed plans etc. Snow is not left on the streets for long time.

Usage of more environmental equipment's in hauling the snow and in antiskid treatment. Also use more environmental materials in antiskid treatment to minimize pollution. Look in to more frequent street cleaning (dust). Ways to use ursalt, it is less expensive, no need to transport it long distances.



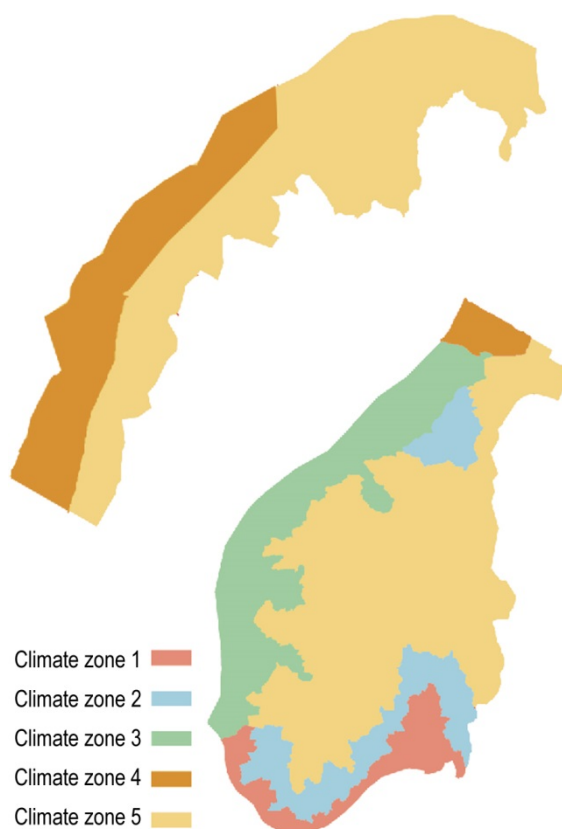
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## 3 Best Practices in Winter Maintenance in Norway

### 3.1 General Information about the Country's Winter Conditions

Norway has 428 municipalities in 19 counties through-out the country, which stretches 1700 kilometers from the southernmost to the northernmost point of mainland at 71 degrees north. Norway has a very long coastline with deep fjords and many islands. The most populated areas are the south-eastern lowlands (close to Oslo) and along the southern and western coast. The smallest municipalities have a population of 200, and the biggest, the capital Oslo, has a population of 620 000.

The climate varies very much according to latitude, height above sea-level and location east or west of the mountain-range along the middle of the country. Due to the Gulf-stream the climate along the coast is relatively mild compared with other parts of the world at the same latitude.



In the lowland east of the mountains the climate is drier with low winter-temperatures down to  $-20^{\circ}\text{C}$ , occasionally down to  $-30^{\circ}\text{C}$  and  $-40^{\circ}\text{C}$ . Along the coast the winter-temperatures often varies around  $0^{\circ}\text{C}$ , and rarely below  $-10^{\circ}\text{C}$ . But the western parts often have difficult winter conditions due to a lot of rain, snow and wind which changes rapidly. In addition, the moist climate along the sea often causes humidity to freeze to black ice on the roads. In recent years' problems with freezing rain and rain on frozen roads has become more frequent, especially in the eastern parts.

In the mountains there are many snowstorms during winter, increasing as you go further north. This causes roads crossing the mountains having to close or administering convoys for the vehicles to pass safely. Some roads in the mountains close for the winter. They are plowed in the spring when snow-falls and storms are less lightly.



Climate-zones					
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Number of winter, days	152	173	157	206	201
Snow-depth	41 cm	55 cm	41cm	63cm	72cm
Precipitation as snow	158 mm	225 mm	258 mm	332 mm	248 mm
Precipitation as rain	830 mm	734 mm	1,632 mm	860 mm	603 mm
Mean temp. Jan C°	-3	-6	0.7	-3.3	-7.8
Mean temp. March C°	1.1	-1.4	2.6	-1.6	-3.3

It is not possible to determine which local practice in winter maintenance is the best, as the whole country is populated and practices vary according to the local climate.

### 3.2 Clearing and Haulage of Snow

The Norwegian Public Roads Administration (NPRA) is responsible for all maintenance activities on national roads (10 580 km) and county roads (44 320 km). They use contractors that perform all kinds of maintenance according to a set of pre-defined qualities and standards. All national and county roads are classified according to traffic-volume and importance. Based on this classification they are maintained to different standards. The best standard (important national roads) is that

the road in general should be clear of snow and ice. Approximate 20 % of the total maintenance budget for national and county roads is connected to winter maintenance.

The municipalities are responsible for clearing of snow on the municipal roads (38 970 km). Many municipalities use contractors, and many combine contractors with their own work-force. Standards and configuration of contracts vary a lot. In general municipalities serve a lower standard The Norwegian Public Roads Administration, but the largest cities often provide the same level. In some regions it is a tradition that the municipal own and service the snow-clearing equipment that the contractors use on their tractors.



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## 4 Best Practices in Winter Maintenance in Sweden

### 4.1 General Information about the Country's Winter Conditions

Sweden has a population of a little over 9.8 million inhabitants, 290 municipalities and 21 counties. With an area of 447,435 square kilometers, Sweden is the fifth largest country in Europe, geographically.

All of Sweden experiences some kind of winter each year, but the climate provides for varying types of winter road conditions in different parts of the country. Within the discipline of meteorology one usually refers to averages experienced in the past to specify what is considered to be "normal". According to normal standards, winter starts around the second week of October in northern Sweden (Norrland), while it starts at the end of January in southern Sweden (Göteborg). The first day with snow cover will normally be the first week of October in the far North, but the second week of December in the far South. These are averages and the dates may vary from year to year. Maps for these normal, average values are available by visiting the SMHI website. (Swedish Meteorological and Hydrological Institute, [www.smhi.se](http://www.smhi.se).) A link for an English version is provided.

In addition to weather forecasting from media outlets, detailed information is also available through the Swedish Transportation Administration's (Trafikverket) official weather information system. It consists of 775 data stations measuring: surface temperature; air temperature; humidity; type and amount of precipitation; and wind speed and direction. Data stations are strategically placed where there is a serious risk of slipping. Individual municipalities may also arrange for tailored road weather services with individual weather companies. In recent years the winters have been both snowy and long in many parts of Sweden. The question has not been if extreme situations will occur but rather, when they will occur. The weather is never entirely predictable, but with this variety of weather

information systems and the extensive number of measuring points available to support the decision making process, Sweden has significantly increased prospects for successful snow removal and deicing.

### 4.2 Clearing and Haulage of Snow

Readiness is a very burdensome expense, and only by having the emergency response organization impose significant price pressure in contracts has Sweden been able to lower costs for winter road maintenance. Through this cooperation local governments are able to provide more winter maintenance activity overall and for less money.

Dispatch criteria for winter maintenance actions includes snow depth and the degree of cold snow versus wet snow, and vary across the country depending on standard conditions and the quality objectives of each municipality. There are often differentiated objectives for bus routes, downtown streets, pedestrian and bicycle paths, residential streets, and municipal property. A decision to dispatch is often difficult, particularly when it comes to choosing the extent of the operation, since there are many resources and large workforces to be activated. An example of a dispatch criteria is 2 cm of snow depth (1 mm of rain is approximately equal to 1 cm of snow depth) for pedestrian paths and stairs, 3 cm for bike lanes, and 4 cm for the streets. With sleet, the 2 cm criterion applies for all three instances, however.

Good visibility and accessibility to pedestrian paths and driving lanes is important so that pedestrians and vehicles can circulate safely. Hauling of the snow becomes necessary when windrows and snowbanks prevent visibility and accessibility, and when there is no more room for storage within the roadway area or adjacent land. Other reasons for removal may be that snow embankments pose danger to third parties or may cause damage to public or private property.

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After a long and snowy winter, the amount of snow hauled in major cities amounts to several hundred thousand cubic meters. The haulage of snow is therefore a costly endeavour for the requestor. It is important that storage facilities are available and marked on maps so that the hauler can quickly and effectively haul away the snow.

The transport of snow puts stress on the environment and the snow storage must be nearby in order to keep haul distances to reasonable levels. During a snowy winter, it is also common for snow dumps and landfills to be filled up long before the winter is over.

A dozen municipalities use the ocean, lakes, or other water systems for snow dumping. The issue is controversial and its reliability as a long-term strategy is also influenced by approvals for tipping in the ocean, lakes, or other water systems. Current tipping approvals are limited in duration and must be re-examined regularly. Seeking alternative solutions may be necessary in the future to come to grips with the problem.

Sundsvall's hospitals are using snow as a resource to produce cooling. The method is not new, but is very beneficial. The consumption of both refrigerants and electricity has declined significantly for the hospital and there is less impact on the environment as a result. The principle of snow-cooling is as simple as it is ingenious. During the winter the snow from the parking lot and surrounding streets is tipped in a large pit. In the spring, the pit is covered with insulating wood chips and when the snow slowly melts the cold water is pumped into the cooling system. Two heat exchangers lead the warmed water back into the pit which in turn melts more snow. Read more about the Sundsvall project at <http://www.snowpower.se> (Click the British flag in left top corner for English version.)

### 4.3 Antiskid Treatment

Anti-skid agents are usually divided into two groups: thawing and friction-enhancing. Among the thawing agents, road salt in various

forms is the most common. The direct friction-enhancing materials are dominated by sand and different types of crushed rock. Often a combination of friction-enhancing materials and a thawing agent is used; generally road salt and sand are mixed in these products.

For anti-skid agents, there are essentially two different methods of use: preventative and remedial. The preventative spread of road salt is carried out when ice has not yet been formed, but is expected to occur. The remedial spread of a thawing agent is done to melt already existing snow or ice on the roadway.

A method of using warm, wetted sand has been tested in recent winters for skid control on pedestrian and bike paths in Umeå. The Swedish National Road and Transport Research Institute (VTI) has evaluated the results of several tests in its Report No. 796 (2013) ([www.vti.se](http://www.vti.se)). The method uses a mix of coarse and fine sand mixed with scolding hot water at the moment of application. The effect will be that the sand adheres to the cold surface through a process of melting and freezing, providing an immediate friction-enhancing effect. The study of the application of warm, wetted sand is limited, and like traditional sanding, melting temperatures are a drawback. One of the conclusions of VTI's study is that the method can be good for separated pedestrian and bicycle paths. In regards to environmental impact, one should note that the wetted sand releases some smaller grains of sand into the air. Further study will include, among other things, the evaluation of the impact that warm wetted sanding has on air quality.

Research and development of possible alternative anti-skid agents is helping to reduce dependence on road salt. One of the methods that has comparatively less environmental impact is a sugar solution. Studies have shown that an admixture of sugar and road salt (glucose/saline) can reduce the use of road salt and has equal skid resistance to that of a saturated salt solution.

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When it comes to different types of heated roadways, energy consumption will most likely limit use if the strategy gains popularity in the future. While the development of heated roadways is in progress, a new technology that can be likened to geothermal energy, where the asphalt is used to generate heat, which is then stored for the cold season, is providing hope for more reasonable energy consumption.

#### 4.4 Preparing for the Winter

Some of the incidents and damage that occur each year is due to lack of routine inspection of the maintenance section and infrastructure prior to any snowfall. Accurate knowledge and thorough documentation of maintenance sections increases the safety for snow removal operators and road users who can be alerted to important conditions ahead. The operators are most effective if they are knowledgeable of the maintenance areas before the winter maintenance begins.

A typical example of some requirements set in a contract document for bidding winter road maintenance: "The contractor is required to orient themselves (survey) and have good knowledge of the conditions in the area to be maintained. This applies particularly to free heights at viaducts, confined spaces, special alignments of roads, gravel areas, curbs, widths, green space, controller cabinets, drainage structures adjacent to the pedestrian and bicycle tunnels." In the survey, in which the operator of the winter maintenance vehicle for the area shall be involved, and all damage and deficiencies shall be documented (preferably with GPS position on a map) and photographed. Documentation and photographs are to be submitted to the requestor no later than September 30. In conjunction with the survey, the contractor shall note any streets where the contractor determines that it will be difficult to address the full width, and a plan for how that can be handled. The report shall also address appropriate locations for snow storage in each district.

With the correct information, clearly identified geographically, the most is accomplished (won) in winter maintenance. It is important to review what and how to communicate between different groups in order to achieve a properly functioning system. Winter maintenance is a concern of not only the maintenance managers, operational leaders, communicators, and operators, but also to municipal administrators, local residents, and vendors. A municipality's winter budget, as is commonly known, is rarely sufficient to cater to all parties' requirements and wishes. Optimizing and communicating are critical.

The main groups involved in the winter maintenance communication are municipal governments, local residents and the performers (operators/contractors). These groups communicate in all directions, but to different extents. Communication can be roughly divided into two types: internal and external. Internal communication takes place between the Administration and the performer/s and external communication takes place between local authorities and local residents (users).

As a general rule, it is when the winter season starts that the complaints, and therefore the information needs, are the greatest. Therefore, it is important that the municipality is active early with up-to-date information on winter road maintenance.

Technical management of road maintenance includes many specialities. Knowledge of all aspects is important to assure effectiveness of work tasks. In small municipalities, many work alone with unanswered questions about winter maintenance and often face problems which are difficult to solve. It takes a long time to grasp the whole picture. It is important to have professional resources and a sounding board both inside and outside the municipality. Through collaboration and networking one can improve overall thinking and open up cross-border solutions.

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There are examples in Germany where local authorities successfully partnered on the purchase and storage of anti-skid materials to ensure sufficient access throughout the season. Before this partnering the salt suppliers criticized local authorities because they had too little storage capacity for salt, and consequently raised prices sharply for purchases during the winter season. The joint purchase and storage allowed for more salt to be purchased at reasonable prices.

#### 4.5 City Planning

Wisdom and creativity are needed to conserve resources for snow removal, snow storage, and snow tipping, not only for budgetary reasons, but also for land and environmental resource concerns. Creative work is fragile; gaining cooperation across municipal boundaries in free permissive forms is important.

To get maximum capacity in snow logistics as a whole, there is a need for an effective system of resource and route planning. A digital platform to track and record vehicles, workload, performance, and distribution routes is necessary for both management and client needs. The reports should be easy to read and an important consideration is which statistics, planning guidelines, and efficiency analyses one can get out of the system. Also, these operation logs provide a basis for: liability claims tied to flaws in winter road maintenance; invoicing of services; and comparative analysis. Such a system also reduces material consumption and reduces the set times. Hence the system quickly recoups the acquisition cost (i.e. pays for itself).

#### 4.6 Future Prospects

Briefly listed below are three current research and development projects on Swedish winter road practices.

Injured Pedestrians – The Cost of Pedestrian Injuries Compared to Winter Maintenance Costs.

By Gudrun Öberg and Anna K. Arvidsson. Research commissioned by the Swedish Association of Local Authorities and Regions (SALAR), conducted at the Swedish National Road and Transport Institute, Linköping. Report 2012.

Overall, the study shows that the cost to society for pedestrians injured as a result of snow and ice is about twice as high as the cost of winter maintenance. The municipality of Solna, is given as an example, where the hospital costs for pedestrian injuries was three times higher than the total cost of winter maintenance. Not included were injured that seek non-hospital health care or do not seek medical care for their injury at all.

The project's aim was to analyze if there is any difference whether it is the municipality or the property owner who conducts the winter maintenance, but was not answered, because there is insufficient data.

##### e-Adept, GPS for pedestrians

GPS for pedestrians is an applied project run by the Västra Götaland region. Coordinated by Torbjörn Lahrin, Astando AB. The project's main funders are PTS, the Stockholm City Accessibility Project, Trafikverket (the former National Road Administration, the Swedish Rail Administration) and the City of Malmö.

The end product will be a support for people with disabilities and the elderly, so that they can get out on their own and participate in society. The product should work the same way as a car navigation system but fixed for pedestrians. To create a GPS for pedestrians a digital pedestrian/road network is needed for the entire municipality or a test area, a test or implementation project, mobile phones and positioning devices, planning for the provision of server functions, and the establishment of user support.

Dust minimized operation and maintenance of paved roads – measures and strategies

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Gustafsson, Mats; Blomqvist, Göran and Jonsson, Per. VTI report 701, 2011. This project aims, among other things, to map the dimensions that are important for a road paving's dust forming properties, provide a systematic review of the effect of various operational measures to reduce the amount of inhalation particles and to formulate policy proposals to minimize dust in all road maintenance operations for Swedish conditions.

In summary, the following factors are important for PM10 (inhalable particulate matter) formation from winter sanding: the amount of sand spread and accumulated in the road environment; the size of the material fractions

(avoid small fractions); and the material fragmentation resistance and hardness.

High amounts of PM10 have been measured at the cleanup after the winter season. If winter sand is swept up, the amount of PM10 is reduced. Sweeping up as soon as possible after the season and seizing as much as possible of the output-laid material is recommended. The collected material can be reused. If winter conditions arise after the sweeping, it is appropriate to use MgCl<sub>2</sub> (magnesium chloride), SMA (calcium magnesium acetate), CaCl<sub>2</sub> (calcium chloride), or formate. These also work as dust suppressants. The risk of corrosion and environmental impact must be considered.

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## 5 Best Practices in Winter Maintenance in Estonia

### 5.1 General Information about the Country's Winter Conditions

Estonian capital Tallinn is situated on the southern coast of the Gulf of Finland. The distance from the nearest capital, Helsinki, is approximately 80 km so the weather conditions are quite similar.

In the course of the last decade, circulation of atmosphere in Northern Europe has changed a little. Although the distance between Helsinki and Tallinn is only 80 kilometres, the climatic conditions in the neighbouring capitals are somewhat different. In the winter, Tallinn faces cyclones from the West which bring warmth, humidity and precipitation in the form of slush

and rain. In Helsinki, on the other hand, winter weather is often dominated by the Northern cyclones from the Arctic Ocean, bringing dry cold air. In the Gulf of Finland, the ice cover always forms first on the Northern coast around the area of Helsinki, then on the Southern coast of the bay.

Last winter in Tallinn, compared to the previous ones, was exceptionally mild and lacking of snow. The daily temperatures did not fall permanently below zero until January 11, which is one and a half months later than average (November 19). The daily temperatures ascended above zero in February 22, which is three weeks earlier than average (March 14).

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Below are the numbers of days in Tallinn with snow cover:

	Oct	Nov	Dec	Jan	Feb	Mar
Winter 2012/13	6	4	31	31	28	31
Winter 2013/14	0	2	10	21	12	7
Median average 1971-2000	5	11	21	24	24	21

On an average year, permanent snow cover is on the ground from December 19 to March 9 when it starts to disintegrate. In winter 2013/14, snow cover duration in Tallinn was only 30 days.

Below is average thickness of snow cover in cm during the winter months in Tallinn:

	Oct	Nov	Dec	Jan	Feb	Mar
Winter 2012/13	2	2	21	7	23	29
Winter 2013/14	0	0	2	6	4	3
Median average 1971-2000	0	2	4	8	12	9

The maximum thickness of snow cover:

- 2013/2014 - 15 cm (measured on January 17)
- 2012/2013 – 35 cm (measured on March 5)

Throughout history, the greatest thickness of snow cover, 62 cm, was measured on 3 January 2010.

Below are the numbers of precipitation days:

	Nov	Dec	Jan	Feb	Mar
Winter 2012/13	11	11	8	10	5
Winter 2013/14	16	17	10	10	6
Median average 1971-2000	14	14	12	9	9

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In Tallinn, year-round cleaning of public transport streets and green areas, including winter maintenance, is organized by Tallinn

Municipal Engineering Services Department.  
Cleaning of the side streets and the streets of

internal quarters is organized by District governments.

Winter Maintenance is carried out by contractual partners that are pursued in public procurement procedure.

## 5.2 Clearing and Hauling of Snow

The streets of Tallinn are divided into four class categories:

- **Class 1** - side streets in a low-intensity. Some (up to 10 cm) snow and ice on the road surface is acceptable; de-icing is carried out only in hazardous locations.
- **Class 2** - side streets in a medium-intensity, internal residential streets. Some (up to 8 cm) snow and ice on the road surface is acceptable; de-icing is carried out over the whole route.
- **Class 3** - public transport streets, sidewalks and pavement running trails. Car trails must be kept snow- and ice-free; de-icing is carried out over the whole route.
- **Class 4** - high-intensity public transport streets, sidewalks and roadways. Completely snow- and ice-free; de-icing is carried out over the whole route.

The duration of maintenance cycle i.e. the period during which the required state level from the beginning of slickness and formation of snow must be ensured:

- **Class 1** - 36 hours for removing slush from roadway; 24 hours for de-icing; 12 hours for cleaning sidewalks.
- **Class 2** - 12 hours for removing slush from roadway; 8 hours for de-icing; 12 hours for cleaning sidewalks.
- **Class 3** - 5 hours for removing slush from roadway; 4 hours for de-icing; 8 hours for removing snow and salt mixture from carriageway
- **Class 4** - 2 hours for removing snow and slush from roadway; 6 hours for cleaning sidewalk and bicycle lanes, and de-icing.

Tallinn uses seven locations for hauling and storing snow. The deposit sites are evenly distributed throughout the territory of the city so that distance from cleaning sites is less than 5 km. Last winter, 1700 loads of snow was hauled; in 2012/13, the corresponding number was 4310.

Snow is cleared and hauled from public transport stops, intersections, bridges, and narrow streets used by public transport.

Since the streets of Tallinn Old Town are very narrow, snow is also regularly removed from there during the winter.

Tallinn has two Squares: Freedom Square and the City Hall Square - the snow is also carried away from both and granite splinters are used against slipperiness.

Number of snow loads (about 15 m<sup>3</sup> each) hauled in 2008-2014:

Period	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Loads	1870	14 270	40 600	1770	4310	1710

## 5.3 Antiskid Treatment

Tallinn uses salt treatment against slickness on roadways.

The objects of high priority antiskid treatment are public transport streets and street rises/hills. Slippery hills can cause kilometers of congestion, and because of the many cars, it is not possible to carry out a quick street salting. According to the agreement called "less than 20 minutes' hills maintenance", twenty minutes from the beginning of the snow or the

formation of skid is the expected time street rises need to be de-iced.

Next come pedestrian crossings at intersections and waiting areas for public transport stops. These streets belong to **Class 3** and **Class 4** categories.

Granite splinters are used in Old Town, sidewalks, bicycle routes and waiting areas for public transport stops, gravel splinter size 2-6 mm is allowed. The use of sand as an antiskid treatment is forbidden.

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In specific climatic conditions, it is acceptable to use a mixture of salt and granite splinters.

## **5.4 Preparing for the Winter**

Before each winter season, contractors submit their winter maintenance equipment and snow storage sites to be reviewed by representatives of the city.

In April 2014 - May 2014, Municipal Engineering Services Department is organizing a public procurement to find a long-term contractor for year-round street maintenance.

Each autumn before the season of winter maintenance, the curbs of roadways and sidewalks are inspected for nearby objects like flowerpots, benches, restriction rocks etc. To prevent breaking the winter maintenance equipment, these objects are shifted further from the curb to accommodate the snow ploughed from the roadway.

## **5.5 City Planning**

Around the areas of apartment buildings that were built around thirty years ago, car parking spaces were not established. Today, as the number of vehicles has multiplied, apartment societies in collaboration with city authorities have diligently started to expand parking areas around apartment buildings. This in turn has made the winter maintenance around these areas more complex and time-consuming.

New construction projects must receive an approbation from the maintenance division of the Municipal Engineering Services Department. Construction specifications must enable mechanical cleaning of the streets in winter.

### **Parking**

Street-side parking is problematic. In Old Town, winter parking regulations are set, by which the parking area is divided into two parts. During the winter, parking is prohibited in different areas on odd and even dates. Winter parking regulations are harsher because of the anticipated need for clearing the snow.

Although inhabitants and car owners are actively notified about these regulations by city authorities, there are still ones who disregard them, which makes clearing the snow very time-consuming.

### **Snow storage / piling sites**

The storing of the snow hauled from the streets demanded particular attention in the winter of 2010/2011. Tallinn used a total of eleven piling sites for snow, all evenly located within the city territory. To ensure the maximum capacity of the snow storage sites, snow was repositioned on sites. Because extremely low temperatures are rarely long-lasting in Tallinn, snow layering is not utilized for storage.

Seeing the overflow of snow on the streets, many estate owners even offered their free land to store the excess snow!

### **Snow logistics as a whole**

Every maintenance region of the city has its own snow deposit site.

The decision about need for haulage and the location of the site is made operatively in the maintenance location depending on each situation; it is possible due to the wide range of deposit sites.

## **5.6 Future Prospects**

For the sake of good upkeep of the city, it would be advised to arrange even capacious haulage of the snow. This in turn raises an issue of the capability to melt the deposited snow.

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## 6 Best Practices in Winter Maintenance in Denmark

### 6.1 General Information about the Country's Winter Conditions

Denmark has a coastal climate which means that the weather is primarily wet and cold, with many days of freezing wet roads, but only snowy a few days a year. The cold period is 21 November to 22 March. Daytime temperature is below 6 degrees on average in this period.

Different parts of Denmark are only one or two days a Year covered by snow in a snowstorm, until main roads and bridges are closed. This situation will only be of one or two days, but it can be winter with more than minus 5 degrees for one or two weeks every Year. Average snowfall and thickness of snow cover in a winter varies from 6,8 cm on average in January to a few cm the rest of the winter.

Mainly all roads are open all the Year around. The State is responsible for State Roads, and Municipalities are responsible for all other public roads. The winter maintenance differs from municipality to municipality, but mainly all public roads are open all the winter.

Municipalities has the right to prioritise. This means, that they give priority to the maintenance of more significant transport routes. The maintenance classification should be performed separately for vehicle traffic, and footways and cycle paths.

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### 6.2 Clearing and Haulage of Snow

Most winter maintenance are covered by salting, and it is very effective to keep roads, cycle routes and pedestrian areas free of snow and ice. Ploughing are only critical factors some shorter periods a Year.

Copenhagen's winter maintenance processes are among the most effective. The city lives up to its cycling city reputation in summer and winter, as the efficient and proactive use of salt prevents the cycle paths from icing over, keeping the cycling conditions safe throughout the year. Thanks to good winter maintenance, cycling is a quick and efficient alternative to other kinds of transport, even in the wintertime.

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### 6.3 Preparing for the Winter

Winter maintenance is mainly organized based on the weather conditions, which vary from municipality.

There is not a lot of snow in the winter, but slipperiness often causes problems. This means that most winter maintenance are covered by effective salting, and ploughing are only critical factors a few days some periods a Year. Most municipalities use salt, but some municipalities use sand together with a small amount of salt on minor roads I rural areas.



### 6.4 City Planning

Thanks to good winter maintenance, cycling is a quick and efficient sort of transport, even in the wintertime in many parts of Denmark.

But in cities, where bicycling policy are seen as a vital sort of transport, the have prioritized a network of routes to be maintained at a

particularly high maintenance quality level. The network is used to inform the citizens of the routes that are suitable for pedestrians and cyclists throughout the year, regardless of the weather. Cyclists and pedestrians must be sure that the route is always going to be safe to use.



### 6.5 Future Prospects

In Copenhagen, one of the top bicycling cities of the world, the transportation by bicycle covers up to 45 % of all journeys between the inhabitant's home and work or study places over the year. Copenhagen has set a goal of 50 % transport by bicycle and are planning and upgrading cycling conditions every year. The bicycle report says that more than 75 % of all Copenhageners feel safe when they cycle in Copenhagen, even during the winter.

Many municipalities have different goals for bicycling and are working hard to raise the level of bicycle transport all of the year.

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## 7 Best Practices in Winter Maintenance in USA & Canada

### 7.1 General Information about the City's Winter Conditions

#### 7.1.1 Ottawa, Canada

Ottawa is Canada's capital city and is located between Toronto and Montreal within the province of Ontario. Winter usually begins towards the middle of November and lasts until the end of March but winter weather monitoring and patrolling begins Oct 1 and extends to the end of April.

The yearly average snowfall over the last 25 years was 226cm and has varied between a minimum of 100cm and a maximum of 370cm. On average, there are 61 days of snowfall.

Temperatures throughout the winter season generally vary between -30°C and +5°C. The warmer temperatures result in some thawing during the winter season such that the 40yr average snow on ground is about 35cm. Additionally, with the warmer temperatures comes an average of 178mm of rain and 67 hours of freezing rain during the winter season. Freezing rain and flash freezes in particular present challenges for winter maintenance especially on sidewalks and residential roads.

#### 7.1.2 Fargo, North Dakota, USA

- How many days with snow cover are there on average in a year?  
110 days on average
- What are the average snowfall and thickness of snow cover in a winter?  
Average snowfall 40 inches,  
Average snow depth 11.8 inches
- What is the length of a winter? (When is it counted to have begun and when to have ended?)  
November 1<sup>st</sup> - April 15<sup>th</sup>.
- What kind of winter maintenance policy does the country have?  
In order to make the most efficient use of available resources, we have established priorities using the assumption that the severity of a storm is not beyond the normal capabilities of the City's snow removal resources. Depending on the nature of the snowstorm, changes in these policies can occur.  
The established priorities are as follows:
  - Arterials Primary Streets 1<sup>st</sup> Priority,

- Collector Secondary Streets 2<sup>nd</sup> Priority,
- Residential Streets 3<sup>rd</sup> Priority,
- Alleys 4<sup>th</sup> Priority,
- Downtown Snow Hauling 5<sup>th</sup> Priority,
- Hauling of Arterials, Collectors and Residential Streets as needed 6<sup>th</sup> Priority.

#### 7.1.3 Ministry of Transportation, Province of Ontario, Canada

- How many days with snow cover are there on average in a year?  
150 days on average
- What are the average snowfall and thickness of snow cover in a winter?  
Average snowfall 150 cm. Average snow depth 25 cm
- What is the length of a winter? (When is it counted to have begun and when to have ended?)  
October 15-April 15 in the south part of the province, Sept 15-May 15 in the north
- What kind of winter maintenance policy does the country have?
  - Are for example streets closed in severe snow situations?

There are five categories of winter maintenance service. Categories describe the time allowed to begin operations, plowing and salting circuit times, and the maximum time allowed to restore bare pavement after a storm. Maximum allowable depth of snow is implied by circuit time and average snowfall rate – 90% of storms are less than 2cm per hour. The standards are based on performance rather than on details of how the work is done. The highway categories are discriminated by traffic volume.

### 7.2 Clearing and Haulage of Snow

#### 7.2.1 Ottawa, Canada

In Ontario, the provincial government enacted legislation in 2002 that defined the Minimum Maintenance Standard ([MMS](#)) for Roads including snow clearing, ice prevention, patrolling, and weather monitoring. However, prior to the creation of the MMS, the City of Ottawa amalgamated twelve municipalities in January 2001 and as part of that process

approved its own Maintenance Quality Standard (MQS). Relative to the MMS, the MQS provides for a higher level of service through immediate deployment of equipment (anti-icing), reduced times to clear snow and treat icy conditions (eg 4h vs 12h for class 3 roads), and a bare pavement treatment

standard that encourages salting operations over alternatives such as sanding. Like the MMS, the MQS road classes are based upon AADT and posted speed limits but with a slightly different weighting scheme. Winter maintenance response is the same for day or night operations.

Road Maintenance Class	Road Type	Minimum Depth of Snow Accumulation for Deployment of Resources (Depth as per MMSMH)	Time to Clear Snow Accumulation From the End of Snow Accumulation or Time to Treat Icy Conditions (Time as per MMSMH)	Treatment Standard		
				Bare Pavement	Centre Lane	Snow Packed
1	A	High Priority Roads	2 h (3-4 h)	✓		
	B			✓		
2	A	Most Arterials	3 h (3-6 h)	✓		
	B			✓		
3	A	Most Major Collectors	4 h (8-12 h)	✓		
	B			✓		
4	A	Most Minor Collectors	6 h (12-16 h)	✓		
	B				✓	
	C					✓
5	A, C	Residential Roads and Lanes	7 cm (10 cm)			✓
	B		10 cm (not defined)			✓

Notes: - Refer to Table 101.01.01 for description of road maintenance classes.  
- MMSMH refers to Ontario Regulation 239/02, Minimum Maintenance Standards for Municipal Highways.

City of Ottawa Maintenance Quality Standard vs MMS – Roadway Clearing

Clearing of highways, arterials and collectors begins as soon as accumulation starts. Residential roads are cleared after 7cm of snow accumulation. The City of Ottawa enacts a bylaw restricting on-street parking whenever a 7cm snow accumulation is forecasted to help ensure the efficient clearing of snow. The City of Ottawa also conducts snow clearing and treatment of sidewalks and pathways according to the Maintenance Quality Standards.

Snow Removal (haulage) to snow disposal facilities is started when the encroachment of the snow banks either impedes traffic or creates a safety hazard for sightlines or roadway flooding in accordance with the City's Maintenance Quality Standards. The minimum cleared widths and times are shown in the following table for each class of road.

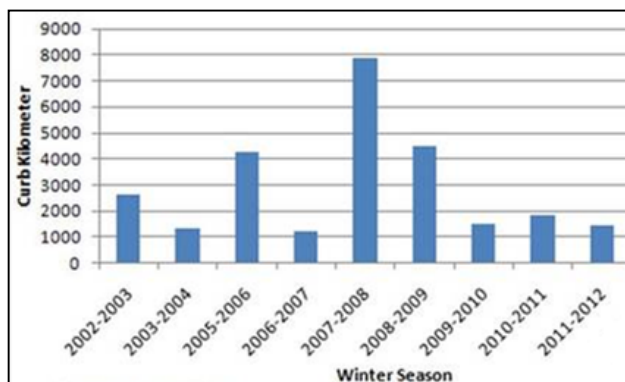
Road Maintenance Class		Road Type	Minimum Cleared Width	Time
1	A	High Priority Roads	No encroachment onto travel lanes	16 hours
	B			2 days
2	A, B	Most Arterials	Encroachment not to reduce width of any travel lane less than 3.3 m.	2 days
3	A, B	Most Major Collectors	<ul style="list-style-type: none"> <li>Where a parking lane is provided, a clear width of 2.2 m is to be maintained.</li> <li>Streets with high parking permit demand, or with meters or taxi stands on both sides are to have two parking lanes with a clear width of 2.2 m each.</li> <li>Roads with ditches and no curbs that have posted speeds greater than 60 km/hr are to have two parking/shoulder lanes with a clear width of 2.2 m each, where possible.</li> </ul>	8 days
4	A, B, C	Most Minor Collectors	Encroachment not to reduce clear width less than 6.0 m (2 lanes of 3.0 m). <ul style="list-style-type: none"> <li>On streets with high parking permit demand, or with meters or taxi stands on both sides, the clear width is to be 8.2 m.</li> </ul>	14 days
5	A, C	Residential Roads and Lanes	Encroachment not to reduce clear width less than 5.0 m (2.8 m travel lane plus 2.2 m parking lane). <ul style="list-style-type: none"> <li>On streets with high parking permit demand, or with meters or taxi stands on both sides, the clear width is not to be less than 7.2 m (2.8 m travel lane plus 2 parking lanes of 2.2 m each).</li> </ul>	14 days
	B		Encroachment not to reduce clear width less than 2.5 m.	

*Notes: - Refer to Table 101.01.01 for description of road maintenance classes.*

#### City of Ottawa Maintenance Quality Standard – Snow Removal

There are eight primary snow disposal sites operated by the City of Ottawa. Four are located in the urban area and four in suburban areas. All are land sites with a total cumulative capacity of 3.15 million cubic metres. Six are fully engineered sites with collection ponds, lighting, and paved surfaces and receive about 97% of all removed snow. Melting is generally accomplished naturally over the summer months. Water quality is monitored at all sites in accordance with requirements from the Ministry of the Environment.

Snow is hauled using trucks varying from 9m<sup>3</sup> single axle dump trucks to 41m<sup>3</sup> semi-trailers. Due to the variability in truck capacity, the number of hauled loads is not typically used as a performance metric. Instead, the quantity of snow hauled in cubic metres is shown in the table below for the past six winter seasons as well as the snowfall.



City of Ottawa Curb Meters of Removal by Season

	SnowFall (cm)	Total
Design/Average	236	1,500,000
2007/2008	437	3,772,000
2008/2009	225	2,700,000
2009/2010	138	970,000
2010/2011	171	658,000
2011/2012	108	811,000
2012/2013	250	2,105,000

City of Ottawa Cubic Meters of Removal by Season

### 7.2.2 Fargo, North Dakota, USA

- What are the action times and quality requirements of snow removal?  
The depth and timing of snow accumulation, weather forecasts and traffic volumes, will normally dictate when snow plowing operations will begin. Plowing will take place when the level of snow received has reached a point in which travel is being negatively impacted. Generally when snow accumulation has reached 1 inch in depth plowing will begin.
- How many snow dump sites do you have?  
We have four snow dump storage locations.
- Are sites close by used for storage of snow or is all snow hauled to snow dump sites?  
Any and all snow that is hauled is transported to the snow dump storage sites.
- How many loads have been hauled per winter?  
On average, approximately 18,000 loads of snow are hauled to the snow dump storage sites.
- What are the action times and quality requirements of snow removal?

### 7.2.3 Ministry of Transportation, Province of Ontario, Canada

Plowing begins when snow depth accumulates to 2.0 cm, salting begins when snow begins to accumulate, circuit times vary from 1.3 to 10 hours depending on highway class.

- How many snow dump sites do you have?  
Snow is plowed toward and off the right shoulder. It is normally not transported

away from the highway to a dump site. If snow needs to be moved from the right of way, environmentally acceptable sites are used.

- Are sites close by used for storage of snow or is all snow hauled to snow dump sites?  
Plowed snow is stored within the highway right-of-way.
- How many loads have been hauled per winter? 0

## 7.3 Antiskid Treatment

### 7.3.1 Ottawa, Canada

In Ottawa, salting is used on roads requiring bare pavement or centre-bare treatment standards (highway, arterial and collector roads) and abrasives (grit or sand) is used on snow packed treatment standard roads (residential). Gritting/sanding may alternatively be used when temperatures are too cold for the effective use of salt.

Application rates are selected based on the forecasted road temperature and precipitation/weather event as shown in the table below. A network of road weather information systems (RWIS), contracted weather forecasting services, and vehicle based infrared thermometers are used to provide accurate estimates of weather timing and intensity and treatment effectiveness. Salting rates are reduced by 20% when wetting the salt using a winter liquid such as Calcium Chloride.

MATERIAL APPLICATION POLICY					
BARE PAVEMENT					
Pavement Temperature °C	Material	Frost and Black Ice Kg/2-lane km	Light Snow <1cm/hr Kg/2-lane km	Heavy Snow >1cm/hr Kg/2-lane km	Freezing Rain Kg/2-lane km
0 to -5°C	DRY SALT	70	100	140	230
	WET SALT	55	80	110	185
-5 to -10°C	DRY SALT	85	140	180	230
	WET SALT	70	110	145	185
-10 to -18°C	DRY SALT	85	180	230	230
	WET SALT	70	145	185	185
< -18°C*	ABRASIVE	350	350	350	-

City of Ottawa Salting, Bare Pavement, Variable Application Rates

Advance salt treatment is carried out for the majority of the salting operation by sizing the equipment and staff resources to permit treatment as soon as accumulation begins. Rock salt used is coarse crushed with grain size averaging around 2.5mm.

Abrasives are used where required on snow packed streets to provide traction. Grit is typically used in urban areas and sand in rural areas. Grit is dark, coarse, crushed aggregate with a grain size mainly between 0.6 and 2.5mm. The grain size of sand is less than 1mm. Both products are produced from local private quarries.

Street sweeping and summer dust suppressing are also conducted by the Roads branch. Sweeping is started immediately when the conditions allow it, usually by early April. Operations are initially concentrated in the urban centre and spread outwards.

### 7.3.2 Fargo, North Dakota, USA

- What kind of salt and crushed stone are used for antiskid treatment?  
Bulk Highway De-icing Salt that meets the following physical composition is used:
  1. Gradation
    - a. Passing a 1/2 inch (12.5 mm) sieve 99 to 100%
    - b. Passing a 3/8 inch (9.5 mm) sieve 88 to 100%
    - c. Passing a No.4 (4.75 mm) sieve 20 to 90%
    - d. Passing a No. 8 (2.36 mm) sieve 10 to 60%
    - e. Passing a No. 30 (600 um) sieve 0 to 15%
  2. The deicing salt shall arrive in a free flowing and usable condition.
  3. Reclaimed or re-crushed rock salt will not be accepted.
  4. Any shipments of deicing salt which are delivered in a frozen or caked condition, or which contains free water will be rejected.
  5. The sodium chloride content shall be not less than 95.0 percent.

Liquid Anti-Icing products meeting the following specification are used:

Salt Brine 23.3% salt/76.7% water

Agricultural Based Liquid meeting the following specifications:

#### GENERAL DESCRIPTION

1. Shall be a natural, agricultural, renewable resource that is derived from the sugar beet plant or approved equal that is less corrosive than traditional chlorides and is less harmful to the environment
2. Should improve the ice melting ability and help prevent ice hard pack from bonding to the road surface
3. Biodegradable and non-toxic to humans, animals, and aquatic life
4. Acceptable for use as a corrosion inhibitor for salt brines and thus able to be blended with all salt solutions without stratification at any time
5. Able to be used as an admix for salt stockpile mixing to prevent freezing of the pile without leaching when blended at a 1 to 1 ratio with salt brine and applied at the rate recommended by the manufacturer

#### TYPICAL PROPERTIES

1. Freeze point of at least -6 to -20° F
2. Minimum viscosity of 30 cP at 25° F
3. Minimum concentration of 62% solids and 16% sugar level
4. Maximum of 1% chloride and any chloride present must be naturally occurring in the product
5. Specific Gravity 1.275 ± .05  
Pounds per Gallon 10.6 ± .4  
PH 6-9  
Water Miscibility Completeb

An 80% Fine Washed Aggregate/20% Salt mixture is used when temperatures restrict the use of straight salt.

- In what kind of conditions is antiskid treatment (salt or crushed stone) used?

Pre-wetted salt (12 gallons per ton, 50% Salt Brine/50% Carbohydrate Enhancer) is applied at 200 pounds per lane mile on paved street surfaces as needed down to temperatures of 10°F. When temperatures fall below 10°F paved road surfaces are treated as needed with 800 pounds per lane mile. The sand/salt mixture that is also pre-wetted at the spinner to limit bounce and scatter.

Prior to snow event primary and secondary routes are anti-iced with liquids as follows:

Anti-Ice Application Guidelines:					
PAVEMENT	APPLICATION OPERATION				
<i>Surface Temperature</i>	<i>Pavement Surface Conditions</i>	<i>Weather Conditions</i>	<i>Application Action</i>	<i>Liquid Application Rates (Gal/Lane Mile)</i>	<i>Comments</i>
Above 32° F, (Temp. is Steady or Rising)	Dry	Clear	Apply Salt Brine	54	
20° - 32° F,	Dry	Clear	Apply Blend 90% Salt Brine 10% Carbohydrate Enhancer.	54	
20° - 32° F,	Dry	Light Snow/Wind Speed < 15 mph With No BS	Apply Blend 90% Salt Brine 10% Carbohydrate Enhancer.	54	
20° - 32° F,	Dry	Light Snow/Wind Speed > 15 mph With Visible BS	Do not Apply Liquids	0	
14° - 20° F,	Dry	Clear	Apply Blend 85% Salt Brine 15% Carbohydrate Enhancer.	54	
14° - 20° F,	Dry	Light Snow/Wind Speed < 15 mph With No BS	Apply Blend 85% Salt Brine 15% Carbohydrate Enhancer.	54	
14° - 20° F,	Dry	Light Snow/Wind Speed > 15 mph With Visible BS	Do not Apply Liquids	0	
8° - 14° F,	Dry	Clear	Apply Blend 80% Salt Brine 20% Carbohydrate Enhancer.	54	
8° - 14° F,	Dry	Light Snow/Wind Speed < 15 mph With No BS	Apply Blend 80% Salt Brine 20% Carbohydrate Enhancer.	54	
8° - 14° F,	Dry	Light Snow/Wind Speed > 15 mph With Visible BS	Do not Apply Liquids	0	
Below 8° F,	Dry	Clear	Do not Apply Liquids	0	

### 7.3.3 Ministry of Transportation, Province of Ontario, Canada

- What kind of salt and crushed stone are used for antiskid treatment?  
Rock salt is used down to temperatures of -18°C, after first plowing loose snow. In some cases liquid salts are added to rock salt, normally at 5% by mass. Anti-icing liquid without rock salt is applied in advance of snow accumulation on high traffic freeways when temperatures are expected to remain above -7°C.
- In what kind of conditions is antiskid treatment (salt or crushed stone) used?  
Winter sand is applied when temperatures are too cold for salt to be effective at providing bare pavement, and on Class 5 low-volume highways where a driveable snow packed surface is maintained all winter.
- If you would like to receive the specification for salt and winter sand, let us know.

## 7.4 Preparing for the winter

### 7.4.1 Ottawa, Canada

Preparing for winter is a continuous process including many activities that are started during

the previous spring. Contracts for materials, equipment and services are ushered through competitive tendering. The yearly salt management report is submitted to Environment Canada and summer water quality monitoring is started. Bases at snow disposal areas are repaired. Administration, vehicle and material facilities are repaired as well as weather stations as required.

As the winter season approaches, typical preparations include the stock piling of materials, life-cycle replacement of equipment, updating policies and beats, spreader calibration, training, filling vacant positions, snow fence installation, contractor vehicle inspections, and preparing contact lists and communication plans. Other activities include marking the location of fire hydrants and road culverts, and auditing corn fences left in the rural areas to mitigate blowing snow.



During exceptional weather events, Roads management meet centrally with other branch

representatives including emergency responders to ensure efforts are coordinated City wide. The traffic control centre provides access to cameras across the City, weather forecasting, and GPS locations of fleet vehicles whereby mobility and safety issues can quickly be identified and efficiently resolved.



City of Ottawa Traffic Control Centre

The City of Ottawa regularly reviews its winter maintenance policies within the context of emergency planning and climate change to ensure it meets the challenges presented by extreme weather. Best efforts are used to achieve its approved Maintenance Quality Standards even during extreme events such as the 1998 ice storm and high snowfall years such as 2007/08.

#### 7.4.2 Fargo, North Dakota, USA



City of Ottawa Typical Suburban Street

## 7.5 City Planning

### 7.5.1 Ottawa, Canada

#### Parking

Street side parking is quite common in Ottawa. To alleviate the impacts on snow clearing operations, the City of Ottawa enacts a bylaw restricting on-street parking whenever a 7cm snow accumulation is forecasted. This helps ensure the efficient clearing of snow, especially on residential roads. Cars parked in violation of the bylaw may be ticketed and towed. In areas with high parking demand, on-street parking permits can be obtained that exempt vehicles from the by-law.



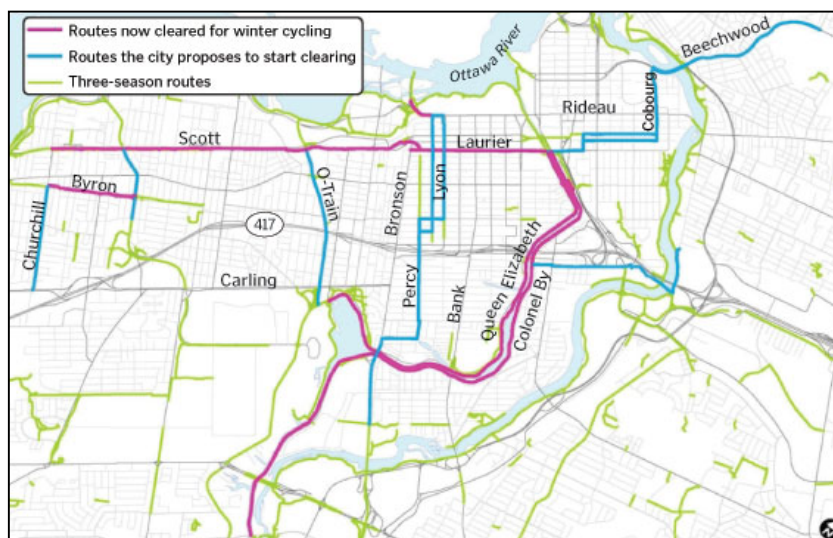
During snow removal operations, temporary no-parking signs are placed along the road segments where removal is planned. The restriction applies to all vehicles, including those with on-street parking permits.

#### Snow Storage

The goals of intensification and planning to mitigate urban sprawl often create challenges for winter road maintenance operations. Policies that tend towards narrow lots, reduced house setbacks, wide driveways, and abutting sidewalks have resulted in less on-street snow storage capacity and increased snow removal operations.

## Cycling

The City of Ottawa continues to promote cycling as a lifestyle and viable commuting option through infrastructure investments such as dedicated bike lanes and paved shoulders. A recent initiative has additionally created a plan to support winter cycling through enhanced clearing and removal operations on specific routes.

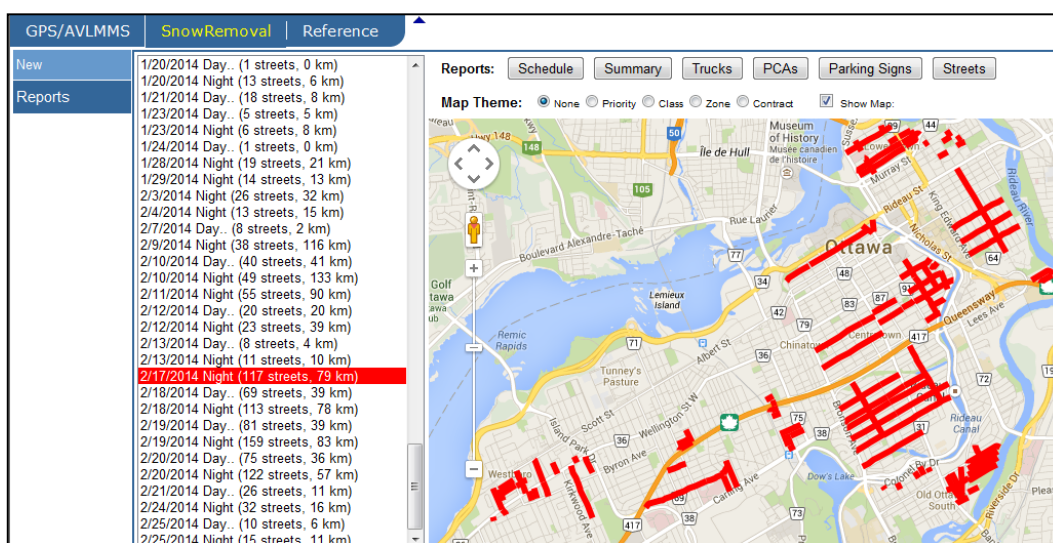


City of Ottawa Winter Cycling Network

## Winter Logistics

The City of Ottawa categorizes each street into one of three snow removal frequencies based upon a calculated snow balance factor that considers the road maintenance class (ie clear width required) and available storage space.

Therefore similar snowfall conditions trigger removals on similar functioning streets when snow exceeds on-street storage capabilities. Selection, scheduling and tracking of snow removal operations are accomplished using scheduling software.



City of Ottawa Snow Removal Scheduling and Reporting System

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While a process is in place for each new development application to be circulated through infrastructure and public works branches for comment, planning solutions on the whole often concede winter maintenance requirements to other priorities. Recently, targets to increase the urban tree canopy have started to create policies that also benefit winter maintenance operations since the space and volume requirements for road-side trees also result in winter time snow storage space.

### 7.5.2 Fargo, North Dakota, USA

Implementation of a Snow and Ice Control Procedures manual that calls out established service levels in respect to the management of snow or ice and maintenance of road systems during the winter months.

Parking is prohibited on all Primary Snow Removal Routes.

Seasonal night parking restrictions are in place from November 1 through April 15 which restricts parking on the street between 1 a.m. and 7 a.m. These night parking restrictions apply on alternate days as follows:

- Monday, Wednesday, Friday and Sunday  
East/West Avenues No Parking
- Tuesday, Thursday and Saturday  
North/South Streets No parking

Seasonal parking restrictions also limit parking to one side of the street or avenue as indicated by signing from November 1 through April 15.

Central Business District overnight parking restrictions are in place year round between the hours of 2 a.m. and 7a.m. as follows:

- Monday, Wednesday, Friday and Sunday  
East/West Avenues No Parking
- Tuesday, Thursday and Saturday  
North/South Streets No parking

### 7.5.3 Ministry of Transportation, Province of Ontario, Canada

- What kind of planning solutions improving winter maintenance have been used in your city?  
Winter Class system that defines performance standards for each road class.

Snow drift control infrastructure (snow fences, hedges, snow storage ditches, free-flow profile) is installed on approximately 150 km of the ~16,000 centre-line km highway system.

A network of 139 road weather information stations is used to provide advance warning of winter conditions to highway maintenance crews and to help them select the best treatment type and schedule.

Winter maintenance services are provided through turn-key contracts of 10 years+ duration, with fixed, lump-sum annual payments.

Winter driving conditions are reported to the public through a web-site and free '511' telephone service.

## 7.6 Future Prospects

### 7.6.1 Ottawa, Canada

Through OMBI, OGRA and other organizations representing the interests of municipalities in Ontario, initiatives to benchmark, share experiences, and improve legislation result in united efforts and consistent policies regarding winter maintenance. The outcome is improved services, cost effectiveness, and environmental stewardship.

### 7.6.2 Fargo, North Dakota, USA

- cost efficiency:
  - In place snow melting vs. haul and store,
  - Installation of in ground snow melter at current snow storage locations vs. acquisition of additional property for snow storage.
- environmental friendliness  
Continue staff education on proper usage of ice control products. Education and understanding is key to the realization that over application of ice control products is not the answer. Apply only what is needed don't over treat your roadways.

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### 7.6.3 Ministry of Transportation, Province of Ontario, Canada

- cost efficiency  
Cost efficiency is achieved through long-term, low-bid contracts and by promoting innovation among contractors.
- environmental friendliness  
Environmental friendliness is achieved through contract requirements that contractors meet all applicable provincial

and federal environmental regulations and laws. The Ministry follows a Road Salt Management Plan developed in consultation with the Government of Canada, and works with the Ontario Road Salt Management Group of highway agencies to develop more effective salt management approaches, and works with maintenance contractors to test and evaluate advance technology for salt management.



Ottawa