A FRAMEWORK FOR ASSESSMENT OF THE DECISION-MAKING PROCESS OF WINTER ROAD MAINTENANCE OPERATIONS

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by

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ABSTRACT

Road networks are the most prevalent and reliable element of the transportation systems. Roads provide freedom of movement, are continually available, and form the backbone of the economy. Road maintenance, including snow and ice control, is an essential part of ensuring a safe and efficient road network. Winter road maintenance operation is a series of activities performed at various times to keep roads safe and passable during severe winter conditions. Winter road maintenance components must be coordinated to allow operation's managers to make the right decisions at the right time. Decisions made for winter road maintenance operations are dependent on factors such as weather conditions, road temperature, de-icing material, and equipment. Many decisions are made for the timely mobilization of resources for winter maintenance activities such as salting or snow removal. Given the uncertainty associated with the variability of winter, it is inevitable that maintenance decisions will be made with a proportion of inaccuracy. However, untimely or ill-informed decisions result in unnecessary over usage of resources, or deficient maintenance efforts. This thesis is focused on reducing the margin of decision error by establishing a framework or a methodology for measuring and assessing decision effectiveness.

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I would like to thank the City of Toronto and the wonderful staffers who helped provide data for my research.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway & Transportation Officials
AHUA	The American Highway Users Alliance
AVL	Automatic Vehicle Location
CaCl	Calcium Chloride
CMA	Calcium Magnesium Acetate
CMC	Canadian Meteorological Centre
DART	De-icing Anti-icing Response Treatment system
FHWA	Federal Highway Administration (USA)
GEM	Global Environmental Multiscale
GIS	Geographic Information System
GPS	Global Positioning System
IRT	Infrared Thermometers
KAc	Potassium Acetate
km	Kilometres
LAN	Local Area Networks
LOS	Level Of Service
MDSS	Maintenance Decision Support System
METRo	Model of the Environment and Temperature of Roads
MgCl	Magnesium Chloride

MTO	Ontario Ministry of Transportation
NaCl	Sodium Chloride
NCHRP	National Cooperative Highway Research Program (USA)
RWIS	Road Weather Information System
TAC	Transportation Association of Canada
TMMS	Toronto Maintenance Management System
Transport Canada	The Federal Ministry of Transportation of Canada
WAN	Wide Area Networks
WMMS	Winter Maintenance Management System

CHAPTER 1

INTRODUCTION

1.1. Background

Road networks plays major role in the movement of people and goods while considered the most commonly used element of the national transportation systems. Even with all the advancements in air and sea travel, roads are the backbone of any economy. Roads take this level of importance for their ubiquity, permanency, and high capacity. They provide freedom of movement, mobility, and are continually available for road users. Road networks accommodate several modes of transportation, commercial and private including trucks, buses, passenger vehicles, bicycles, walking and even horse and carriage.

The economies of scale for transportation are quite significant, according to Transport Canada [Transport Canada, 2008] in fiscal year 2008-2009, all levels of government combined spent $35.4 billion on transportation of which 71% ($25.1 billion) were spent on roads. The remaining 29% ($10.3 billion) were spent collectively on other modes of transportation such as public transit, marine, air and multimodal. The 2008 report by Transport Canada indicated that the different modes of transportation activities (e.g. road, air, rail) would attain an annual total cost of as much as $233 billion with road transportation alone accounting for 86% ($201 billion) of the total cost including the perceived social cost of transportation [Transport Canada, 2008]. According to same report, the social costs associated with the impacts of transportation activities in the year 2000, were estimated to be up to $39.5 billion, measured in five areas, listed in the order of importance: 1) accidents, 2) air pollution, 3) congestion, 4) greenhouse gas emissions and 5) noise [Transport Canada, 2008].

Regular maintenance of roads is necessary to ensure continual operation of the road network, and for the safe and timely movement of people and goods. Road maintenance includes penetrative and restorative activities such as crack sealing, pothole repair, minor and major resurfacing. On the other hand, routine maintenance includes activities such as sweeping, debris removal, litter pick up, catch basin and ditch cleaning, grass cutting and roadside vegetation control, and snow and ice control during the months of winter.

The cost for snow and ice removal exceeds $2 billion annually in the United States alone [Minsk, 1998]. It is also estimated that the various agencies in Canada spent, in 1998, nearly $1.3 billion annually on their winter maintenance operations [Jones, 2003]. The delay, failure, or the inability to provide winter road maintenance will have significant effects economically, socially, and environmentally. The American Highway Users Alliance (AHUA) [American Highway, 2010] commissioned a study to measure the economic costs of disruptions caused by snowstorms. The study shows that there is "significant expense, both directly and indirectly, a major storm has on businesses and government because of impassable roads, as much as $300-700 million in some states for just a one day shutdown" [American Highway, 2010]. The direct cost was attributed to loss of income and sales, while the indirect component is the cost associated with the rippling effect through the economy that would have been stimulated by the wages and sales that were lost [American Highway, 2010].

The effects of winter weather on Canadian roads are also significant for municipal road authorities. For example, according to information obtained from the City of Toronto [Toronto, 2009], the City allocates an annual budget of nearly $80 million for roadway winter operations; broken down to approximately 50% for road plowing, 30% for road salting, and 20% for sidewalk clearing. In general, winter road maintenance activities will form the largest single item in a road maintenance budget for Canadian municipalities.

Winter road maintenance operation is a series of activities and tasks performed at various stages of a snowfall or ice event to produce safe and passable roadways. Winter maintenance consists of several operations which must be coordinated to allow operations managers to make the right decisions at the right time [AASHTO, 1999]. Decisions made for winter road maintenance operations are dependent on factors such as weather conditions, precipitation type, time of the day, road temperature, de-icing material, equipment, and labour resources. Many decisions need to be made for the timely mobilization of resources for winter maintenance activities such as salting or snow plowing. Given the inherent complexity of the decision making process and the uncertainty associated with the variability of winter conditions, it is expected that inaccurate decisions for winter road maintenance will be made resulting in increasing costs and economic losses. Therefore, there is a need to establish a systematic framework for decision making for winter road maintenance operations. Furthermore, as decisions are made and executed in the field, they are rarely evaluated for effectiveness against a standard or a benchmark. This generates questions such as: Was the effort exerted upon executing a decision properly apportioned to the road condition? Was the equipment mobilized at the right time? Was the salt application suited for the amount of snow accumulation and road temperature? Such questions point to the need to have benchmarks for measuring the effectiveness of winter road maintenance decisions. Consequently there is a need to further investigate the decision-making process for winter road maintenance operations in order to develop a framework for systematic decision making, and to identify better evaluation methods in an attempt to quantify the decisions made for winter road maintenance.

1.2. Objectives

Based on the preceding discussions, the objectives of this thesis are as follows:

- To carry out literature review to identify key elements contributing to the decision-making process of winter road maintenance operations and to determine any deficiencies that might exist.
- To propose a framework for a systematic decision-making process for winter road maintenance operation.

- To demonstrate the benefits of the developed framework by analyzing the relationship between winter maintenance operational mobilizations, weather conditions, and winter related collisions, using actual post-event operational data.
- To identify a better methodology to quantify efforts resulting from winter maintenance operational decisions.

1.3. Research Plan

To achieve the objectives of this thesis, the research plan started with a literature review of winter road maintenance operations to identify key elements contributing to its decision-making process. Elements were explored for their influence over the operation; such elements included road weather monitoring and forecasting, pavement temperature, materials' types and application techniques. Based on the understandings obtained through the identification of the winter maintenance operation's key elements, a framework for a systematic decision-making process was proposed and shown in a flowchart format. The process includes process flow for pre-storm and in-storm decision-making.

Weather information, for six winter seasons from 2004 to 2010, were obtained from Environment Canada, including daily temperature and snowfall readings. In addition, actual post-event winter maintenance operations data from the City of Toronto were collected, cross-referenced with weather information, and reduced into a working data set. The data set is focused on the deployment of maintenance vehicles as representation of mobilizations' decisions. Analysis of the data set was performed to examine the implication of decision actions, and to determine relationships between winter maintenance operational mobilizations, weather conditions, and winter related collisions. The analysis shows benefits of the proposed framework on salting and anti-icing activities. Finally, based on data analysis, identify a methodology to quantify efforts resulting from winter maintenance operational decisions. This provides road maintenance practitioners with improved decision making for winter operations. A simplified flow chart is shown in Figure 1.1.

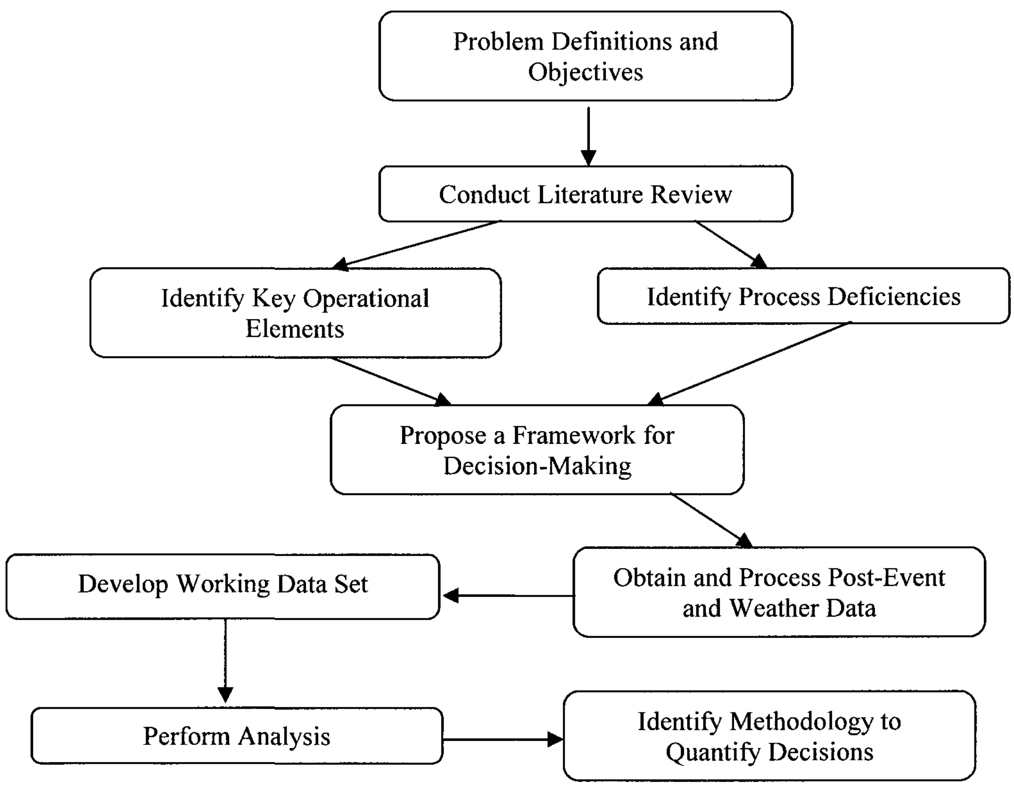

Figure 1.1: Research Plan

1.4. Scope of The Research

The scope of the presented research is limited to road winter maintenance operations directly related to snow and ice control. More specifically the type of maintenance activities adopted in this thesis is the one related to the utilization of material application (salting) and direct liquid application (anti-icing) to road surfaces in Ontario. The analysis will be conducted on data collected from one of the four districts for the Road Operations unit within the Transportation Services Division of the City of Toronto. The study period is limited to six winter seasons from 2004-2005 to 2009-2010.

1.5. Thesis Organization

The thesis is comprised of six chapters; Chapter 1 provides an introduction into the importance of road transportation networks and the impact winter road maintenance has on the economy, and outlines the research needs and objectives. Chapter 2 provides a literature review of winter maintenance including road weather forecasting and monitoring. The chapter also explains the role of snow and ice control materials and techniques for road application. In addition, the chapter discusses factors in the operation such as equipment, level of service, and maintenance policies. Chapter 3 discusses decision support for winter operations and associated systems such as planned operational routes, equipment utilization, operational data collection and centralized management systems. Chapter 4 presents the main steps of the proposed framework for decision making process for winter operations and showing typical sequential steps for winter maintenance operation decisions. Chapter 5 describes the case study subject, data collections, and analysis showing possible links between winter maintenance operational mobilizations, weather conditions, and winter related collisions, while Chapter 6 provides important conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1. Winter Road Weather, Monitoring and Forecasting

Winter maintenance programs are dependent on climate and weather conditions occurring in the area. This makes the study of weather patterns and historic data rather important. Climate conditions refer to the average weather events that occur over a long period of time, as well as the frequency of extreme events. Recurring site conditions such as cold spots, or windy areas, are referred to as microclimates and require special attention [Blackburn, 2004]. While weather conditions refer to the "measurable or identifiable meteorological events that occur at a given site or in a given area at a particular point in time." [Blackburn, 2004]. They include conditions such as visibility, precipitation, temperature, relative humidity and are the most crucial elements when determining an effective winter maintenance strategy. Current weather conditions vary in their effect on the road, based on local topography such as hills, curves and bridges. The above, combined with traffic conditions, influence winter maintenance operational decisions, such as type of materials and equipment to be used, and timing and priority of treatments.

Road Weather is a term used to refer to the weather on or near roadways that specifically affects the function of the road. Air temperature, pavement temperature, relative humidity, wind speed, precipitation type and rate of intensity, and cloud cover have a direct effect on the chemical process being used to control snow and ice. Therefore, monitoring road weather helps to identify the opportune window of time for de-icing, anti-icing, or snow removal operations.

The surface of the road is the contact plane for snow and ice; it has been identified as a key element affecting the formation of ice on the road and the overall behaviour of materials used for snow and ice control. Pavement temperature directly influences the formation, development and breaking of the bond between fallen or compacted precipitation and the road surface, as well as the effectiveness of chemical treatments [AASHTO, 1999].

Pavement temperature can be monitored with non-contact Infrared Thermometers. They are usually used by road authorities and are of two types: handheld and vehicle-mounted, shown in Figure 2.2. The hand held device is for manual use by an operator and gives intermittent readings. The vehicle-mounted device is permanently installed to point to the road surface and to display the readings on an in-dash display. Such readings may provide enough information to make a decision such as calling out salt spreaders. For example, within the City of Ottawa and City of Toronto nearly all of the patrol and supervisor vehicles are equipped with vehicle-mounted infrared thermometers.

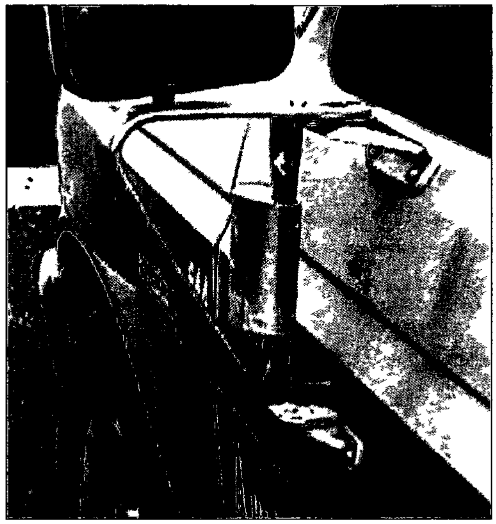

Figure 2.2: Vehicle-mounted Infrared Thermometer
(Roadwatch Infrared Road Temperature Sensor, photo by author)

A Road Weather Information System (RWIS) is a "collection of instruments to measure the meteorological and environmental variables that have been found to have the greatest value for microclimatic assessment and the communication system necessary to collect this information and transmit it to a central location" [Minsk, 1998]. RWIS includes automated micro-weather reporting stations equipped with a collection of sensors in and below the road surface, and on nearby roadside towers. The system collects sensor readings and transmits them through a communication network to a central computer server or a data processing centre. The data collected is then accessed by users for a variety of purposes. RWIS data include air temperature, relative humidity, road surface temperature, subsurface temperature, road moisture, chemical presence, precipitation, wind speed and direction. RWIS stations may include additional equipment such as video cameras and ice-sensitive photo sensors. RWIS stations are typically located in a representative location of the coverage area, with a spacing range of approximately 30 to 50 kilometres [FHWA, 2005]. RWIS data can be used in real-time applications to remotely monitor pavement conditions, as part of a process to decide on treatment type and time. RWIS data is also used by trained forecasters to produce road-specific weather reports and forecasts. The data may be used to determine area-specific weather patterns and supplement atmospheric weather forecasting [FHWA, 1996]. A typical road weather station is shown in Figure 2.3.

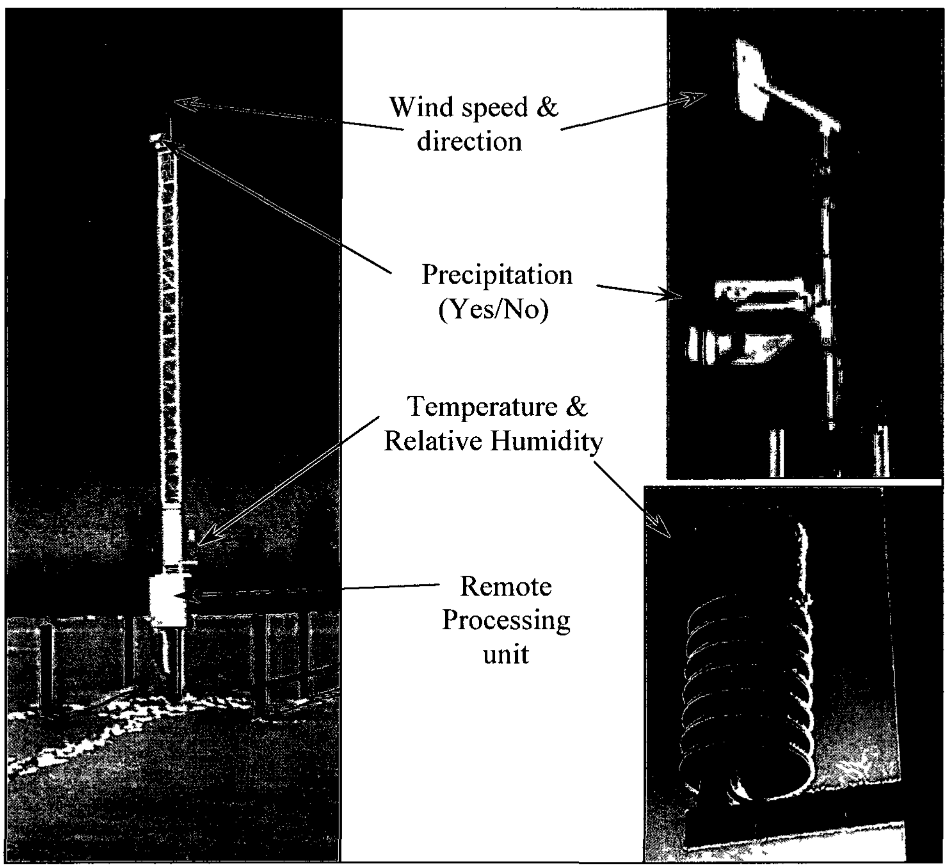

Figure 2.3: Typical Road Weather Station
(Photos by the author)

The information generated by RWIS is used for real-time condition monitoring and forecasting road conditions for the purpose of snow and ice control. There are several private companies and public agencies that provide road condition forecasting using a number of different forecasting models, such as the Canadian heat balance model, METRo. "The main part of such a system is a new physically based numerical Model of the Environment and Temperature of Roads (METRo), which has close connections with the Global Environmental Multiscale (GEM) operational regional numerical weather prediction model run at the Canadian Meteorological Centre (CMC) in Montreal. METRo was first implemented at the Ottawa Regional Centre in October of 1999, and is currently in operational use at other Canadian weather centers. METRo incorporates a full road-condition forecasting system that can predict the road surface temperature as well as the pavement condition." [Crevier & Delage, 2001]. Road weather service providers, with the advent of the internet are able now to provide web-based access to their clients with up-to-date detailed weather forecasts, road condition forecasts, and concurrent road temperature readings relative to forecast time. This serves as an added tool to support operational decision making.

2.2. Winter Road Maintenance Operations

Winter road maintenance operation is a series of activities and tasks performed at various stages of a snowfall or ice event to produce safe and passable roadways. Winter maintenance consists of many components, including: 1) level of service, 2) policy and standards, 3) material types, 4) road and weather conditions, 5) equipment, 6) labour, and

7) technology and methodology. These components must be coordinated to allow operations managers to make the right decision at the right time [AASHTO, 1999]. The winter road maintenance operation's objective is to remove snow and ice from road surfaces to make it safe for driving motorists. Snow and ice control can be achieved by mechanical means, which involve physically moving snow and ice from the travelled lanes to elsewhere. Mechanical snow removal includes techniques such as snow plowing, snow blowing and snow sweeping [Minsk, 1998]. Snow and ice control can also be achieved by chemical means, whereby the composition of snow and ice is changed from total water that freezes at zero degrees Celsius to a mixture of water and chemicals that freeze at a temperature below zero degrees Celsius. The lower temperature is determined by the type of chemical used, its concentration in the solution and the ambient temperature at the time. This process is known as 'de-icing', "De-icing is a snow and ice control strategy of removing compacted snow or ice already bonded to the pavement surface by chemical or mechanical means or a combination of the two" [NCHRP 526, 2004].

2.3. Materials for Snow and Ice Control

Materials used for snow and ice control may be separated into two categories: 1) Abrasives, and 2) Chemicals. Abrasives are designed to create or increase friction on surfaces covered with snow and ice. Abrasives for snow and ice control include: sand, stone dust, crushed rocks and volcanic cinders. They are typically used when pavement temperatures are lower than the effective temperature of de-icing chemicals. Abrasives are also used on gravel roads and in areas where abrasives are deemed to be a more viable environmental choice over de-icing chemicals. However, abrasives are rarely used by themselves without any other additives. It is common to mix other de-icing materials, at a minimum of 2% to 5%, such as salt or calcium chloride, with abrasives in order to prevent the stockpiles from freezing. This also makes the material mixture more workable for transportation and delivery as well as the on-road spreading application. It is also possible that the small percentage of salt in the sand helps the sand stick to ice surfaces creating a rough surface, thereby increasing surface friction on the road. [Minsk, 1998]

Chemicals for snow and ice control are used to change the freezing point of snow and ice to keep it in a fluid state to drain it away from the road surface. Chemicals that are freeze-point depressants are known as de-icing chemicals. De-icing chemicals are mainly in the family of chlorides and Acetates. The following are five of the most commonly used de-icing chemicals: 1) Sodium Chloride (NaCl), 2) Calcium Chloride (CaCl), 3) Magnesium Chloride (MgCl), 4) Potassium Acetate (KAc), 5) Calcium Magnesium Acetate (CMA). These chemicals could be naturally available and man-made. Sodium Chloride, in the form of road salt has been the most widely used de-icer in both dry and liquid applications [TAC 1999]. However, road salt and other de-icing chemicals have limitations, and understanding their chemical properties will help establish when and where to use a certain chemical within winter operation.

It should be noted that de-icers must be in a solution to work. When using a dry form of the material, it is virtually inactive and must be dissolved in water (mixed with snow) to activate it and initiate the chemical reaction to release the chemical energy that changes freezing temperature of the solution. This process is dependant on ambient temperature, solution concentration and atmospheric pressure. However, since the material is used on roads in an open air environment, the control elements are reduced to only two; 1) temperature and 2) solution concentration. Material phase changes in physical state, at various concentrations, are represented by Phase Diagrams. A typical Phase Diagram is shown in Figure 2.4. [FHWA 1996]

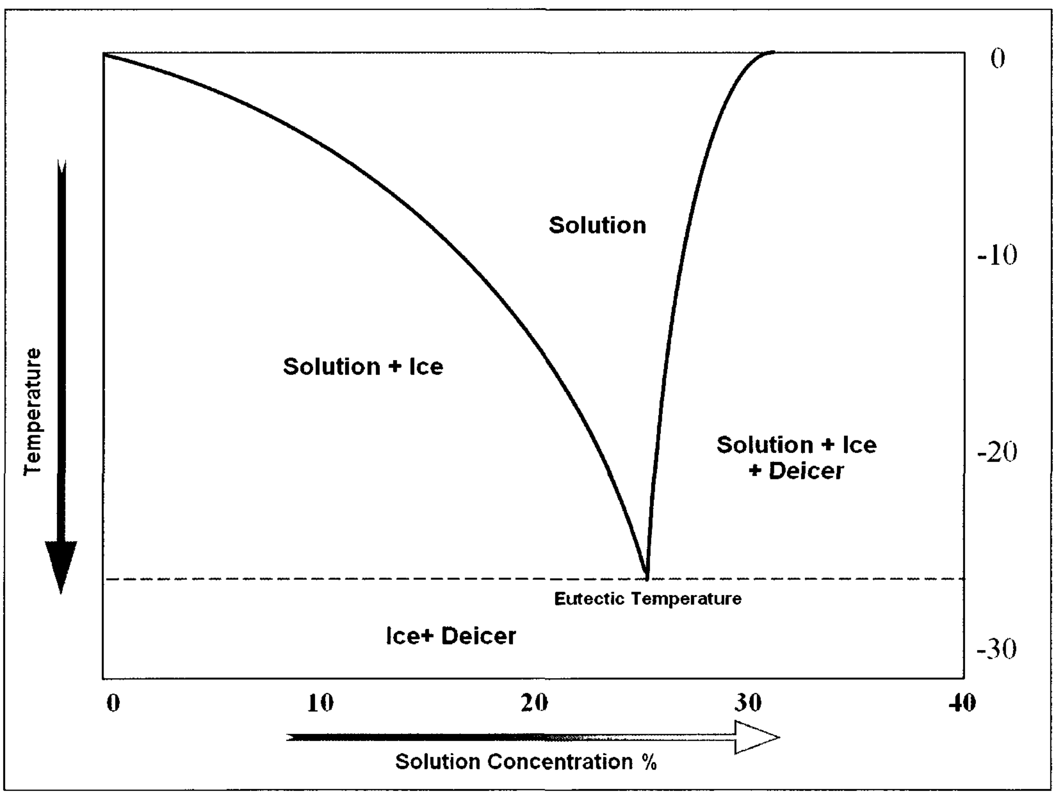

Figure 2.4: Typical Phase Diagram
(Adapted from Federal Highway Administration [FHWA 1996])

The phase diagram shows a typical solubility curve of a de-icer chemical. The lowest point on the curve signifies the Eutectic Temperature, which is "the temperature at which a chemical solution freezes completely without change in composition" [Minsk, 1998]. Figure 2.5 shows the superimposed phase diagrams of the five most common chemicals. It is noted that the general shape of the solubility curve is similar. However, the vertical depth of the curve varies, which varies the envelope where each chemical is most effective for melting snow and ice [FHWA 1996].

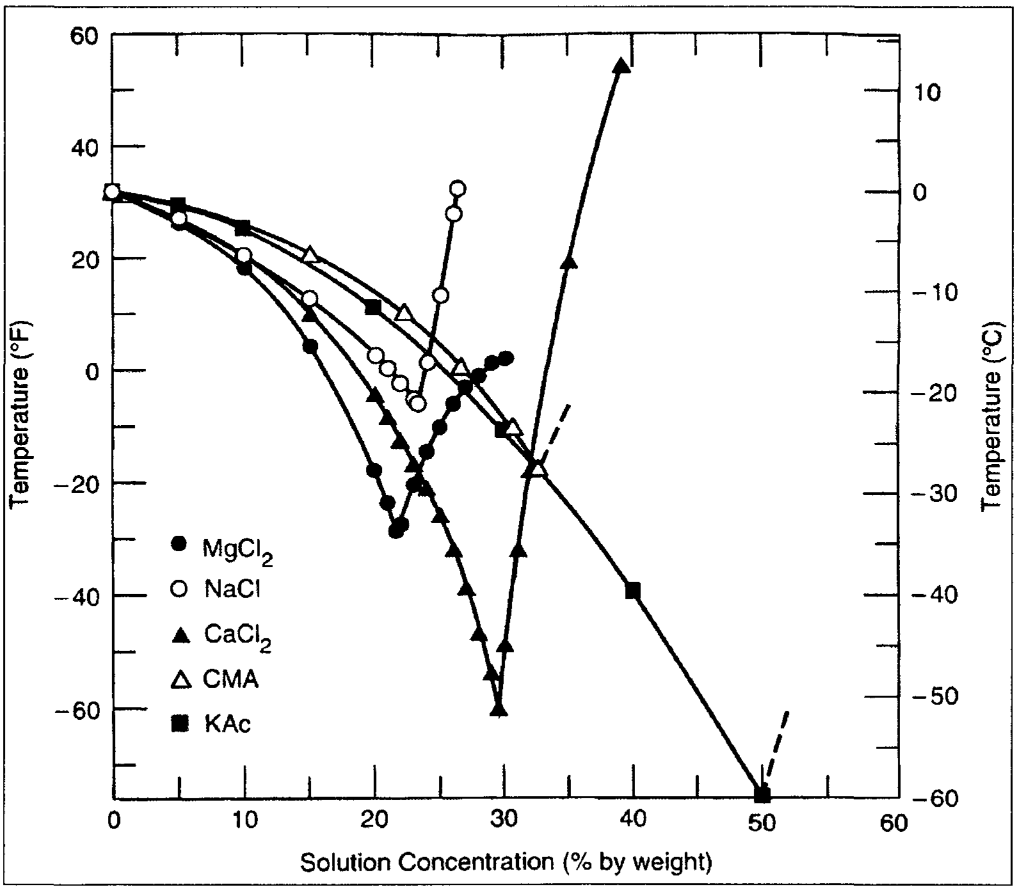

Figure 2.5: Phase Diagram of Common Deicing Chemicals
(Source: Federal Highway Administration, [FHWA 1996])

The Eutectic Temperature is the lowest temperature that a de-icing chemical will, theoretically, still be able to melt ice, and it is the same point where more concentration of the chemical will not lower the freezing point of the solution. The chemical concentration at this point, is known as the Eutectic concentration, beyond which, higher chemical concentration into the solution will cause chemical precipitation and change the freezing point upward [FHWA 1996].

Nevertheless, in actual field conditions, the Eutectic Temperature is not a practical decision point. The chemical would be too volatile for its purpose, and any slight variation in concentration would change effectiveness of the de-icer. Therefore, there is a need to establish a "working temperature", also know as "effective temperature", for each de-icer where it can be optimally utilized. Effective temperature of a de-icing chemical is accepted to be the lowest temperature at which the de-icing chemical starts melting snow and ice within a 15 minute time window. Effective temperature is also where the addition of more chemical would not increase significantly the melting capacity of this chemical. Table 2.1 shows the Eutectic and effective temperatures for commonly used de-icing chemicals. The listed effective temperatures may vary with the other conditions, such as purity of material, and dilution rate [TAC,1999].

Table 2.1: De-icing Chemicals Temperature & Concentration
(Adapted from Transportation Association of Canada [TAC1999])

Chemical	Eutectic Temperature °C	Eutectic Concentration %	Effective Temperature °C
Sodium Chloride (NaCl)	-21	23.3	-9
Calcium Chloride (CaCl)	-51	29.8	-32
Magnesium Chloride (MgCl)	-33	21.6	-15
Potassium Acetate (KAc)	-60	49	-26
Calcium Magnesium Acetate (CMA)	-27	32.5	-6

2.4. Material Application Techniques

De-icers can be applied in dry, pre-wetted or liquid format, depending on road temperatures, weather conditions and material availability. Dry salt is usually applied after snow has started to accumulate or ice has formed on the road. Pre-wetting is a technique whereby dry winter material is coated with a liquid before being applied on the road. Pre-wetting is used on rock salt and occasionally used on sand. Brine solutions (such as NaCl, $CaCl_2$, or $MgCl_2$) are used as pre-wetting agents. Organic based solutions are also commercially available. Pre-wetting increases the retention of material on the road and shortens the de-icer reaction time. While direct liquid application is mostly used for anti-icing activities, however, it can also be used to de-ice black ice and frost on road surfaces, and in specialized configurations such as fixed automated bridge spray systems.

Anti-icing is a proactive strategy for snow and ice control. It is the application of a chemical de-icer on the pavement before the start of, or at the onset of a winter weather event. Anti-icing is a preventative measure designed to inhibit snow and ice from bonding to the pavement surface. Anti-icing has been practiced in the past and became more viable with advancements in weather monitoring and road condition forecasting, advanced spreading equipment with computerized electronic controls, and more research and field experimentations [Minsk 1998]. Though less effective, anti-icing may also be performed with dry or pre-wetted de-icers. Successful deployment of anti-icing strategies must be accompanied by the necessary tools and components of a systematic decision making process. The concept of anti-icing can not be properly applied without road weather information and road condition forecasting systems. [FHWA 1996].

2.5. Equipment for Winter Operations

Equipment for snow and ice control varies from the simple handheld snow shovel to GPS-equipped automatic de-icing operations, and from the single-function unit to the multi-functional multi-season combination unit. Such equipment may include the capability to spread dry, pre-wet and liquid de-icers or a combination thereof. The most important feature of any material spreader is the rate-controller that controls the amount of material applied on the road. Knowledge and control of material application is critical in achieving a mandated level of service. Winter maintenance equipment also includes snow moving equipment such as: snow plows, snow blowers, graders, loaders, snow sweepers and snow melters. Other technologies are also employed such as Global

Positioning Systems (GPS) and Geographic Information Systems (GIS), which are used in conjunction with data collection systems to monitor how equipment is performing, provide automatic vehicle location, material spreading rate and vehicle speed [Minsk, 1998].

2.6. Winter Maintenance Policy and Level of Service

A winter maintenance policy defines the minimum acceptable level of service for winter road maintenance. An established winter maintenance policy provides a medium for declaring the goals and objectives of the organization, such as commitments to environmental protection, operational efficiency and proper use of resources, and it serves to document the intent, capabilities and procedures of the snow and ice control program. Furthermore, a policy sets a platform for a common understanding of the agency's mandate and public's expectations. A written policy provides operations managers and staff with consistent methodology for delivering the same level of service. It provides guidelines and procedures on the use and allocation of resources such as materials, equipment and labour. A written policy establishes a legal basis for winter maintenance practices and affords a reasonable attestation of an agency's due diligence towards its winter maintenance mandate [AASHTO, 1999].

"Level of Service (LOS), in the context of roadway snow and ice control operations, is a set of operational guidelines and procedures that establish the timing, type and frequency of treatments" [NCHRP 526, 2004]. Road authorities define their LOS in a variety of ways; some are legislated by government, while others are based on a combination or subset of road classification systems, service priority, traffic volumes, speed limit, number of lanes, essential road links, availability of equipment, staff, material and public and political expectation [AASHTO, 1999]. A good example of legislated LOS is Ontario Regulation 239/02, Minimum Maintenance Standards for Municipal Highways, enacted under the 2001 Ontario Municipal Act. This legislation provides a minimum standard for maintenance on several road maintenance fronts, such as patrolling, potholes, shoulder drop-offs, cracks, debris, luminaries, signs, bridge deck spalls, roadway and sidewalk surface discontinuities, and snow accumulation and icy roadways [Ontario, 2002].

The Ontario regulation also provides a road classification system based on a simplified criterion of speed limit and traffic volumes as represented by the Average Annual Daily Traffic (AADT). Table 2.2 illustrates this classification. The regulation also sets the type of treatment as per road classification, where it sets a depth of allowable snow accumulation at which the municipality will start to "deploy snow-clearing resources as soon as practicable" and have a set amount of time to clear the road to this accumulation depth or less, as well as define the minimum width of road that needs to be cleared. There is also a similar threshold for icy roads. However, it is noted that road classification 6 is not listed within the level of service requirements and it is assumed that there is no set level of service for this type of low-volume low-speed roads [Ontario, 2002].

Table 2.2: Ontario's Classification of Highways
(Reproduced from Ontario Reg. 239/02 [Ontario, 2002])

AADT (number of motor vehicles)	Posted or Statutory Speed Limit (kilometres per hour)						
	91 - 100	**81 - 90**	**71 - 80**	**61 - 70**	**51 - 60**	**41 - 50**	**1 - 40**
15,000 or more	1	1	1	2	2	2	2
12,000 - 14,999	1	1	1	2	2	3	3
10,000 - 11,999	1	1	2	2	3	3	3
8,000 - 9,999	1	1	2	3	3	3	3
6,000 - 7,999	1	2	2	3	3	3	3
5,000 - 5,999	1	2	2	3	3	3	3
4,000 - 4,999	1	2	3	3	3	3	4
3,000 - 3,999	1	2	3	3	3	4	4
2,000 - 2,999	1	2	3	3	4	4	4
1,000 - 1,999	1	3	3	3	4	4	5
500 – 999	1	3	4	4	4	4	5
200 – 499	1	3	4	4	5	5	5
50 – 199	1	3	4	5	5	5	5
0 – 49	1	3	6	6	6	6	6

Table 2.3: Snow Accumulation Triggers
(Source: Government of Ontario, O. Reg. 239/02, [Ontario, 2002])

Class of Highway	Depth	Time
1	2.5 cm	4 hours
2	5 cm	6 hours
3	8 cm	12 hours
4	8 cm	16 hours
5	10 cm	24 hours

Table 2.4: Icy Roads Triggers
(Source: Government of Ontario, O. Reg. 239/02, [Ontario, 2002])

Class of Highway	Time
1	3 hours
2	4 hours
3	8 hours
4	12 hours
5	16 hours

The City of Ottawa provides another good example illustrating the link between road classification and level of service. The City's website states the winter maintenance objective "is to keep streets safe and passable by reducing the hazards caused by snow and ice accumulation", while providing a table showing their targeted level of service titled Maintenance Quality Standards [Ottawa, 2005]. The City's quality standard is based on a road classification system specially designed for maintenance, which differs from the road classification system established under City bylaws. The standard indicates road maintenance class and road type, a deployment trigger and a time limit to complete or repeat operational activities until the "Treatment Standard" is reached. Table 2.5 describes these maintenance quality standards.

Table 2.5: City of Ottawa Maintenance Quality Standards - Roads
(Source City of Ottawa, www Ottawa ca and [Ottawa, 2005])

Road Maintenance Class		Road Type	Minimum Depth of Snow Accumulation for Deployment of Resources	Time to Clear Snow Accumulation From the End of Snow Accumulation or Time to Treat Icy Conditions	Treatment standard		
					Bare Pavement	Centre Bare	Snow Packed
1	A	High Priority Roads	As accumulation begins	2 hours	X		
	B				X		
2	A	Most Arterials		3 hours	X		
	B				X		
3	A	Most Major Collectors		4 hours	X		
	B				X		
4	A	Most Minor Collectors	5 cm	6 hours	X		
	B					X	
	C						X
5	A, C	Residential Roads and Lanes	7 cm	10 hours			X
	B		10 cm	16 hours			X

2.7. The Human Side of Decision Making

The human behavioural aspects of decision making should to be considered for its influence on the decision making process, and to better understand how people make decisions. A 'decision' is defined as a "choice made between alternative courses of action in a situation of uncertainty" while 'decision making' is defined to be: "the thought process of selecting a logical choice from among the available options" [Business 2010]. Decisions are made up of three main elements: belief, facts and data. One must acknowledge that data alone is not useful, it must be analyzed and processed and it needs to be reliable. This is the essence of a good decision [McDermott, 2008].

There are many types of decision-making. Types vary by human nature, ambient environment or decision subjects. However, common types of decision making include; the 'rational', 'intuitive' and 'recognition-primed' types. Rational decision making is the most common as it is easy to understand and quantify. It is logical, sequential and emphasizes the importance of working out the most suitable course of action based on measurable variables. Intuitive decision making is a process where no reason or logic is used and mainly relies on inner feelings, tacit knowledge, intuition and ESP (Extrasensory Perception). This type of decision making is sometimes perceived to be inconsistent and unreliable. Decisions made using this method are perceived as unlikely coincidences, lucky guesses, or some kind of spurious magic. However, intuitive decision making is not necessarily the complete opposite of rational decision making; rather it is seen as a different and sometimes faster type of decision-making. Seemingly, there is logic and innate process to this type of decision making, though not easily visible behind the intuition. A third type of decision-making is known as 'recognition-primed'. In this type, the decision maker mentally rehearses the process, reviews and analyses alternatives and outcomes, and then selects a course of action based on the belief that it will work and yield the desired outcome. However, should the first scenario not mentally work, then the decision maker chooses another option and repeats the mental process until the best decision has been selected [McDermott, 2008].

Different approaches and styles are followed when making decisions, with breadth and diversity as diverse as the human emotions. Styles can be analytical or conceptual; there is also the impulsive, where a decision is made with little or no consideration to the outcome. Close to that, is the fatalistic or resigned style where decisions are made with an attitude of apathy. The procrastinating style is where the decider delays the making of the decision for one reason or another, while the 'play-it-safe' style prefers selecting the choice with the least amount of risk. Some people have a style of agony where they worry overwhelmingly over a particular decision, and others would be compliant or dependant: going along or allowing others to make the decision. There are also the proactive or the flexible styles where the decider uses more than one, or a mix of different style categories. There are many degraders that can damage a decision or hinder the process to the point where the decision is not made or the wrong decision is made. Decision degraders may include delays, mistakes, traps and fallacies [McDermott, 2008].

CHAPTER 3

DECISION SUPPORT FOR WINTER OPERATIONS

The discussions in this chapter are based on the author's experience as a long time municipal engineer within public works departments of major municipalities. The discussions are the author's understandings of the decision support tools within winter maintenance operations, and a complement to the literature review in chapter 2.

3.1. Operational Routes for Decision Support

Maintenance activities are usually delivered through repetitive, cyclic activities based on a preset frequency. This facilitates planning work ahead of time in the format of cyclic routes (beats). While winter operations' planning is an extensive discussion subject, the focus in this section is on planning (creating) operational routes for activities such as plowing, salting, sanding, liquid application or snow removal.

At a simple level, route creation is the amount of distance, within a time limit, a maintenance vehicle can travel while performing an activity before it needs to reload, refuel, or runs out of time. For example, in the case of a material spreader: Assuming an application rate of 130 kg/2-lane-km, and a spreader truck with (10) metric tons of capacity. The unit will be able to cover 76.92 km (10,000 kg ÷ 130 kg/2-lane-km = 76.92 km), and assuming a 32km/h average route speed, this unit should complete the proposed route in approximately 2.4 hours.

The above simple calculations indicate that an operation route for salt spreading could cover 76 kilometres of a 2-lane roadway and be completed in 2.4 hours, or cover approximately 38 kilometres of a 4-lane roadway in the same amount of time. Route creation is a decision support tool that allows for verification of field results of operational activities such as actual application rate, total amount of salt spread, and average driving speed.

Operation routes can be created with a complex set of variables to create optimal routes for operational activities. Route creation variables may include; road classification, area topography, traffic volumes, road width, turn and directional restrictions (one way, no left turns), traffic restriction and peak times and parking prohibitions. On the operational side, factors include jurisdictional limits, operational polices and procedures, level of service, cycle times, material supply depots, fuelling stations, material application rate, maintenance vehicle type, operating speed, number, storage location and capacity, and the sequence of maintenance activities.

3.2. Decisions and Equipment

Different types of equipment can influence decisions made for winter operations. A decision made with single unit salt spreaders or plow units will vary from one made with combination units (plow and spreader units). This will affect the process flow of the operation, and will demand different procedures be established for making a decision based on, or largely influenced by, what equipment is available in the agency's fleet.

For example, if a road authority had plow-only and spreader-only units in their fleet, they would then develop "plow-only" routes and "spreader-only" operational routes. Such routes may not necessarily be the same, due to the different characteristics of the equipment. The option may be to have a set of plows deployed when snow accumulation reaches a certain depth, while the spreaders are deployed when salting alone is sufficient. Using the same logic, the "plow only" routes will be focused on opening major roads and intersections, while the spreaders will focus on salting hills, curves and bus routes. There is also the possibility of teaming up the fleet with a plow and a spreader on each route; however, plow units deliver their function at a different rate of speed than a spreader unit with varying road coverage and production rate. A plow can plow/remove snow from one lane width at a time, while a spreader can be configured to spread over several lanes at the same time and at a higher speed. The decision for using a multifunctional piece of equipment, or combination unit, requires a different thought process than single function units. The deployment frequency for a combo unit is different from a single-function unit, therefore operational procedures will differ and subsequently the decision making tree is affected. This illustrates the different decisions that need to be made directly relating to equipment. The number of possible decisions will increase when considering locations of associated facilities such as work depots, material storage domes, and snow disposal facilities.

3.3. Operational Information for Decision Making

Operational information refers to detailed knowledge recorded about the winter maintenance activities performed during the operation. Such information includes in part route length, material type and application rate, time of completion. This information has always existed and has been recorded on paper forms and daily reports. However, with the computerization of maintenance vehicles, this information and much more are recorded electronically and are made available. For example, it is common practice in the industry that salt spreader units are equipped with an electronic spreader controller. The controller allows for precise control of material spreading, and at the same time is able to record events such as start and end times, material types, quantity and material application rate, and if equipped with a Global Positioning System (GPS), location tracking. Furthermore, through advanced wireless communication, there exists the ability to place this information into the hands of decision makers while the operation is in live progress, making it a valuable decision support tool.

Automatic Vehicle Location (AVL) is a commonly used term to describe the automatic tracking of the geographic location of a moving vehicle using coordinates of the Global Positioning System (GPS). AVL is used as a stand-alone system or as part of the much larger data collection system. Operational information can be used within the framework of decision making, and whether the information is collected manually using pen and paper, or collected using the new sophisticated electronic system, it could be an integral component of decision support for winter maintenance.

3.4. The Snow Desk

A command centre for winter maintenance operations is common within large road authorities, and for major storms, such command centres are referred to as snow desks. The snow desk serves to centralize decision making for winter operations. Information from other agencies will be directed to the command centre. By storing all the information at a central location, managers can perform essential data analysis to assess and modify operational decisions.

A winter maintenance command center does not have to be the classical, physical office where at least one person is available at all times to monitor and respond to the operation. The command and control concept can be achieved by having a virtual command and control center providing access to the same information that is housed in a central location. By utilizing new networking technologies, such as the Internet, Local Area Networks (LAN), and Wide Area Networks (WAN), cell phones, video conferencing, wireless email, instant text and video messaging, road authorities can establish a virtual command center that is accessible by remote means. It allows for all decision makers to access the same information and interact with each other, whether they are in a command room or at a home computer, or anywhere in between via a mobile interface.

3.5. Automated Decision Support Systems

Several systems are emerging in an attempt to automate the decision making process for winter maintenance. The Ministry of Transportation of Ontario (MTO) has developed the De-icing Anti-icing Response Treatment (DART) database. DART is designed to be fed with weather and operational data and in turn it will provide recommendations on a treatment plan based on pre-set criteria for snow and ice control material application rates. The Federal Highway Administration (FHWA) Office of Transportation Operations initiated a program in 2001 for the development of a winter road Maintenance Decision Support System (MDSS). The system would integrate data from road weather information systems, weather forecasting, road operations operational procedural policies, and represent them in a simplified manner for decision makers, as well as provide recommendation to operations managers on possible treatment options and proposed courses of action for snow and ice control. MDSS has been in various prototype stages for the past several years with several challenges yet to be addressed.

Another example of automating some decisions for winter operations is the development of a GPS-controlled material spreader. The concept revolves around planning a material spreading route, where the actions of the operator, such as start of spreading, change in spreading width, liquid application start and end, and material rate change are recorded electronically with the appropriate GPS stamp. The recording is then saved into the spreader controller, and when activated, the driver need not operate the spreader; it will recognize its GPS location and will start reproducing all actions based on where they were recorded in relation to the GPS coordinates. This system allows the driver to focus on driving, while the vehicle's automated features operate the rest of the unit. EpoSat©, by Epoke of Denmark, is such a system and it has had some limited success in Canada.

3.6. Winter Maintenance Management Systems

A Winter Maintenance Management System (WMMS) combines information and procedures needed by operators and operation managers in a single decision making tool. Once the decision is made to mobilize equipment and staff for the operation, the system then provides support, allowing operators and supervisors to manage all aspects of the operation and associated activities.

A good management system would have the ability to integrate the various types of equipment data outputs into a unified database, allowing for a consistent presentation of information for decision making, regardless of the source generating data, ranging from manual input to the fully automated live data collection schemes. A winter maintenance management system built with the proper components can be the ultimate decision support system. Such a system would be utilized before, during, and after each winter maintenance event, and would allow for flexibility to adapt to changing demands for winter road maintenance. A good example is the Danish Road Authority's model for winter maintenance management, which in collaboration with local municipalities in Denmark developed a winter maintenance management system (Vinterman). The system is used by road authorities and contractors, to manage winter maintenance operations. The Danish system was designed to be operated by local municipalities, where RWIS information is obtained from local stations, in conjunction with the local practices and established levels of service. Operational decisions are made locally for local roads. However, the local road authority could choose to share their system's data with the national road authority. The system then sends relevant local data on road status from spreaders, plows, and contractors to the national road authority, where the data is stored and maintained in a database that is synchronized nationally. This information is compiled by the national road authority, and displayed on a website for road users nationwide.

CHAPTER 4

DECISION MAKING FRAMEWORK

Decision making is not an exact science; it is rather an art of balance and judgment. There is no one right answer or fixed course of action all the time, rather there is the best answer or the most appropriate course of action, based on the circumstances and the given input variables at a point in time. This is the nature of winter maintenance decision making, because the input variables change every time the weather changes. So how can one make a decision the same way every time with these varying inputs? This is where a framework may provide value, and allow for a consistent approach to make decisions for winter maintenance operation to provide safe and passable roads, and safeguarding human life and property.

4.1. Decision Points

Decision points within the winter maintenance operation need to be defined in terms of when they occur and for what key element of the operations. To illustrate this issue, take the example of pavement temperature as a key decision factor for when to apply salt and sand for snow and ice control. By knowing that salt starts to depress the freezing point at just below zero degrees, it makes a pavement temperature of zero a decision point at which the decision to apply salt would be the proper course of action. However, should the temperature be less than the working temperature of salt (-9° C), then a decision has to be made at that point in time when pavement temperature is less than -9°, to change that applied material to a salt/sand mix. Should the temperature be even lower, then another decision point emerges to stop salting or change to a more effective chemical suitable for the new situation. Figure 4.6 shows a flowchart illustrating decision points. However, in a multifaceted operation, decision points may not be so simple and be dependant on single factor. The more likely scenario is that there are several key factors interacting to determine decision points.

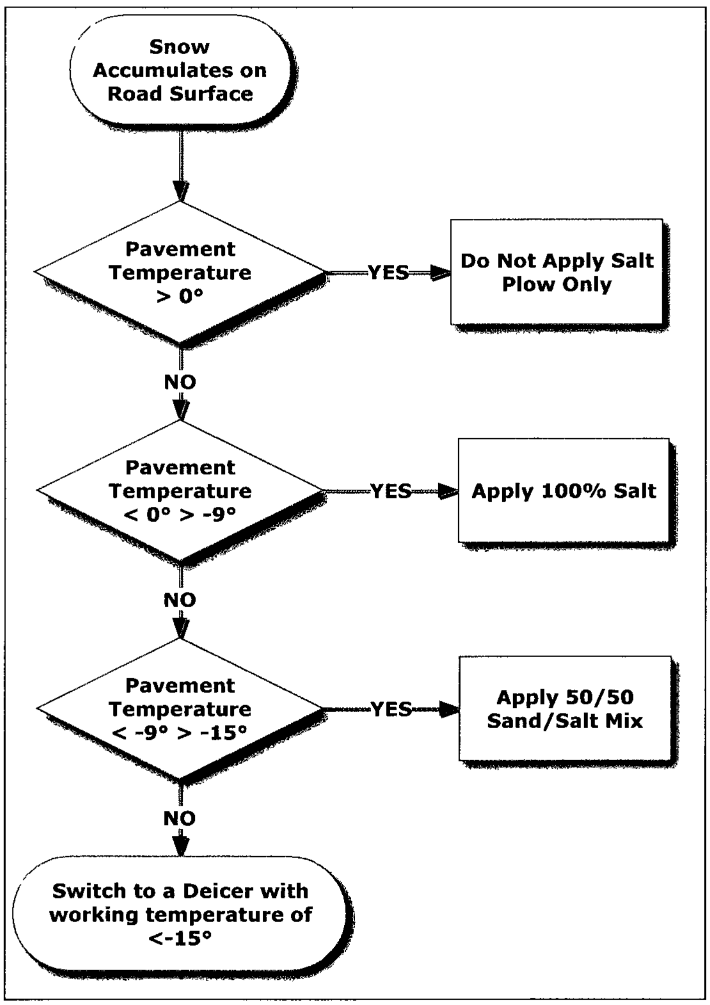

Figure 4.6: Decision Points for Pavement Temperature

4.2. Decision Making Hierarchy

The organizational structure within the winter maintenance road authority is a major factor in building frameworks for decision-making. The size of an organization will play a significant role in the shape of its organizational structure, and subsequently the chain of command for any decision making. A small town would have a smaller hierarchy, while a large municipal or provincial road authority would have multi-level and branching hierarchies which may complicate the process. This will mandate that more rules and guidelines be instituted for how and who can make a decision.

In order to have a systematic framework for making decisions, one of the first steps for a road authority is to establish a decision making hierarchy, where decision makers within the organization are designated at their appropriate level, and their area of responsibility is outlined, in terms of who can make a decision for each specific activity. A Decision-making matrix would be established, based on the particular winter operations activities undertaken by the road authority, as well as the number and available levels of decision makers. The matrix may be configured in a way to incorporate which operation can take precedence over another. For example, a city where the downtown area does not have on-road snow storage, de-icing (salting) will take precedence over plowing, and should plowing become necessary, it would have to be initiated in tandem with snow removal operations. When operational activities have been assigned a priority level, then a decision-making level is assigned, thus designating which level of management can make a decision on initiating the specific operation. A typical outline of an organizational structure and operational decision-making levels is shown in concept in Figure 4.7.

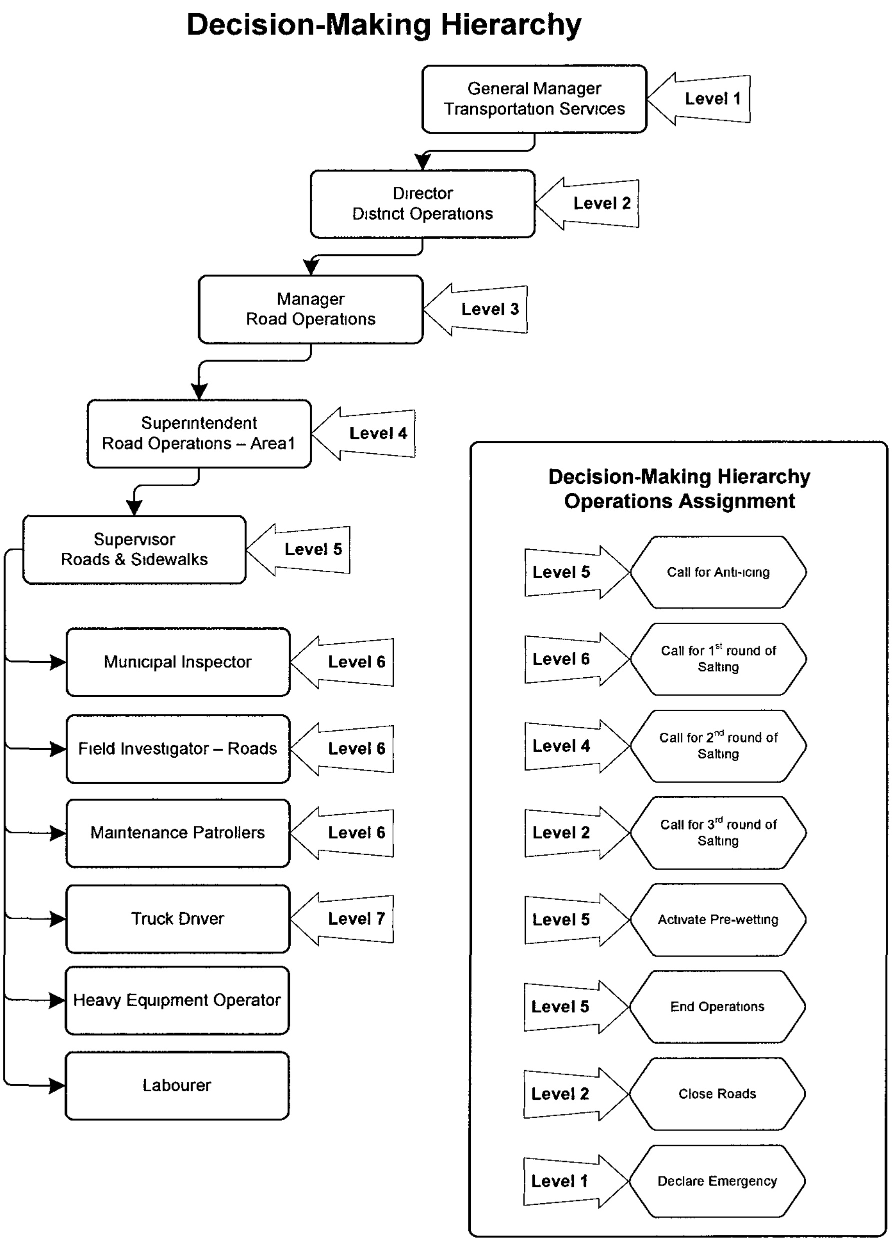

Figure 4.7: Typical Decision-Making Hierarchy

4.3. Decision Making Process

Once a decision-making matrix is in place within an organization, decisions can be made in stages as they are called for by the proposed framework. The first stage is a pre-storm stage, which is usually initiated by mid-October for most Canadian cities. In this stage, preparations for winter operation would have begun with clear milestones to ensure readiness at the onset of the first snow event of the season. At this stage, decision makers will monitor available support systems in order to make the appropriate decisions at the right time.

The flow chart shown in Figure 4.8 shows a typical pre-storm decision making process. The operation manager monitors all the available inputs, such as information from the road patrollers, field observations by staff, reading by the road weather information system, weather forecast, road condition forecast, and pavement temperatures. Once the determination has been made of an impending weather event, the decision is based on the type of the anticipated storm. Storm type will influence the decision of whether or not to mobilize winter maintenance services. Should mobilization be required this in turn will determine the type of operation to be initiated first, (e.g. salting or plowing). At this point, the decision-making hierarchy would be applied to ensure that the proper level of response has been authorized by the appropriate level of management. This also ensures that communication channels are utilized, as well as provide the platform for the next set of decision choices. At the end of this cycle, the selected mobilization plan will be implemented.

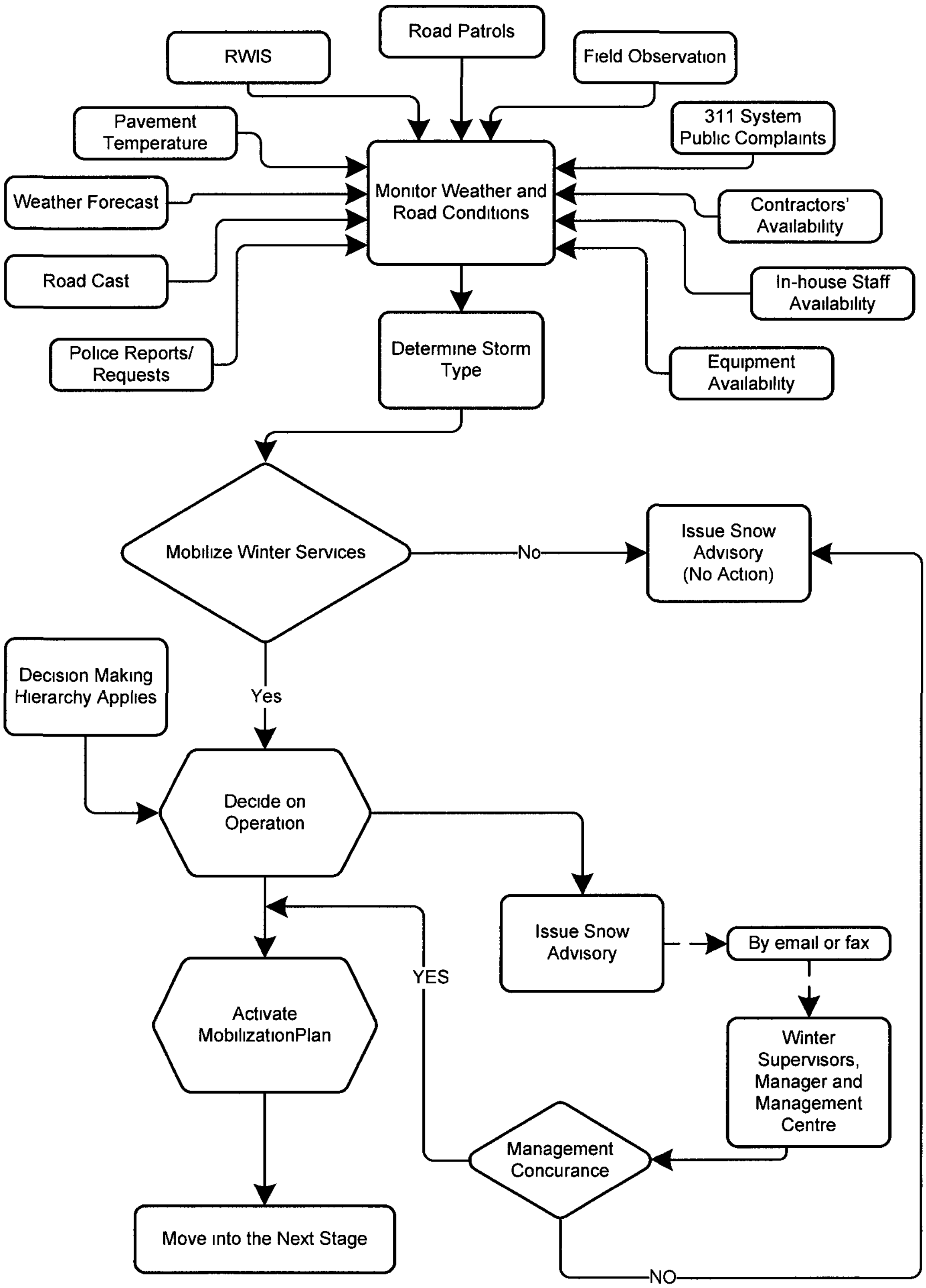

Figure 4.8: Typical Pre-Storm Decision Making Process

Once a decision has been made to activate a mobilization plan the operation moves into the next stage of the framework. A mobilization plan may consist of one activity based on a simple trigger, such as 'apply salt at 130 kg/lane-km at the start of the snow event', or it could be more complex with multiple activities. No matter how complex a plan is, it must be outlined in advance of the actual operation.

The flow chart shown in Figure 4.9 illustrates actions to be taken upon the activation of the mobilization plan. Figure 4.9 is a continuation of the process illustrated in Figure 4.8. In this example, the decision was made to initiate an anti-icing activity.

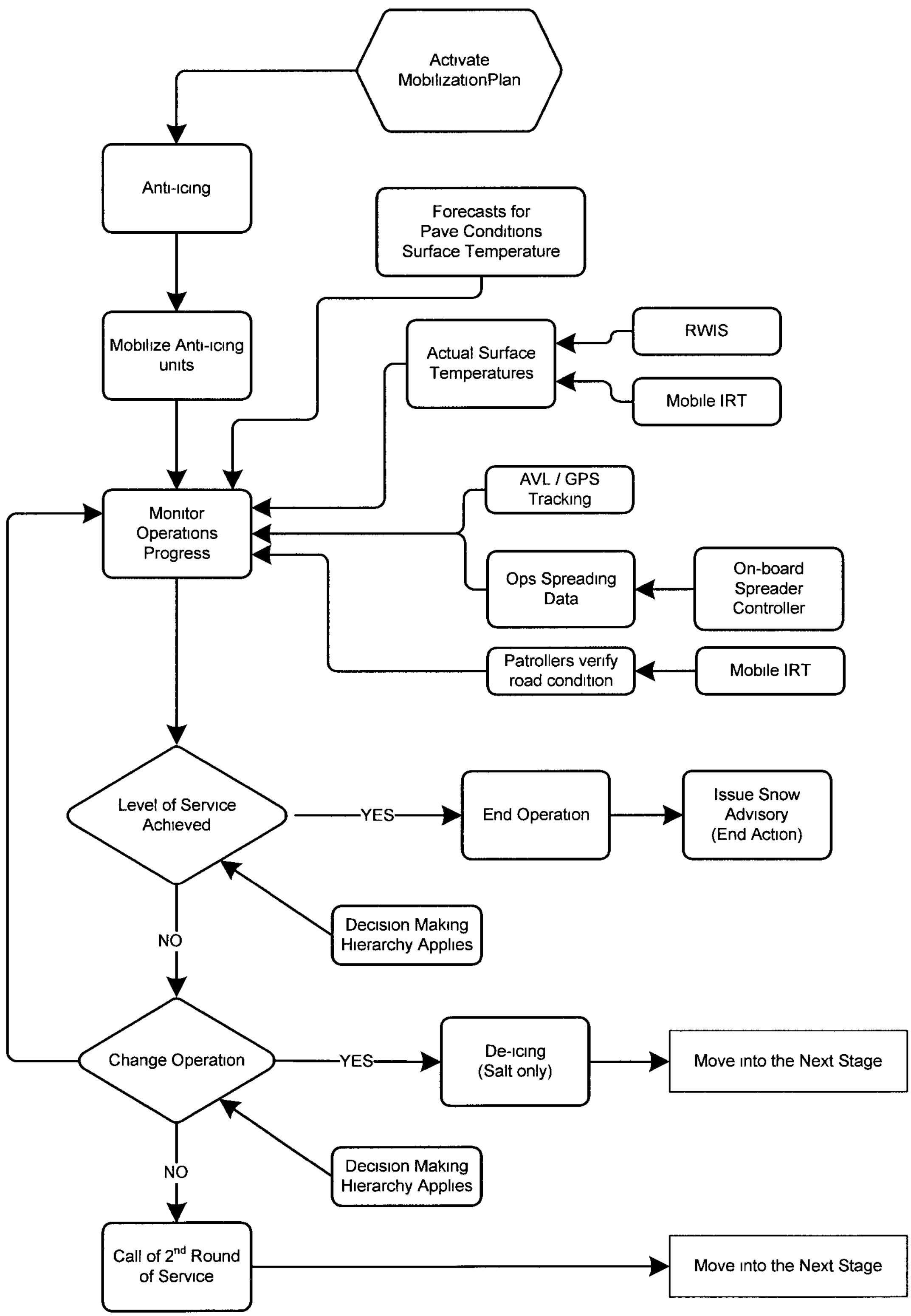

Figure 4.9: Typical in-Storm Decision Making Process

CHAPTER 5

CASE STUDY AND ANALYSIS

The City of Toronto has been selected for this case study. The decision-making process for winter maintenance operations for the City has gone through several transformations since the creation of the new City of Toronto, after the amalgamation of seven area municipalities, as of January of 1998. Toronto is Canada's largest city with a population of approximately three million people. The Greater Toronto Area is estimated to have a population of approximately six million residents. The focus of this case study is the decision-making within Road Operations of the Transportation Services Division for the delivery of winter maintenance operation. The research will use data from the city's road operations section, and weather information from Environment Canada weather archives, and work to associate winter road operational data with recorded weather information, and will examine the relationship between levels of effort as they relate to decisions made to mobilize winter vehicles and winter related collisions for six winter seasons from 2004-2005 to 2009-2010. The focus of the study is on salting and anti-icing activities.

5.1. Transportation Services Division - Background

The City of Toronto Transportation Services Division is responsible for maintaining the City's roads infrastructure. The division is responsible for 5,600 km of roads, 7,945 km of sidewalks, 442 bridges, 504 pedestrian crosswalks, 2,184 traffic signals, 4,100 bus shelters, and over one million street signs. The road network also includes 112 km of bike lanes, 168 km of bike trails, and 138 km of bike routes. This is in addition to 25,000 pieces of street furniture. The Division carries a multitude of activities in order to continually maintain liveable streets for all Toronto residents. Such activities include minor and major road and sidewalk maintenance, street cleaning, snow clearing and road salting, traffic signs and pavement markings, traffic signals and traffic safety, red light camera operations, construction planning and policies, pedestrian and cycling programs, installing street furniture, developing public spaces, and issuing permits for on-street parking, construction, and street events [City of Toronto]. Transportation Services Division is divided into 4 Districts, each headed by a Director of Operations, and a number of managers reporting to each Director. Each manager heads an operational portfolio such as Road Operations, Traffic Management, Surface Maintenance and Right of Way Management. The focus in this case study will be on winter road operations.

5.2. Winter Road Operations

The City of Toronto winter road maintenance operation operates with a budget of $80 million. Transportation Services delivers winter maintenance services using 571 road plow machines, 322 sidewalk plows and 203 dedicated salt trucks. The nearly 1100 unit fleet is operated by 536 City Staff and 1,068 Contractors' staff. The operation uses an average of 138,500 tonnes of salt per year, worth approximately $7.5 million (as budgeted in 2009) spread over 40 to 50 de-icing events. The historic 30-year average of snowfall for Toronto is an average annual of 133cm [City of Toronto]. The City of Toronto employs specialized weather forecasting services, a limited scale road weather information system, and a GPS-enabled automatic vehicle location system. They also use pre-wetting capable salt spreaders, and a limited number of liquid anti-icing units. This is accompanied by a series of policies and operational guidelines such as the Salt Management Plan and salting and plowing charts.

The City of Toronto classifies winter storms in four major categories based on the forecasted snow accumulation. The four storm types are: 1) Storm Type 1: Snow accumulation up to 5 centimetres, 2) Storm Type 2: Snow accumulation from 5 up to 15 centimetres, 3) Storm Type 3: Snow accumulation from 15 to 25 centimetres, and 4) Storm Type 4: Snow accumulation over 25 centimetres. Each storm type requires a pre-determined level of management authorization, and a specified level of service response. For the purpose of winter maintenance, the City classifies roads into several categories; each road classification is assigned a Level of Service, largely based on city policies and provincial minimum maintenance standards. For example, Expressways and Arterials have a “Bare Pavement” level of service, while Collector roads have a level of service of “Centre Bare Pavement”. Table 5.6, Toronto’s Road Classification Salting Chart, shows road classifications and their associated levels of service [Toronto, 2009].

Table 5.6: Toronto's Road Classification - Salting Chart
(Adapted from City of Toronto Salt Management Plan 2009)

Road Classification	Typical	Winter Service Levels	De-icer	Application Rate kg/lane-km	Time Frame To Complete De-icer Operations
Expressways	Don Valley Parkway	Bare Pavement	100% Rock Salt	70 / 140 / 180	Up to 2.5 cm of snow 1-2 hrs
Arterials (minor / major)	Yonge Street, Sheppard Ave.	Bare Pavement	100% Rock Salt	70 / 140 / 180	Up to 5 cm of snow & continuing 2-4 hrs
Collectors	Main Streets through sub-division	Centre Bare Pavement	100% Rock Salt	70 / 140 / 180	Up to 8 cm of snow & stopped 4-6 hrs
Locals	Residential Streets	Safe and Passable Pavement	100% Rock Salt	70 / 90	Up to 8 cm of snow + stopped 8-12 hrs
Laneways		Safe and Passable Pavement	100% Rock Salt	180	24 hrs

The decision-making hierarchy, within the Transportation Division, is aligned with the organizational structure; however, the hierarchy is reversed for winter operations' decision making. Frontline staff is tasked with making the first decision under preauthorized criteria. As the storm and road conditions escalate, the need to escalate the operation requires the next level up on the organizational chart to make a decision. In this configuration, the front line staff can be considered level zero, their supervisors would be level one and the managers are level two followed by the winter director at level three. The winter director would have the responsibility of coordinating citywide responses to winter events, as well as resolving conflicts between the winter district managers when opinions differ on coordination issues between these districts. Other senior management staff are kept informed throughout the process to ensure consistency and continuity of the decision making process. Figure 5.10 has been reproduced from an existing flow chart for the Toronto-East York District, illustrating the district's winter mobilization procedure. It should be noted that the mobilization procedure further separates type 2 stores into two subcategories, from 5 cm to 8 cm and from 8cm to 15 cm, thus setting the 8 cm mark as the threshold for initiating snow plowing activities.

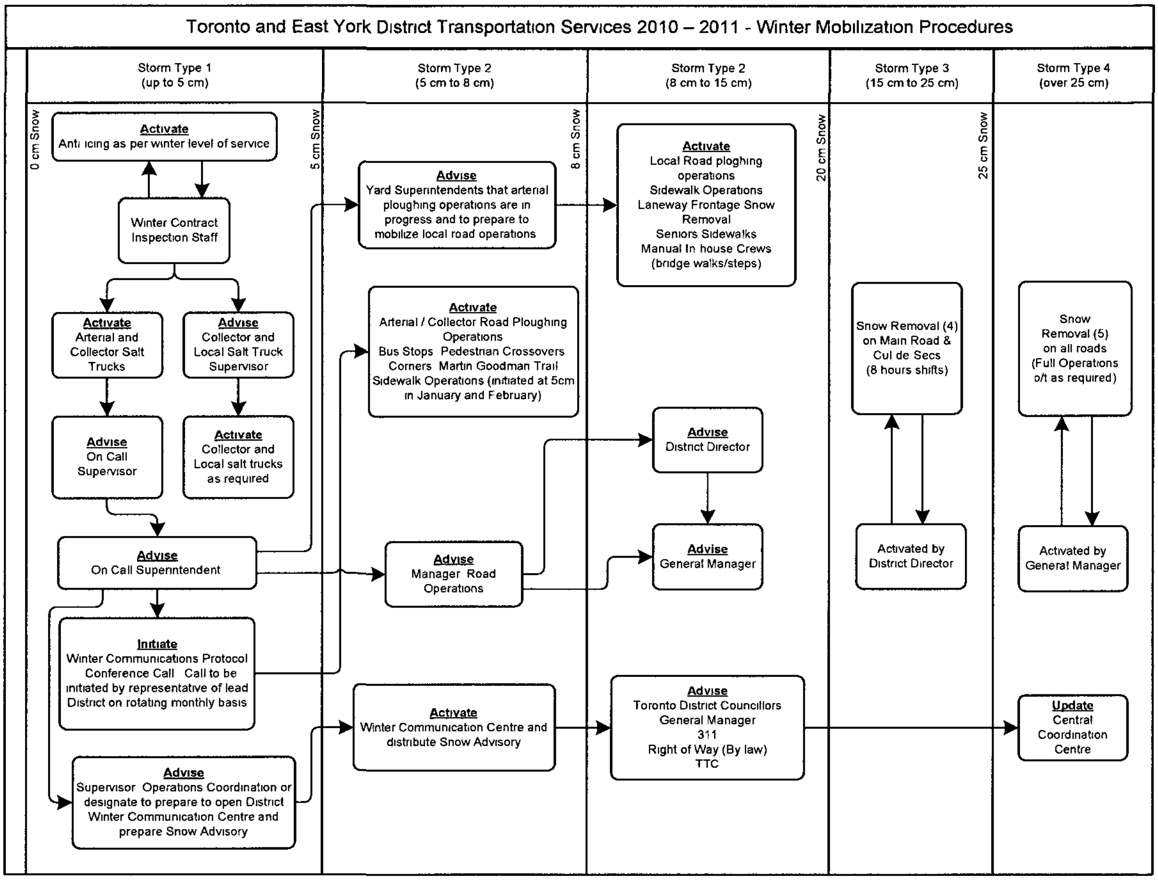

Figure 5.10: Winter Mobilization Procedure
(Source: City of Toronto, reproduced)

5.3. Weather Data for Toronto

Weather data for the Toronto area was obtained from the National Climate Data and Information Archive [Environment Canada, 2010], provided by the Canadian Ministry of the Environment, Environment Canada. The information extracted was for the Environment Canada weather station at the Toronto Lester B. Pearson International Airport, which is positioned at a Latitude: 43°40'38.000"N , Longitude: 79°37'50.000"W, and an Elevation of 173.40 metres. Daily data for each of the winter months for the years 2004 to 2010 was extracted in the monthly weather report summary formats. The months starting with November and ending with April, inclusive, are considered the winter months and are treated as one season; therefore each season has a designation similar to 2004-2005. The report includes temperature, precipitation and wind recordings. A sample report for the month of December 2008 is shown in Figure 5.11.

Environment Canada Environnement Canada Canada

National Climate Data and Information Archive
www.climate.weatheroffice.gc.ca

Daily Data Report for December 2008

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days °C	Cool Deg Days °C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	3.4	-0.9	1.3	16.7	0.0	3.2	0.4	3.6	0	21	46
02	0.6	-1.6	-0.5	18.5	0.0	0.0	T	T	T	26	44
03	6.4	-1.0	2.7	15.3	0.0	0.4	0.0	0.4	0	20	44
04	4.8	-4.3	0.3	17.7	0.0	1.0	T	1.0	0	27	56
05	-2.2	-8.0	-5.1	23.1	0.0	0.0	T	T	0	26	52
06	-1.7	-6.6	-4.2	22.2	0.0	0.0	2.2	1.8	T	19	37
07	-2.1	-12.7	-7.4	25.4	0.0	0.0	T	T	2	30	63
08	-2.6	-11.2	-6.9	24.9	0.0	0.0	3.4	1.4	2		<31
09	3.7	-3.4	0.2	17.8	0.0	6.4	6.0	12.4	6		<31
10	2.6	-9.6	-3.5	21.5	0.0	3.6	0.4	4.2	1	34	44
11	-1.8	-10.1	-6.0	24.0	0.0	0.0	0.0	0.0	1		<31
12	-1.4	-11.9	-6.7	24.7	0.0	0.0	T	T	1	29	41
13	1.1	-12.9	-5.9	23.9	0.0	0.0	0.2	0.2	1	20	39
14	5.1	0.6	2.9	15.1	0.0	1.0	T	1.0	1	22	37
15	10.6	-7.3	1.7	16.3	0.0	3.8	T	3.8	0	24	74
16	-3.3	-7.6	-5.5	23.5	0.0	0.0	4.4	4.0	T		<31
17	-0.1	-5.8	-3.0	21.0	0.0	0.0	5.4	4.6	8	28	39
18	-2.2	-8.4	-5.3	23.3	0.0	0.0	0.0	0.0	7	26	33
19	-4.2	-14.5	-9.4	27.4	0.0	0.0	16.0	15.2	7	3	57
20	-10.4	-17.7	-14.1	32.1	0.0	0.0	0.4	0.2	22	7	32
21	-3.6	-13.7	-8.7	26.7	0.0	0.0	5.4	5.4	24	25	69
22	-7.1	-13.5	-10.3	28.3	0.0	0.0	T	T	24	30	59
23	-1.4	-11.7	-6.6	24.6	0.0	0.0	11.0	11.6	23	18	35
24	6.1	-1.5	2.3	15.7	0.0	10.8	1.8	12.6	36	27	93
25	1.2	-4.6	-1.7	19.7	0.0	0.0	0.2	0.2	31	28	74
26	2.5	-4.9	-1.2	19.2	0.0	T	2.2	1.8	30		<31
27	14.2	1.4	7.8	10.2	0.0	9.0	0.0	9.0	22	20	39
28	15.9	0.1	8.0	10.0	0.0	0.8	0.0	0.8	2	25	93
29	5.1	-2.2	1.5	16.5	0.0	T	T	T	T	30	85
30	-0.5	-5.9	-3.2	21.2	0.0	0.0	3.8	3.4	T	29	72
31	-5.8	-14.3	-10.1	28.1	0.0	0.0	1.6	1.2	5	31	57
Sum				**654.6**	**0.0**	**40.0**	**64.8**	**99.8**			
Avg	**1.1**	**-7.3**	**-3.1**								
Xtrm	**15.9**	**-17.7**								**27S**	**93S**

Figure 5.11: Monthly Weather Records
[Environment Canada, 2010]

The weather data was then processed and sorted to provide daily data reports for the six winter seasons from 2004-2005 through to 2009-2010. Based on the winter season weather information, it is possible now to determine the frequency of storm occurrences within the study period for each winter season. Using the criteria established by the City for the four types of storms, and applying the criteria on the Environment Canada weather data for each of the winter seasons, the type, number, and total of snow storms for each season have been categorized and tabulated in Table 5.7. It is observed that the majority of snow storms are of type 1 and to a lesser extent of type 2, while type 3 is infrequent, and type 4 is extremely rare. Further, using the same categorization on a monthly basis rather than seasonal, it can be seen that the months of December, January and February have the most number of storm occurrences, and the most are of type 1 snow storms, which is less than five centimetres of accumulations per storm. Figure 5.12 shows the monthly frequency of the four types of snow storms for the winter months within the study period.

Table 5.7: Snow Storm Type and Frequency

Winter Season	Snow Storm Type 1 0-5cm	Snow Storm Type 2 5-15cm	Snow Storm Type 3 15-25cm	Snow Storm Type 4 >25cm	Total number of Snow Storms
2004-2005	67	10	-	-	**77**
2005-2006	74	5	-	-	**79**
2006-2007	79	4	-	-	**83**
2007-2008	78	8	2	1	**89**
2008-2009	68	10	1	-	**79**
2009-2010	56	2	-	-	**58**

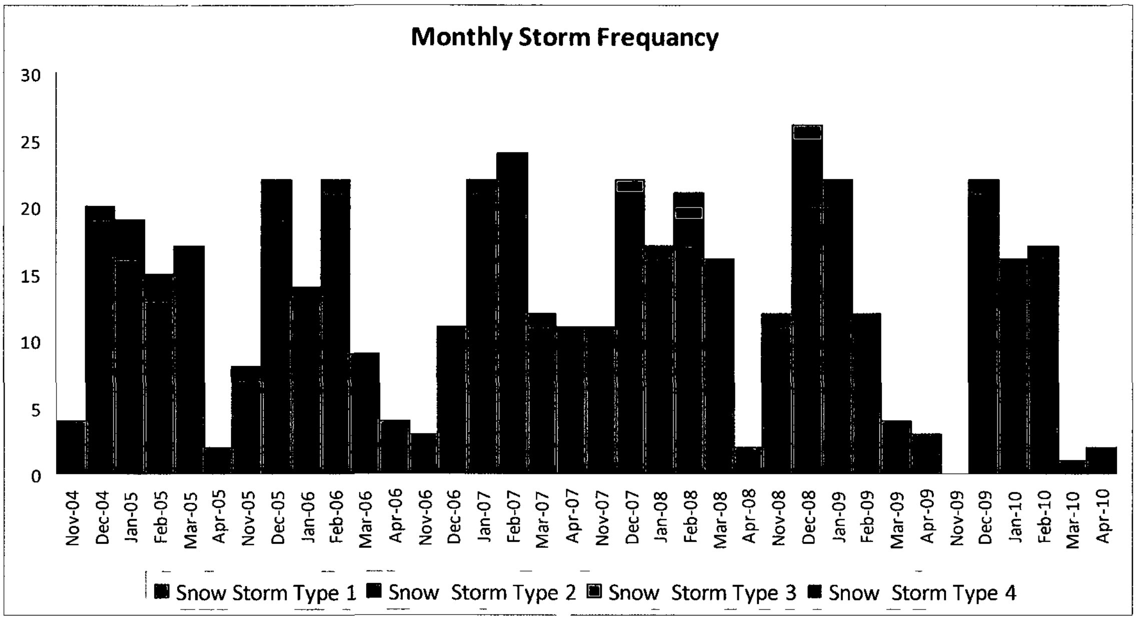

Figure 5.12: Monthly Snow Storm Frequency

5.4. Winter Operation's Data from the City of Toronto

Operational data was obtained from the Toronto's Transportation Services West District (Etobicoke-York). The amount of data available was rather massive; therefore, the data sample was limited to the one district above, and more specifically for the contracted winter services. Data records were extracted from the Toronto Maintenance Management System (TMMS), an activity based maintenance management system used to record, track, and pay for in-house resources and outsourced services. The data sample included a significant number of records. A record refers to one line of data with 41 columns; a sample raw data screen capture is shown in Figure 5.13. The number of records extracted from TMMS for each winter season is listed in Table 5.8.

Table 5.8: Raw Data Records used in Study

Winter Season	No. of Data Records
2004-2005	6339
2005-2006	4629
2006-2007	4279
2007-2008	7441
2008-2009	3210
2009-2010	1463

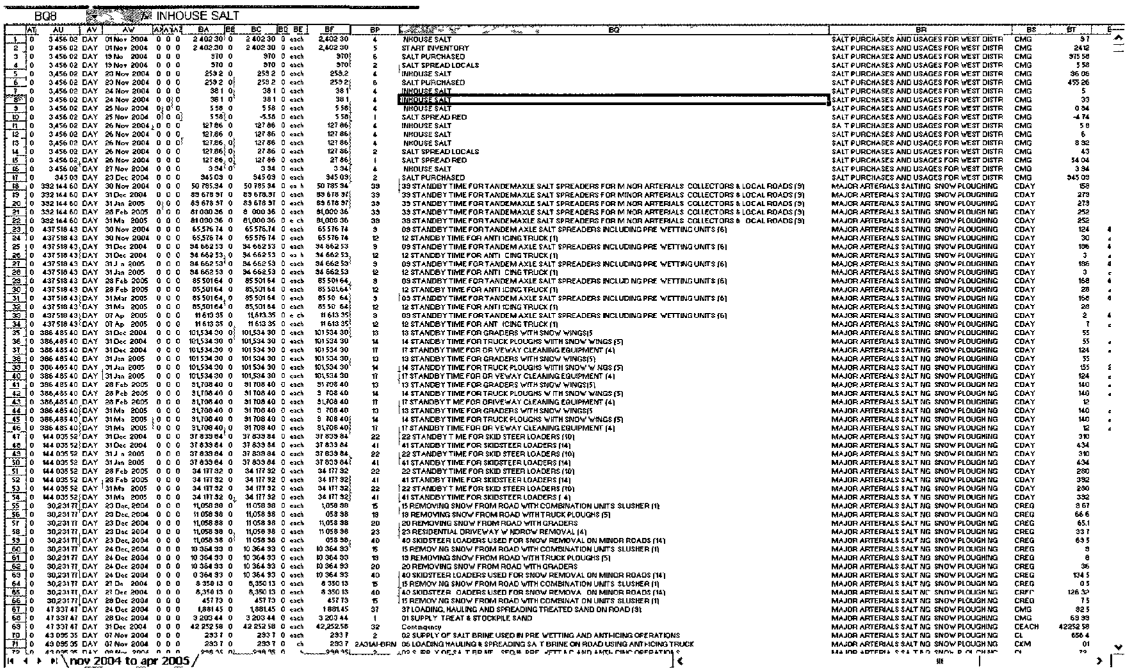

Figure 5.13: Winter Operations Raw Data -Screen Capture

The raw data obtained was for contracted services which included salting, anti-icing and plowing for the West District. The data records also contained other activities such as loading and unloading salt, equipment standby time payments, staff standby time, shift and overtime premiums, and contingency maintenance, as well as some in-house information. The focus was on slating and anti-icing vehicles hired under contract at the two maintenance depots within the west district road operation. Those hired units are believed to have the most representative records for decision-making for mobilization. Also known as callouts, mobilizations represent how many times the vehicles were called out for service. The data was manipulated to extract the records that directly relate to vehicle mobilization; accordingly other records were ignored. This was done for the two focus activities of this research, namely salting and anti-icing. Winter maintenance equipment is identified as a 'resource' within TMMS, using the units' identification numbers, in combination with resource descriptions and position descriptions, and applying successive data filtering techniques, a reduced data set was produced. The data set includes dates of mobilization, number of mobilizations for each date, number of vehicle units mobilized per day, and the amount of kilometres driven collectively by all units deployed that day, and the type of operation carried out whether salting or anti-icing. Table 5.9 shows a sample of the reduced data set, which is also included in Appendix B.

The data terminologies and descriptions differed slightly for the seasons of 2004-2005, 2005-2006, 2006-2007, and 2007-2008, from those of the winter seasons of 2008-2009 and 2009-2010. This could be attributed to change in contract service providers, where one contract concluded at the end of the winter season in 2008 and another started for the following winter season in 2008-2009. However the differing terminologies were unified in the reduced data set and operations were grouped under unified activity labels of Anti-icing and Salting. Other concerns with the raw data were measurement units for salting and anti-icing. They have been per the kilometre driven, which has been consistent throughout the study period. However, only three winter seasons had records of few incidents where the service measurement units were by the hour of service. These occurrences were infrequent and near negligible for the purpose of calculating the number of vehicle deployments. It could however affect the distance driven for each winter event, but not enough to alter the calculations. The few incidents of hourly charges were extracted, and their presumed values in terms of kilometres were included in the total number of kilometres.

Table 5.9: Sample Data – Winter Mobilization

Mobilization Data for Winter 2004-2005 City of Toronto - West District					
Winter Day No.	**Date**	**Mobilization Per Date Totals**	**Units per Day**	**KM Driven per Day**	**Operation**
3	03-Nov-2004	1	1	22.8	Salting
7	07-Nov-2004	2	2	258	Anti-icing
8	08-Nov-2004	2	2	258	Anti-icing
11	11-Nov-2004	2	2	258	Anti-icing
13	13-Nov-2004	2	2	258	Anti-icing
25	25-Nov-2004	17	17	436.2	Salting
26	26-Nov-2004	61	40	1709.34	Salting
28	28-Nov-2004	2	2	258	Anti-icing
31	01-Dec-2004	2	2	258	Anti-icing
33	03-Dec-2004	2	2	258	Anti-icing
34	04-Dec-2004	2	2	258	Anti-icing
36	06-Dec-2004	100	38	2729.2	Salting
37	07-Dec-2004	79	38	2097.12	Salting
41	11-Dec-2004	76	38	2030.19	Salting

Analyzing the reduced data set further, it is possible to calculate the following:

- Mobilization Days: days where at least one salt spreader or anti-icing unit was called out for service.

- Service Trips: indicates the number of mobilizations (i.e. callouts, trips, beats, routes) per day of mobilization.
- Trip-Vehicles: is the total number of vehicles mobilized per season, for each day of mobilization regardless of how many trips they have done on that particular day. Trip-vehicle totals are the aggregation of "units per day" shown in Table 5.9 for the each of winter seasons.
- Kilometres Driven: The number of service kilometres driven by all vehicles during mobilization days within a winter season.

The mobilization information was combined with the corresponding weather information to show the number of mobilization days, alongside the number of snow days and the total snow accumulation per winter season as presented in Table 5.10. For example, for the winter season of 2004-2005, the summary indicates that there were 83 days in that season where at least a single salt spreader truck was mobilized. In those 83 days, there were 4,541 individual salting trips performed by 2,111 trip-vehicles, driving a total of 141,896 kilometres.

Table 5.10: Winter Mobilization and Weather Data Summary

Winter Season	Mobilization Days	Service Trips	Trip-Vehicle	Km's Driven	No. of Snow Days	Total Snowfall
2004-2005	83	4,541	2,111	141,896	77	148.1
2005-2006	62	4,053	1,232	112,419	79	85.0
2006-2007	58	3,851	1,389	125,415	83	60.3
2007-2008	80	5,871	2,209	187,483	89	194.0
2008-2009	74	1,987	1,986	103,066	79	152.7
2009-2010	54	1,227	1,226	65,263	58	52.4

5.5. Synthesis of Findings and Implications

Using the combined data set of operational and weather data, and for the analysis of anti-icing and salting mobilizations, the following terminologies are used:

- Anti-icing Mobilization Days: Number of days where at least one unit was mobilized for anti-icing operations.
- Salting Mobilization Days: Number of days where at least one unit was mobilized for salting operations.
- Anti-icing & Snowfall Days: Number of days where at least one unit was mobilized for anti-icing operations, and at least a trace of snowfall were recorded.
- Salting & Snowfall Days: Number of days where at least one unit was mobilized for salting operations, and at least a trace of snowfall was recorded.
- Snowfall without Mobilization Days: Number of days where at least a trace of snowfall was recorded and no units were mobilized.
- Anti-icing Mobilization without Snowfall: Number of days where at least one unit was mobilized for anti-icing operations, and no snowfall was recorded for the same day.
- Salting Mobilization without Snowfall: Number of days where at least one unit was mobilized for salting operations and no snowfall was recorded for the same day.
- Storm Days or Snow Days: Number of days where at least a trace of snowfall was recorded

- Snowfall Amount: The amount of annual cumulative snowfall recorded daily for the subject weather station by Environment Canada, measured in centimetres.

5.5.1. Analysis for Anti-icing Decisions

While Anti-icing is relatively recent to the winter maintenance operation, it has been slowly integrated and utilized. The complement of anti-icing units dedicated for anti-icing operations within the study area has increased from 2 units to 4 units starting the winter of 2008-2009. The number of units is not critical to this analysis as it is focused on the number of times a decision was made to mobilize those units. The objective here is to investigate how many times the anti-icing units were called out and if that decision was appropriate for the weather and road conditions. The anti-icing mobilization days are summarised in Table 5.11. It is observed that there are incidents where anti-icing units were mobilized with no recorded snowfall events. However, in order to qualify these decisions, the anti-icing days were compared to weather and RWIS data for the same days. This included air and pavement temperatures as well as snowfall records. Air temperatures were obtained from the Environment Canada weather archives, and pavement temperatures were obtained from the City's RWIS website. Unfortunately the data from RWIS was only available for the last 3 winter seasons of the study period.

Table 5.11: Anti-icing Mobilizations

Winter Season	Anti-icing Mobilization Days	Anti-icing & Snowfall Days	Anti-icing Mobilization without Snowfall
2004-2005	19	6	13
2005-2006	24	13	11
2006-2007	14	2	12
2007-2008	8	5	3
2008-2009	13	7	6
2009-2010	16	3	13

Referring to Table 5.11, it is observed for the winter of 2007-2008 that the anti-icing units had been mobilized a total of 8 times, 3 of which had been with no snowfall recoded. This is near 38% of over mobilization. However, when examining the minimum and max temperatures of the 3 missed days, it is found that 2 days had a pavement temperature of less than one degree Celsius, while the max pavement temperature on all three days had reached above 9 degrees Celsius, which would not allow any precipitation to form ice on the road. This means that at least one of the anti-icing mobilizations could have been avoided, provided a more reliable pavement condition forecast had been used in making the decision to mobilize the anti-icing units. Similarly, for winter 2008-2009, it is observed a 46% of possible false mobilizations, and upon further examination of the daily pavement temperature extremes, they indicate that 5 of the 6 mobilizations could have been eliminated due to higher pavement temperatures (ranging from a minimum of 1 degree Celsius up to a maximum of 26 degrees Celsius. Meanwhile, for winter of 2009-2010 it is observed that there was 13 days of mobilization without snowfall, and based on pavement temperatures, 6 of the 13 days of mobilizations could have been avoided.

It should be understood that an anti-icing activity is called out in anticipation of snowfall, which may give rise to realization that anti-icing is highly speculative, and requires an increased level of experience and judgement. Nevertheless, it is possible to enhance the accuracy for mobilization decisions by employing more reliable pavement forecasts, and increased usage of live pavement temperature monitoring.

5.5.2. Analysis for Salting Decisions

The decision to mobilize salting operations is by virtue of its nature less speculative than decisions to mobilize for anti-icing, as they are usually a direct response to snow falling on the road. However, it is not an exact science, and there is still some degree of speculation since it also relies on weather forecasts. Premature mobilization, or under-mobilization, may be caused when the decision is based on inaccurate or incomplete information. The operation could also continue with the deployment of salt spreaders beyond what is required. The objective of this analysis is to investigate how many times the salting units were called out, and if these decisions were appropriate for the weather, and subsequently to compare the results with winter vehicular collision data. Table 5.12 shows a summary, per winter season, of mobilization frequency of salting units against the number of days with snowfall accumulations.

Table 5.12: Salting Mobilization Days

Column ID.	A	B	C	D	E
			Salting Mobilization without Snowfall		
Winter Season	Salting Mobilization Days	Salting & Snowfall Days	Salting Mobilization with a day of snow earlier	Possible Premature Mobilization	% missed of Total Mobilization (E = D/A)
2004-2005	64	54	6	4	6.25%
2005-2006	38	33	4	1	2.63%
2006-2007	43	39	2	2	4.65%
2007-2008	71	54	9	8	11.27%
2008-2009	61	51	5	5	8.20%
2009-2010	38	33	4	1	2.63%

The data shows that the number of salting mobilization days is greater than the number of days where it coincided with snowfall. Upon further investigation, the number of days where a snow event was recorded a day earlier were separated and excluded from the count. Those days were either an isolated one-day snowfall event or part of a seemingly multi-day snow storm. The result was calculating the number of days where a decision made to mobilize may have been premature or unwarranted.

With an assumption that a mobilization call is made every time there is snow on the ground, then the number of snowfall days with "Trace" of snow need to be excluded from the counts, which means that while there is snowfall occurring, it may not necessarily mean snow accumulation. Table 5.13 shows that there is close proximity of the number of snow days with accumulations and the actual number of days of mobilization with snowfall. This may indicate that the cause of premature mobilization is mainly within the days of trace snowfall rather than within days with significant snowfall accumulation.

Table 5.13: Salting Mobilization Days vs. Snow Days

			Salting Mobilization without Snowfall		Snow Days		
Winter Season	Salting Mobilization Days	Salting & Snowfall Days	Salting Mobilization with previous snow day	Possible Premature Mobilization Days	Days with "Trace" Snowfall only	Days with Snowfall above "Trace"	Total Snow Storm Days
2004-2005	64	54	6	4	24	53	77
2005-2006	38	33	4	1	39	40	79
2006-2007	43	39	2	2	45	38	83
2007-2008	71	54	9	8	33	56	89
2008-2009	61	51	5	5	33	46	79
2009-2010	38	33	4	1	29	29	58

While the above is focused on the number of times the decision was made or missed, it is worth directing some attention to the strength, or the level of effort, of the response. It is not unusual that the decision to mobilize applies only to some salt spreaders rather than the full fleet. This measured mobilization could be as little as one unit, and up to the full complement of the assigned fleet within the study area.

One method, to measure the level of effort exerted in mobilization, is the amount of kilometres driven by the salt spreaders during the spreading of salt for road de-icing operations. The total kilometres driven were aggregated from the reduced data set in Appendix B. Using the total seasonal snow accumulation, it is possible to calculate the level of effort in terms of the number of kilometres required to treat one centimetre of snowfall. Using the study period average for the amount of kilometres driven per centimetre of snowfall, and comparing each kilometre per centimetre result against the study period average and expressing it in percentages, a 100% reading means the effort is at average, while a 107% means that there was 7% more effort applied for this season than the average for the study period. It can be observed that the winter season of 2008-2009 has the lowest level of effort, with 43% below the average, versus the winter of 2006-2007 that has the highest, with 73% more effort than the study period average. Results are summarized in Table 5.14. It should be noted that the highest snowfall, within the study period, was recorded in 2007-2008 and the lowest in 2009-2010, which does not reconcile with the average expectation of the applied level of effort. This is an indication that decisions for winter operations are not made with the same consistency, and do not resemble a direct relation to prevailing road conditions. However, it should also be noted that this method does not take into account how many days of snowfall it took for all the snow to accumulate for the season.

Table 5.14: Level of Effort – Kilometres per Centimetre of Snow Salted

Column ID.	A	B	C	D
Winter Season	**Aggregated Daily Kilometres Driven per Season**	**Snowfall amount (cm)**	**km per cm of snow**	**% effort variation from study period average of km per cm of snow**
			C = B / A	
2004-2005	136,952	148.1	924.73	79%
2005-2006	105,879	85	1,245.64	107%
2006-2007	121,503	60.3	2,014.97	173%
2007-2008	185,083	194	954.03	82%
2008-2009	100,810	152.7	660.19	57%
2009-2010	61,838	52.4	1,180.11	101%

It is also possible to measure the level of effort applied for slat spreading operations, based on the total seasonal snowfall, in relation to the number of days with significant snow accumulation with more than a trace of snowfall. This produces an average seasonal daily snow accumulation per day of snowfall. For example, the winter of 2006-2007 had an average seasonal daily snow accumulation of 1.59 cm, while for 2007-2009 it was 3.46 cm. Using this average multiplied by the number of salting mobilization days, then one can estimate the theoretical capacity of snow accumulation, that would have been treated by salting for that winter season. Comparing this theoretical capacity with the actual snowfall for the season may determine if the mobilization each season was over or under what was required. Table 5.15 shows that for 5 of the 6 seasons in the study period may possibly be over-mobilized by as much as 33% from the theoretical salting capacity.

Table 5.15: Level of Mobilization vs. Theoretical Salting Capacity

Column ID.	A	B	C	D	E	F	G
Winter Season	Salting Mobilization Days	Salting & Snowfall Days	Days with Snowfall above "Trace"	Snowfall amount (cm)	Average Seasonal Daily Snow accumulation (cm/day)	Theoretical capacity of salting of snowfall for actual days of mobilization (cm/year)	Possible Variation in Mobilization per Seasonal Snowfall
					E = D / C	*F = E * A*	*G = F / D*
2004-2005	64	54	53	148.1	2.79	178.84	121%
2005-2006	38	33	40	85	2.13	80.75	95%
2006-2007	43	39	38	60.3	1.59	68.23	113%
2007-2008	71	54	56	194	3.46	245.96	127%
2008-2009	61	51	46	152.7	3.32	202.49	133%
2009-2010	38	33	29	52.4	1.81	68.66	131%

5.5.3. Winter Collisions Analysis

The City of Toronto keeps annual statistics on road traffic collisions. The collision data includes information on road surface condition at the time of the collision. This information has been extracted to show winter season collision by road surface condition, summarized in Table 5.16. It should be noted that the data has been accumulated from city wide incidents. However, the study area is one district only. Nevertheless, it is assumed that the west district operational data is representative of the city's winter operations. The collision information presented in Table 5.16 is for winter road surface condition, as identified by Toronto Police on collision reports.

Table 5.16: Winter Season Collision by Road Surface Condition
(Source: City of Toronto & Toronto Police Service)

Winter Season Collision by Road Surface Condition					
Winter Season	Road Surface Conditions				Total Collisions
	Loose Snow	Ice	Slush	Packed Snow	
2004-2005	1,924	1,323	991	703	4,941
2005-2006	959	666	449	239	2,313
2006-2007	1,101	601	608	277	2,587
2007-2008	1,909	967	887	741	4,504
2008-2009	1,866	887	1,017	563	4,333
2009-2010	588	316	389	135	1,428

Taking the analysis further, and using the aggregated number of collisions that have been attributed to winter surface conditions, as presented in Table 5.16, and calculating the variation of each seasonal reading with the average of collisions of the study period. This is shown against the variations of the number of kilometres driven for each centimetre of seasonal snowfall, as shown in Table 5.14, then, it is necessary to join the percent variations in Table 5.17 in order to show possible patterns for such variations. Furthermore, using column D and column F from Table 5.17, and illustrating them graphically as shown in Figure 5.14, it is observed that a trend is manifested, in that the variations of both values indicate an opposite relationship in that increases in variation for level of effort seem to correspond to decreases in variations for collisions.

Table 5.17: Kilometres per Centimetre of Snow and Winter Collisions

Column ID.	A	B	C	D	E	F
Winter Season	**Aggregated Daily Kilometres Driven per Season**	**Seasonal Snowfall amount (cm)**	**km per cm of snow**	**% Variation from study period average of km per cm of snow**	**Winter Road Condition Collisions**	**% Variation from study period average of collisions**
2004-2005	136,952	148.1	924.73	79%	**4,941**	147%
2005-2006	105,879	85	1,245.64	107%	**2,313**	69%
2006-2007	121,503	60.3	2,014.97	173%	**2,587**	77%
2007-2008	185,083	194	954.03	82%	**4,504**	134%
2008-2009	100,810	152.7	660.19	57%	**4,333**	129%
2009-2010	61,838	52.4	1,180.11	101%	**1,428**	43%

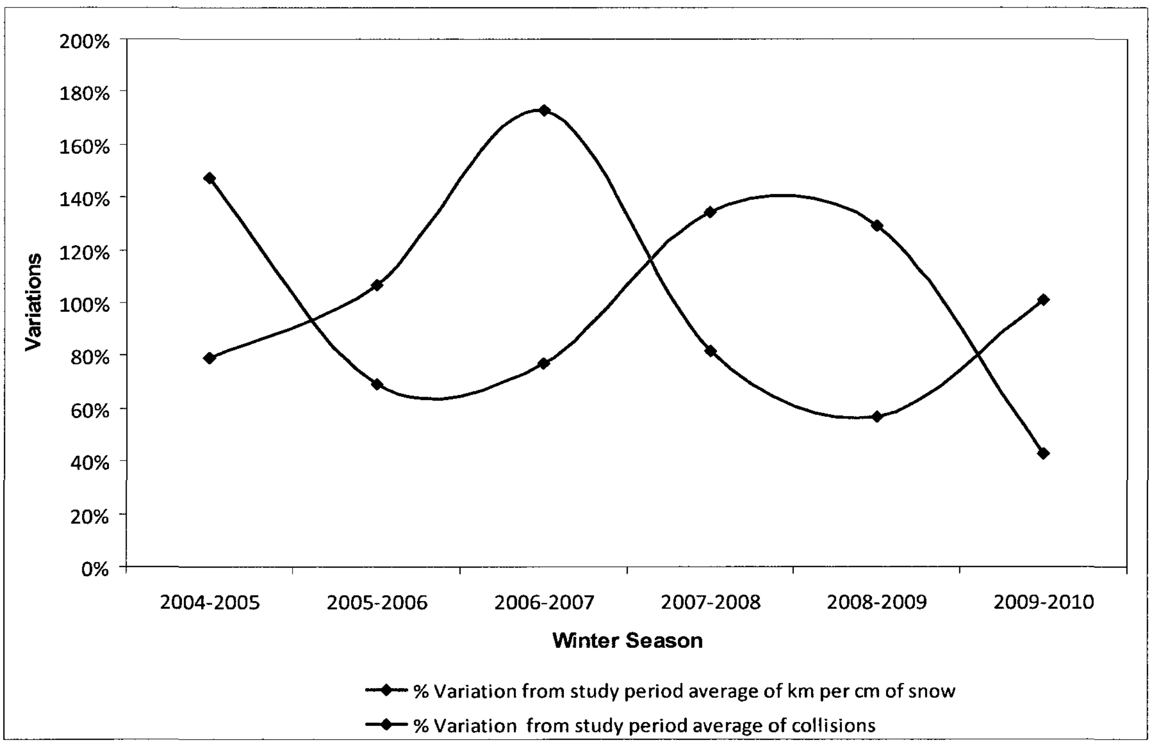

Figure 5.14: Kilometres Driven vs. Collisions Variations

5.5.4. Data Correlation

Furthermore, to investigate a relationship between the various statistics arrived at during the analysis; Table 5.18 was compiled to show the main information identifying the winter maintenance operation within the study period. The columns of Table 5.18 have been identified with the letters A through F, with each column representing one operation's variable. Using the operation variables in Table 5.18, as identified by their column ID, a correlation matrix was developed in order to show the relationship between the various variables against each other. Table 5.19 shows the correlation matrix, noting that the correlation calculations were produced using Microsoft Excel correlation function.

Table 5.18: Study Period Winter Season Statistics

Column ID.	A	B	C	D	E	F
Winter Season	Aggregated Daily Kilometres Driven per Season	Seasonal Snowfall total (cm)	Total Snowfa ll Days above "Trace"	Salting Mobilization Days	Winter Road Condition Collisions	seasonal Daily Average Snowfall (cm of snow per day of snowfall)
2004-2005	136,952.00	148.1	53	64	4,941	2.79
2005-2006	105,879.00	85	40	38	2,313	2.13
2006-2007	121,503.00	60.3	38	43	2,587	1.59
2007-2008	185,083.00	194	56	71	4,504	3.46
2008-2009	100,810.00	152.7	46	61	4,333	3.32
2009-2010	61,838.00	52.4	29	38	1,428	1.81

Table 5.19: Winter Season Statistics –Correlation Matrix

	Correlation Matrix					
Column ID.	A	B	C	D	E	F
A	1.000	0.757	0.876	0.759	0.710	0.590
B	0.757	1.000	0.936	0.962	0.911	0.970
C	0.876	0.936	1.000	0.923	0.944	0.834
D	0.759	0.962	0.923	1.000	0.946	0.907
E	0.710	0.911	0.944	0.946	1.000	0.848
F	0.590	0.970	0.834	0.907	0.848	1.000

Referring to Table 5.19, it can be observed that the strongest relationship seems to be between seasonal snowfall total and the number of salting mobilization days, (Column B & D, r =.962), seconded by a strong relationship between winter collisions and number of salting days, which is rather interesting. One would expect that more salting days would result in fewer collisions; however, it seems that the number of collisions correlates positively and strongly with the amount of seasonal snowfall, number of snow days, and the number of mobilization days. This shows inconsistencies in the relationship between mobilization and collisions, which will require further research beyond the scope of this thesis.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Winter road maintenance operation is a series of activities performed at various times to keep roads safe and passable during severe winter conditions. Winter road maintenance components must be coordinated to allow managers to make the right decisions at the right time. Key elements contributing to the decision-making process of winter road maintenance were explored for their influence over the operation. A framework for a systematic decision-making process was proposed, based on the identified key elements, including road weather monitoring and forecasting, pavement temperature, material types, and application techniques. Subsequently, a working data set was developed for a study period of six winter seasons from 2004 to 2010. The data set consisted of post-event winter maintenance operations data from the City of Toronto, cross referenced to actual weather readings for the same period. The data set was showing deployment of maintenance vehicles as representation of decisions made for resource mobilizations. In addition, the associated winter related collision statistics were also included. Analysis of the data set was performed to examine the implication of decision actions, and to determine if there were any relationships between winter maintenance operational mobilizations, weather conditions, and winter related collisions. The following are conclusions and recommendations drawn from this study:

- Key elements contributing to the decision-making process of winter road maintenance operations can be grouped as follows: 1) Weather, including snow and ice precipitation, weather monitoring, and forecasting. 2) Road, including road surface temperature, road surface condition, road classification, and traffic volumes. 3) Materials for winter control, including abrasives and chemical de-icers, de-icer working temperature range, material application techniques, and material spreading equipment. 4) Policies and procedures, including legislations, level of service, maintenance priorities, and decision-makers organizational hierarchy. And, 5) Operational verification, including data collected from the winter road maintenance operations, such as type, amount, location, and timing of materials applied. The literature review had also revealed a deficiency in the utilization of decision support systems, that also includes a deficiency in incorporating feedback from the maintenance operation into the decision making process for the purpose of verification and decision adjustments.

- A framework was proposed for a systematic decision-making process for winter road maintenance operation. The proposed framework is based on staged processes, a pre-storm stage and sequential alternative stages for in–storm actions; in-storm alternatives are dependant on decisions made in the preceding stage. The proposed framework would be customized to address the specific input variables for a particular road authority. The framework includes a series of decision points based on key operational elements, such as salt application rate change to correspond to road surface temperature. A framework encompassing a hierarchy for decision-making, a prescribed level of service, and a systematic approach designed around key operational elements will help in reducing the margin of decision error, and thus provide for more efficient winter road maintenance operations.

- Results of the analysis of actual post-event operational data allowed quantification of decisions in terms of number of vehicle mobilization recorded to deliver salting or anti-icing activities, and when cross-referenced with associated weather data, it was possible to estimate missed opportunities. However, applying the proposed framework would have reduced the number of possible premature decisions and would have resulted in cost savings. Furthermore, analysis of relationships between mobilization and number of kilometres driven for salting or anti-icing activities showed inconsistencies in the amount of effort applied for the treatment of a seasonal centimetre of snow. On the other hand the relationship between mobilization and collisions was inconclusive and will require further research.

- Measuring the effects of winter road maintenance decisions can be achieved by establishing value for decisions which is measured in terms of cost impact and level of effectiveness. This is done by measuring the number of kilometres driven to treat a seasonal centimetre of snow, whereby a seasonal centimetre of snow is calculated from the total seasonal snow accumulation divided by the number of snow accumulation days for that winter season. Quantifying efforts resulting from winter maintenance operational decisions allows for the benchmarking of operational decisions for effectiveness and efficiency.

6.2. Recommendations and Future Work

In order to further and better define relationships between decision-making, the various elements of the winter road maintenance operations, and the resulting effects, the following is recommended:

- That for road authorities, a decision tracking system be developed for road operations, whereby decisions are recorded every time based on clear definitions. Furthermore, it is recommended that such system be attached to a decisions database holding other relevant information to decisions being made, and aligned with key decision-making elements.
- That further research be undertaken, utilizing a study period that is longer than ten years, whereby a much larger working data set is developed for the purpose of such research.

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APPENDIX A

Daily Data Report for Winter Weather Records
Winter Seasons 2004-2005 to 2009-2010

Daily Data Report for Winter 2004-2005

Environment Canada			National Climate Data and Information Archive					www.climate.weatheroffice.gc.ca			
Day	**Max Temp**	**Min Temp**	**Mean Temp**	**Heat Deg Days**	**Cool Deg Days**	**Total Rain**	**Total Snow**	**Total Precip**	**Snow on Grnd**	**Dir of Max Gust**	**Spd of Max Gust**
	°C	°C	°C	°C	°C	mm	cm	mm	cm	10's Deg	km/h
31/Oct/2004	12.8	7	9.9	8.1	0	T	0	T	0	26	63
01/Nov/2004	10.9	6.3	8.6	9.4	0	T	0	T	0		<31
02/Nov/2004	9	5.3	7.2	10.8	0	13.2	0	13.2	0	33	50
03/Nov/2004	10.2	3.1	6.7	11.3	0	0	0	0	0	34	50
04/Nov/2004	7.4	3.3	5.4	12.6	0	9.8	0	9.8	0	28	72
05/Nov/2004	8.6	2.7	5.7	12.3	0	2.6	0	2.6	0	31	78
06/Nov/2004	13.5	5.7	9.6	8.4	0	0	0	0	0	26	56
07/Nov/2004	14.7	2.4	8.6	9.4	0	0	0	0	0	29	59
08/Nov/2004	5.6	-3.7	1	17	0	0	0	0	0	31	46
09/Nov/2004	2.9	-4.6	-0.9	18.9	0	0	0	0	0		<31
10/Nov/2004	13.4	2.8	8.1	9.9	0	0	0	0	0	23	46
11/Nov/2004	12.4	-2.4	5	13	0	0	0	0	0	34	50
12/Nov/2004	5.5	-3.2	1.2	16.8	0	0	0	0	0		<31
13/Nov/2004	4.9	-3.1	0.9	17.1	0	0	0	0	0		<31
14/Nov/2004	10.2	-3.2	3.5	14.5	0	0	0	0	0	29	32
15/Nov/2004	13.6	-1.7	6	12	0	0	0	0	0		<31
16/Nov/2004	13.9	1.7	7.8	10.2	0	0	0	0	0		<31
17/Nov/2004	12.4	7.7	10.1	7.9	0	0.4	0	0.4	0		<31
18/Nov/2004	14.9	6.8	10.9	7.1	0	0.2	0	0.2	0		<31
19/Nov/2004	10	6.3	8.2	9.8	0	0.2	0	0.2	0		<31
20/Nov/2004	7.6	5.1	6.4	11.6	0	2.2	0	2.2	0	9	41
21/Nov/2004	10	3.9	7	11	0	T	0	T	0	28	35
22/Nov/2004	9.2	0.9	5.1	12.9	0	0	0	0	0		<31
23/Nov/2004	9.7	0.2	5	13	0	T	0	T	0	20	35
24/Nov/2004	7.6	-0.1	3.8	14.2	0	14	2.4	16.4	0	1	52
25/Nov/2004	0.6	-3.2	-1.3	19.3	0	0.2	T	0.2	0	33	54
26/Nov/2004	4.4	-1.4	1.5	16.5	0	0	0.4	0.4	T	25	32
27/Nov/2004	10.4	3.8	7.1	10.9	0	2	0	2	0		<31
28/Nov/2004	9.3	2.1	5.7	12.3	0	12.8	T	12.8	0	25	65
29/Nov/2004	6.1	1.2	3.7	14.3	0	0	0	0	0	29	46
30/Nov/2004	6.8	-0.3	3.3	14.7	0	4.4	0	4.4	0		<31
01/Dec/2004	5.2	1.1	3.2	14.8	0	9.7	2.5	12.2	0	33	70
02/Dec/2004	3.6	0.5	2.1	15.9	0	0	T	T	0	26	33
03/Dec/2004	1.5	-5.7	-2.1	20.1	0	0	0.4	0.4	T	31	63
04/Dec/2004	6.1	-4.1	1	17	0	1.4	0	1.4	0	24	63
05/Dec/2004	4.3	-3.9	0.2	17.8	0	0	0	0	0	31	44
06/Dec/2004	-1.5	-4.7	-3.1	21.1	0	T	3	3	0	7	37
07/Dec/2004	11.9	-2.8	4.6	13.4	0	12.4	T	12.4	2	23	72
08/Dec/2004	7.3	1.6	4.5	13.5	0	0	0	0	0	27	67
09/Dec/2004	5.8	2.8	4.3	13.7	0	0	0	0	0		<31
10/Dec/2004	3.1	1.3	2.2	15.8	0	9.8	0	9.8	0	6	33
11/Dec/2004	1.3	-1	0.2	17.8	0	0.6	2	2.6	T	32	37
12/Dec/2004	2.7	-1.2	0.8	17.2	0	1.4	3	4.4	2	19	33
13/Dec/2004	2.6	-9	-3.2	21.2	0	0	T	T	T	34	56

14/Dec/2004	-4.1	-10.2	-7.2	25.2	0	0	0.4	0.4	T	31	48
15/Dec/2004	0.9	-5.6	-2.4	20.4	0	0	T	T	T	25	41
16/Dec/2004	4.9	-2.8	1.1	16.9	0	T	1.4	1.4	0	22	59
17/Dec/2004	-2.7	-8.8	-5.8	23.8	0	0	T	T	1	28	50
18/Dec/2004	3.4	-5.8	-1.2	19.2	0	T	T	T	1	22	48
19/Dec/2004	1.5	-23.5	-11	29	0	T	0.2	0.2	T	33	61
20/Dec/2004	-7.4	-24.3	-15.9	33.9	0	0	2.6	2	T	15	37
21/Dec/2004	2.5	-7.6	-2.6	20.6	0	0	0	0	3	24	37
22/Dec/2004	1	-4.2	-1.6	19.6	0	0	3.4	4	1		<31
23/Dec/2004	-1.5	-10.4	-6	24	0	4.2	15	19.2	15	32	52
24/Dec/2004	-7.3	-16.2	-11.8	29.8	0	0	0	0	18	27	39
25/Dec/2004	-6.4	-17.7	-12.1	30.1	0	0	1.2	1	16		<31
26/Dec/2004	-8.1	-15	-11.6	29.6	0	0	1.4	1.2	17	2	35
27/Dec/2004	-8.4	-17.8	-13.1	31.1	0	0	0	0	18	34	35
28/Dec/2004	-0.8	-14.2	-7.5	25.5	0	0	0.4	0.4	18		<31
29/Dec/2004	1.8	-0.9	0.5	17.5	0	T	0	T	18		<31
30/Dec/2004	4.2	-1.6	1.3	16.7	0	7.8	0	7.8	17		<31
31/Dec/2004	9.9	3.6	6.8	11.2	0	6.6	0	6.6	8	24	63
01/Jan/2005	4.2	-1.7	1.3	16.7	0	0	0	0	T	10	41
02/Jan/2005	6.4	-1.5	2.5	15.5	0	16.4	0	16.4	T	10	48
03/Jan/2005	3.7	0.5	2.1	15.9	0	0.2	0.8	1	0		<31
04/Jan/2005	1.6	-1.9	-0.2	18.2	0	0	0.8	0.8	T		<31
05/Jan/2005	-0.7	-6.7	-3.7	21.7	0	0	0.4	0.4	T	4	33
06/Jan/2005	-0.8	-8	-4.4	22.4	0	0.2	3.2	7.8	T	27	61
07/Jan/2005	-0.9	-5.1	-3	21	0	0	0	0	3		<31
08/Jan/2005	0.3	-2.4	-1.1	19.1	0	0	0.6	0.6	3		<31
09/Jan/2005	1.6	-2	-0.2	18.2	0	0	0.4	0.4	3		<31
10/Jan/2005	2.7	-2.2	0.3	17.7	0	1.2	0	1.2	1	28	57
11/Jan/2005	-1.5	-3.9	-2.7	20.7	0	0	T	T	1	8	37
12/Jan/2005	5.8	-3.1	1.4	16.6	0	12.4	T	12.4	1		<31
13/Jan/2005	17.6	0.3	9	9	0	7.4	1.8	10.2	T	35	57
14/Jan/2005	1.1	-10.3	-4.6	22.6	0	0	T	T	1	32	52
15/Jan/2005	-6.4	-11.8	-9.1	27.1	0	0	0	0	1	24	37
16/Jan/2005	-7.5	-11.1	-9.3	27.3	0	0	0.6	0.6	1		<31
17/Jan/2005	-8.2	-18.8	-13.5	31.5	0	0	0.4	0.4	2	36	50
18/Jan/2005	-7.7	-23.5	-15.6	33.6	0	0	0	0	2	18	35
19/Jan/2005	-2.2	-8.7	-5.5	23.5	0	0	5.6	4.6	3	34	56
20/Jan/2005	-8.7	-20.1	-14.4	32.4	0	0	T	T	6	34	46
21/Jan/2005	-16.4	-24.2	-20.3	38.3	0	0	T	T	6		<31
22/Jan/2005	-15.2	-18.8	-17	35	0	0	9.6	6.2	8	2	61
23/Jan/2005	-13.2	-21.4	-17.3	35.3	0	0	0	0	11	35	57
24/Jan/2005	-3.8	-17.4	-10.6	28.6	0	0	1.2	0.6	9	24	37
25/Jan/2005	-4.4	-10.4	-7.4	25.4	0	0	7.8	6.8	11		<31
26/Jan/2005	-8.4	-18.9	-13.7	31.7	0	0	T	T	18	36	37
27/Jan/2005	-14.6	-22.7	-18.7	36.7	0	0	0	0	16		<31
28/Jan/2005	-7.4	-21.9	-14.7	32.7	0	0	0	0	15		<31
29/Jan/2005	-2.3	-17.2	-9.8	27.8	0	0	0	0	15		<31
30/Jan/2005	0.2	-9.9	-4.9	22.9	0	0	0	0	13		<31
31/Jan/2005	-0.7	-13	-6.9	24.9	0	0	0	0	12		<31
01/Feb/2005	0.4	-11.8	-5.7	23.7	0	0	0	0	12		<31
02/Feb/2005	1	-12.8	-5.9	23.9	0	0	0	0	11		<31
03/Feb/2005	2.5	-5.6	-1.6	19.6	0	0	0	0	10		<31
04/Feb/2005	5.7	-6.9	-0.6	18.6	0	0	0	0	8		<31
05/Feb/2005	3.7	-4.8	-0.6	18.6	0	0	0	0	5		<31
06/Feb/2005	3.3	-5.3	-1	19	0	0	0	0	4		<31

07/Feb/2005	4.8	-0.3	2.3	15.7	0	3	0	3	1		<31
08/Feb/2005	5.2	-3	1.1	16.9	0	8	0	8	T	34	35
09/Feb/2005	-2.8	-5.4	-4.1	22.1	0	0	6.2	6.6	T		<31
10/Feb/2005	-3.4	-7.5	-5.5	23.5	0	0	0.8	0.4	7	34	48
11/Feb/2005	-0.4	-9.7	-5.1	23.1	0	0	T	T	6	28	41
12/Feb/2005	3.7	-5.9	-1.1	19.1	0	0	T	T	5	31	63
13/Feb/2005	-2.1	-10.4	-6.3	24.3	0	0	0	0	T	11	35
14/Feb/2005	5.5	-2.1	1.7	16.3	0	15.6	0.2	15.8	T	26	52
15/Feb/2005	7.3	0.9	4.1	13.9	0	16	0	16	T	27	46
16/Feb/2005	1.1	-6.5	-2.7	20.7	0	0.4	4	4.4	3	30	39
17/Feb/2005	-1.5	-8.6	-5.1	23.1	0	0	0.6	0.4	2	26	50
18/Feb/2005	-8.5	-13.8	-11.2	29.2	0	0	0	0	2	32	46
19/Feb/2005	-2.2	-11.8	-7	25	0	0	T	T	2	25	52
20/Feb/2005	-1.9	-10.9	-6.4	24.4	0	0	7.8	7.8	2	21	52
21/Feb/2005	1.5	-5.4	-2	20	0	T	3.4	3.4	13	10	39
22/Feb/2005	0.6	-8.9	-4.2	22.2	0	0	0.6	0.6	12		<31
23/Feb/2005	-3.6	-13.1	-8.4	26.4	0	0	0	0	11		<31
24/Feb/2005	-5.5	-15.5	-10.5	28.5	0	0	T	T	11	8	35
25/Feb/2005	-3.4	-16.4	-9.9	27.9	0	0	3.8	3.2	11		<31
26/Feb/2005	-3.4	-12.5	-8	26	0	0	0.2	0.2	15	31	46
27/Feb/2005	-2.8	-13.8	-8.3	26.3	0	0	T	T	15		<31
28/Feb/2005	2	-2.8	-0.4	18.4	0	0	5.8	5.8	15	10	39
01/Mar/2005	-1.4	-6.1	-3.8	21.8	0	0	6.6	5.8	23	10	44
02/Mar/2005	-5.1	-8.5	-6.8	24.8	0	0	1.8	1.4	26	31	52
03/Mar/2005	-4.4	-12.3	-8.4	26.4	0	0	T	T	27	31	41
04/Mar/2005	-0.9	-9.4	-5.2	23.2	0	0	0	0	27		<31
05/Mar/2005	2.8	-11.8	-4.5	22.5	0	0	0	0	26		<31
06/Mar/2005	4.6	-2.6	1	17	0	0	T	T	23	25	59
07/Mar/2005	6.8	-10.5	-1.9	19.9	0	5	T	5	14	34	67
08/Mar/2005	-8.4	-14.2	-11.3	29.3	0	0	0	0	7	32	52
09/Mar/2005	-5.7	-13.8	-9.8	27.8	0	0	1.8	2.2	7	28	54
10/Mar/2005	-2.7	-12.1	-7.4	25.4	0	0	0.2	0.2	9	27	33
11/Mar/2005	0.6	-6.5	-3	21	0	0	2	1.6	10		<31
12/Mar/2005	-0.7	-9.3	-5	23	0	0	3.4	3	11		<31
13/Mar/2005	-2.1	-9.7	-5.9	23.9	0	0	T	T	13	30	33
14/Mar/2005	-0.3	-10.5	-5.4	23.4	0	0	0	0	10		<31
15/Mar/2005	2.1	-7.9	-2.9	20.9	0	0	0	0	8	28	33
16/Mar/2005	2.5	-6.4	-2	20	0	0	0	0	5		<31
17/Mar/2005	2.9	-2.3	0.3	17.7	0	0	1.2	0.8	5		<31
18/Mar/2005	2.3	-4.9	-1.3	19.3	0	0	0	0	4		<31
19/Mar/2005	3	-4.3	-0.7	18.7	0	0	T	T	2	9	48
20/Mar/2005	1.9	-1.3	0.3	17.7	0	0	3.4	3.2	1	10	41
21/Mar/2005	6.2	-2.1	2.1	15.9	0	0	0.6	0.6	5		<31
22/Mar/2005	6.9	-3.9	1.5	16.5	0	0	0	0	1		<31
23/Mar/2005	1.9	-2	-0.1	18.1	0	0	4	3.8	T	8	44
24/Mar/2005	4.9	-1.9	1.5	16.5	0	0	0.6	0.6	4		<31
25/Mar/2005	4.4	-4.7	-0.2	18.2	0	0	0	0	1		<31
26/Mar/2005	5.7	-5.9	-0.1	18.1	0	0	0	0	T		<31
27/Mar/2005	7.3	-4.3	1.5	16.5	0	0	0	0	T		<31
28/Mar/2005	6.9	-0.3	3.3	14.7	0	T	0	T	T	3	33
29/Mar/2005	12.9	0.8	6.9	11.1	0	0	0	0	0		<31
30/Mar/2005	11.6	0.7	6.2	11.8	0	0	0	0	0	9	41
31/Mar/2005	15.3	5.7	10.5	7.5	0	4.6	0	4.6	0	26	57
01/Apr/2005	13	5.4	9.2	8.8	0	0	0	0	0	27	50
02/Apr/2005	6.4	0.3	3.4	14.6	0	13.6	7.6	21.4	0	36	65

03/Apr/2005	3.1	0.2	1.7	16.3	0	4.2	8.6	12.8	3	34	72
04/Apr/2005	11.1	1.1	6.1	11.9	0	0	0	0	0	32	54
05/Apr/2005	12.9	0.2	6.6	11.4	0	0	0	0	0		<31
06/Apr/2005	13.5	5.8	9.7	8.3	0	0	0	0	0	11	32
07/Apr/2005	11.4	2.7	7.1	10.9	0	2.4	0	2.4	0	34	39
08/Apr/2005	14.7	0.8	7.8	10.2	0	0	0	0	0	33	33
09/Apr/2005	14.2	0.4	7.3	10.7	0	0	0	0	0		<31
10/Apr/2005	18.8	2.6	10.7	7.3	0	0	0	0	0	7	33
11/Apr/2005	9.3	1.3	5.3	12.7	0	0	0	0	0	15	32
12/Apr/2005	9.7	2	5.9	12.1	0	0	0	0	0	10	44
13/Apr/2005	13.1	0.2	6.7	11.3	0	0	0	0	0		<31
14/Apr/2005	14.3	4.2	9.3	8.7	0	0	0	0	0		<31
15/Apr/2005	11.5	3.5	7.5	10.5	0	0	0	0	0		<31
16/Apr/2005	19.9	0.8	10.4	7.6	0	0	0	0	0	18	33
17/Apr/2005	20.9	6.8	13.9	4.1	0	0	0	0	0		<31
18/Apr/2005	19.5	7.4	13.5	4.5	0	0	0	0	0		<31
19/Apr/2005	27.5	7.2	17.4	0.6	0	0	0	0	0	24	33
20/Apr/2005	17.9	3	10.5	7.5	0	4.8	0	4.8	0	35	57
21/Apr/2005	10.8	1.5	6.2	11.8	0	0	0	0	0		<31
22/Apr/2005	12.7	1.1	6.9	11.1	0	6	0	6	0	11	33
23/Apr/2005	7.8	4.1	6	12	0	22	0	22	0	5	44
24/Apr/2005	5.7	1.6	3.7	14.3	0	13.2	0	13.2	0		<31
25/Apr/2005	7.2	1.6	4.4	13.6	0	0.4	0	0.4	0	27	46
26/Apr/2005	15.1	3.9	9.5	8.5	0	3.6	0	3.6	0	20	33
27/Apr/2005	13.1	6.6	9.9	8.1	0	5	0	5	0	27	48
28/Apr/2005	9.5	2	5.8	12.2	0	4.8	0	4.8	0	28	46
29/Apr/2005	11.7	0.2	6	12	0	0	0	0	0		<31
30/Apr/2005	6.8	2.7	4.8	13.2	0	1.2	0	1.2	0	1	33

Daily Data Report for Winter 2005-2006

Environment Canada			National Climate Data and Information Archive				www.climate.weatheroffice.gc.ca				
Day	Max Temp	Min Temp	Mean Temp	Heat Deg Days	Cool Deg Days	Total Rain	Total Snow	Total Precip	Snow on Grnd	Dir of Max Gust	Spd of Max Gust
	°C	°C	°C	°C	°C	mm	cm	mm	cm	10's Deg	km/h
31/Oct/2005	13.7	7.8	9.9	7.2	0	2.4	0	2.4	0	26	32
01/Nov/2005	12.8	4.2	8.5	9.5	0	0.8	0	0.8	0	28	41
02/Nov/2005	12.5	2	7.3	10.7	0	0	0	0	0		<31
03/Nov/2005	19.1	8.8	14	4	0	0	0	0	0	26	57
04/Nov/2005	18.3	8.9	13.6	4.4	0	0	0	0	0	23	44
05/Nov/2005	12.8	7.8	10.3	7.7	0	4.8	0	4.8	0		<31
06/Nov/2005	17.7	7	12.4	5.6	0	5.4	0	5.4	0	26	89
07/Nov/2005	12.8	5.8	9.3	8.7	0	0	0	0	0	28	50
08/Nov/2005	11.6	5.6	8.6	9.4	0	0	0	0	0		<31
09/Nov/2005	13.1	5.2	9.2	8.8	0	20.8	0	20.8	0	29	59
10/Nov/2005	6	2.8	4.4	13.6	0	0.4	T	0.4	0	31	80
11/Nov/2005	8.9	2.6	5.8	12.2	0	0	0	0	0	27	35
12/Nov/2005	14.5	2.7	8.6	9.4	0	0	0	0	0		<31
13/Nov/2005	16.9	7.9	12.4	5.6	0	T	0	T	0	26	76
14/Nov/2005	8.9	4	6.5	11.5	0	0	0	0	0	27	61
15/Nov/2005	9.3	5.5	7.4	10.6	0	28.4	0	28.4	0	10	56
16/Nov/2005	16.5	0.2	8.4	9.6	0	1.6	T	1.6	0	24	83
17/Nov/2005	3	-5.5	-1.3	19.3	0	0	T	T	0	32	59
18/Nov/2005	-0.7	-5.9	-3.3	21.3	0	0	0.8	0.6	T	25	32
19/Nov/2005	8.4	-0.8	3.8	14.2	0	0	0	0	1	22	46
20/Nov/2005	10.7	1.1	5.9	12.1	0	0	0	0	0	25	33
21/Nov/2005	6.4	2.5	4.5	13.5	0	T	0	T	0	25	32
22/Nov/2005	4.4	-6.9	-1.3	19.3	0	0	0.2	0.2	0	33	65
23/Nov/2005	-0.8	-9.6	-5.2	23.2	0	0	4	3.6	1	14	32
24/Nov/2005	0.3	-12	-5.9	23.9	0	0	5.2	5.4	6	24	78
25/Nov/2005	-1.8	-13.3	-7.6	25.6	0	0	0	0	7	27	48
26/Nov/2005	-2.4	-5.6	-4	22	0	0	2.2	1	6		<31
27/Nov/2005	3.6	-7.4	-1.9	19.9	0	1.4	0	1.4	6		<31
28/Nov/2005	14.5	3.5	9	9	0	7.6	0	7.6	T	12	32
29/Nov/2005	16.8	3.4	10.1	7.9	0	20.2	0	20.2	0	27	44
30/Nov/2005	3.5	0.7	2.1	15.9	0	0	T	T	0	26	37
01/Dec/2005	2.4	-0.3	1.1	16.9	0	0	1.4	1.4	0		<31
02/Dec/2005	0	-4.6	-2.3	20.3	0	0	1.6	1.2	2	30	67
03/Dec/2005	0.1	-5.4	-2.7	20.7	0	0	0.2	0.2	2	28	48
04/Dec/2005	-0.6	-6	-3.3	21.3	0	0	1.6	1.6	2	26	44
05/Dec/2005	-2.8	-6.9	-4.9	22.9	0	0	T	T	1	27	48
06/Dec/2005	-3.8	-8.2	-6	24	0	0	T	T	1	27	52
07/Dec/2005	-3.9	-9.9	-6.9	24.9	0	0	0.6	0.3	T	27	39
08/Dec/2005	-0.1	-9.6	-4.9	22.9	0	0	T	T	T	9	35
09/Dec/2005	-0.1	-5.2	-2.7	20.7	0	0	11.6	9.6	11	26	50
10/Dec/2005	-0.8	-6.9	-3.9	21.9	0	0	0	0	12	24	48
11/Dec/2005	0.2	-9.6	-4.7	22.7	0	0	1	0.6	12	32	44
12/Dec/2005	-9.4	-14.6	-12	30	0	0	0	0	13	35	35
13/Dec/2005	-3.7	-15.2	-9.5	27.5	0	0	1.8	0.7	11		<31
14/Dec/2005	-3.6	-10	-6.8	24.8	0	0	0.2	0.2	10	11	44

15/Dec/2005	0.2	-5	-2.4	20.4	0	0	5.4	7.3	9	15	37
16/Dec/2005	0.7	-3.5	-1.4	19.4	0	0	1.2	1.2	16	25	50
17/Dec/2005	-2.6	-5.5	-4.1	22.1	0	0	0	0	14	23	35
18/Dec/2005	-3.8	-9.1	-6.5	24.5	0	0	T	T	14		<31
19/Dec/2005	-4.7	-10.1	-7.4	25.4	0	0	0	0	14	26	57
20/Dec/2005	-3.1	-13.2	-8.2	26.2	0	0	2.6	2.4	14	27	56
21/Dec/2005	-2.9	-12	-7.5	25.5	0	0	T	T	16	26	41
22/Dec/2005	2.3	-4.6	-1.2	19.2	0	0	T	T	16	27	65
23/Dec/2005	3	1.6	2.3	15.7	0	3.6	0	3.6	13	24	35
24/Dec/2005	3.8	1.7	2.8	15.2	0	0	0	0	6		<31
25/Dec/2005	4	0.3	2.2	15.8	0	6.2	8	14.2	4		<31
26/Dec/2005	1.1	-0.8	0.2	17.8	0	0.4	0.2	0.8	2	34	54
27/Dec/2005	1.6	-4.2	-1.3	19.3	0	0	0	0	2		<31
28/Dec/2005	4.4	0.9	2.7	15.3	0	7	0	7	2		<31
29/Dec/2005	1.7	-2.8	-0.6	18.6	0	2.8	T	2.8	1	34	46
30/Dec/2005	-0.2	-5.5	-2.9	20.9	0	0	0	0	T	36	33
31/Dec/2005	-1.9	-7.1	-4.5	22.5	0	0	4.4	3.8	1	9	44
01/Jan/2006	1.3	-5.4	-2.1	20.1	0	0	T	T	3		<31
02/Jan/2006	2.5	-0.1	1.2	16.8	0	0.6	0	0.6	1	9	48
03/Jan/2006	2.6	0.3	1.5	16.5	0	T	0	T	T	9	44
04/Jan/2006	5.4	1.6	3.5	14.5	0	3.6	0	3.6	T		<31
05/Jan/2006	4.2	-3.5	0.4	17.6	0	3.8	T	3.8	T	33	46
06/Jan/2006	-3.4	-9.3	-6.4	24.4	0	0	T	T	T	34	39
07/Jan/2006	-0.4	-5.8	-3.1	21.1	0	0	2.6	2.6	T		<31
08/Jan/2006	2.6	-6.5	-2	20	0	0	0	0	2	10	35
09/Jan/2006	3.1	0.6	1.9	16.1	0	1	0.4	1.4	T	29	37
10/Jan/2006	3.5	0.1	1.8	16.2	0	T	0	T	T		<31
11/Jan/2006	8.8	1.6	5.2	12.8	0	1.4	0	1.4	T	22	33
12/Jan/2006	9.5	3.3	6.4	11.6	0	0	0	0	T	25	41
13/Jan/2006	10.1	3.1	6.6	11.4	0	0.8	0	0.8	0		<31
14/Jan/2006	6.5	-8.3	-0.9	18.9	0	0.4	0.2	0.6	T	34	82
15/Jan/2006	-7.9	-12.7	-10.3	28.3	0	0	0.2	0.2	T	34	41
16/Jan/2006	-3.9	-13.1	-8.5	26.5	0	0	0	0	T		<31
17/Jan/2006	4.4	-6	-0.8	18.8	0	18.6	0	18.6	0	10	52
18/Jan/2006	4.7	-2.8	1	17	0	6.2	0.6	7	0	27	65
19/Jan/2006	3.8	-3.4	0.2	17.8	0	0	T	T	T	25	33
20/Jan/2006	11.4	0.6	6	12	0	2.4	0	2.4	0	32	37
21/Jan/2006	1.1	-4.4	-1.7	19.7	0	9.6	2.6	12.2	0	33	56
22/Jan/2006	2.8	-6.2	-1.7	19.7	0	0	0	0	T		<31
23/Jan/2006	3.6	-2.8	0.4	17.6	0	0	0	0	T	32	32
24/Jan/2006	4.8	-3.4	0.7	17.3	0	T	1.2	1.2	0	24	56
25/Jan/2006	1.9	-7.7	-2.9	20.9	0	T	T	T	0	32	67
26/Jan/2006	-3.4	-12.3	-7.9	25.9	0	0	T	T	T	33	50
27/Jan/2006	6.6	-8.6	-1	19	0	0	0	0	0	23	35
28/Jan/2006	10.4	1.3	5.9	12.1	0	0.2	0	0.2	0		<31
29/Jan/2006	8.1	2.9	5.5	12.5	0	15.8	0	15.8	0	10	44
30/Jan/2006	9.1	3.1	6.1	11.9	0	2.2	0	2.2	0	23	44
31/Jan/2006	3.2	-0.8	1.2	16.8	0	0	T	T	0	27	37
01/Feb/2006	3.1	-3.1	0	18	0	0	T	T	0		<31
02/Feb/2006	6.7	0.4	3.6	14.4	0	1.6	0	1.6	0		<31
03/Feb/2006	5.2	1.5	3.4	14.6	0	11.4	0	11.4	0	27	43
04/Feb/2006	3.9	0.5	2.2	15.8	0	19.4	2	22.4	0	8	54
05/Feb/2006	3.1	-4.4	-0.7	18.7	0	2.2	1.6	3.8	0	27	67
06/Feb/2006	-1.7	-5.2	-3.5	21.5	0	0	3	3	1	26	76
07/Feb/2006	-1.2	-5.4	-3.3	21.3	0	0	T	T	2	32	35

08/Feb/2006	-5.4	-10.5	-8	26	0	0	T	T	1	36	32
09/Feb/2006	-4.4	-11.1	-7.8	25.8	0	0	T	T	T	31	48
10/Feb/2006	-2.8	-9.1	-6	24	0	0	2.2	1.4	T		<31
11/Feb/2006	-2.7	-9.3	-6	24	0	0	T	T	1		<31
12/Feb/2006	-3.9	-13.1	-8.5	26.5	0	0	T	T	1	32	32
13/Feb/2006	-1.7	-6.8	-4.3	22.3	0	0	T	T	T	27	67
14/Feb/2006	3.3	-4.9	-0.8	18.8	0	0	T	T	T	25	44
15/Feb/2006	6.8	-0.4	3.2	14.8	0	0	0	0	T		<31
16/Feb/2006	2.2	-2.4	-0.1	18.1	0	13	5.4	18	5	32	41
17/Feb/2006	6.8	-7.6	-0.4	18.4	0	6.2	T	6.2	1	31	91
18/Feb/2006	-7.5	-14.5	-11	29	0	0	1.2	1	1	30	59
19/Feb/2006	-6.8	-13.1	-10	28	0	0	0	0	1	25	50
20/Feb/2006	-3.1	-10.4	-6.8	24.8	0	0	T	T	1	26	52
21/Feb/2006	1.5	-4.6	-1.6	19.6	0	0	T	T	T	25	56
22/Feb/2006	7	-5.1	1	17	0	0	0	0	T	22	33
23/Feb/2006	6	-4.6	0.7	17.3	0	T	0.4	0.4	0	32	65
24/Feb/2006	-0.6	-7.6	-4.1	22.1	0	0	1.4	1.4	T	31	54
25/Feb/2006	2	-8.4	-3.2	21.2	0	0	3.8	3.8	5	30	67
26/Feb/2006	-6.8	-13.8	-10.3	28.3	0	0	0	0	3	36	39
27/Feb/2006	-3.5	-13.8	-8.7	26.7	0	0	0.6	0.4	3	31	54
28/Feb/2006	-4.7	-13.9	-9.3	27.3	0	0	T	T	3	27	54
01/Mar/2006	-1.7	-10	-5.9	23.9	0	0	0	0	2	33	39
02/Mar/2006	-2.1	-8.9	-5.5	23.5	0	0	0	0	1	34	37
03/Mar/2006	-2.4	-11.1	-6.8	24.8	0	0	0	0	1	35	59
04/Mar/2006	3.4	-7.3	-2	20	0	0	0	0	T	33	52
05/Mar/2006	4.6	-4.8	-0.1	18.1	0	0	0	0	T	36	37
06/Mar/2006	0.6	-5.8	-2.6	20.6	0	0	0	0	T	35	33
07/Mar/2006	2.6	-5.7	-1.6	19.6	0	0	0	0	0		<31
08/Mar/2006	3.7	-5.4	-0.9	18.9	0	0	0	0	0		<31
09/Mar/2006	11.5	2.7	7.1	10.9	0	16.8	0	16.8	0	20	32
10/Mar/2006	11.4	1.1	6.3	11.7	0	1.4	0	1.4	0	22	61
11/Mar/2006	10	-0.6	4.7	13.3	0	0	0	0	0		<31
12/Mar/2006	16.3	2.9	9.6	8.4	0	1.8	0	1.8	0		<31
13/Mar/2006	13.3	3.4	8.4	9.6	0	21.4	0	21.4	0	28	56
14/Mar/2006	5	-1.7	1.7	16.3	0	0	1	0.6	0	36	85
15/Mar/2006	3.3	-2	0.7	17.3	0	0	T	T	T	30	83
16/Mar/2006	4.4	-4.5	-0.1	18.1	0	0	0	0	0	31	35
17/Mar/2006	1.6	-7.1	-2.8	20.8	0	0	0	0	0	33	44
18/Mar/2006	0.1	-6.9	-3.4	21.4	0	0	T	T	0	31	59
19/Mar/2006	2.7	-4.8	-1.1	19.1	0	0	T	T	0	30	56
20/Mar/2006	-1	-7	-4	22	0	0	0	0	0	35	41
21/Mar/2006	1.8	-7.8	-3	21	0	0	T	T	0	36	44
22/Mar/2006	2	-2.8	-0.4	18.4	0	0	0.2	0.2	T	30	35
23/Mar/2006	3.4	-0.4	1.5	16.5	0	0	0	0	0		<31
24/Mar/2006	6.2	-1.7	2.3	15.7	0	T	T	T	0		<31
25/Mar/2006	4.5	-0.3	2.1	15.9	0	3.2	0.2	3.4	0		<31
26/Mar/2006	7.7	-1.1	3.3	14.7	0	T	0	T	0	35	39
27/Mar/2006	12.2	-2.2	5	13	0	0	0	0	0		<31
28/Mar/2006	11.1	-2.4	4.4	13.6	0	0	0	0	0		<31
29/Mar/2006	13.5	-0.5	6.5	11.5	0	0	0	0	0		<31
30/Mar/2006	15.6	0.2	7.9	10.1	0	0	0	0	0		<31
31/Mar/2006	17.8	2.4	10.1	7.9	0	3.2	0	3.2	0	24	46
01/Apr/2006	13.8	2.3	8.1	9.9	0	0.8	0	0.8	0	29	63
02/Apr/2006	9.8	-0.8	4.5	13.5	0	0	0	0	0	M	M
03/Apr/2006	15.1	2.5	8.8	9.2	0	5.2	0	5.2	0	29	65

04/Apr/2006	7	-2.8	2.1	15.9	0	0.2	T	0.2	0	33	61
05/Apr/2006	4.6	-3.4	0.6	17.4	0	0.8	T	0.8	T	34	44
06/Apr/2006	14.2	0.3	7.3	10.7	0	0	0	0	0	31	32
07/Apr/2006	7.8	-0.4	3.7	14.3	0	12.2	T	12.2	0	36	46
08/Apr/2006	5	-4.3	0.4	17.6	0	0	0	0	0	2	39
09/Apr/2006	11.2	-3.3	4	14	0	0	0	0	0		<31
10/Apr/2006	16.5	0.5	8.5	9.5	0	0	0	0	0	19	33
11/Apr/2006	16	4.6	10.3	7.7	0	0	0	0	0		<31
12/Apr/2006	17.4	6.3	11.9	6.1	0	7	0	7	0	29	70
13/Apr/2006	21.2	8	14.6	3.4	0	0.4	0	0.4	0	31	54
14/Apr/2006	13.3	7.2	10.3	7.7	0	3.2	0	3.2	0		<31
15/Apr/2006	16	5.5	10.8	7.2	0	0	0	0	0	34	50
16/Apr/2006	14.5	3.7	9.1	8.9	0	0	0	0	0	36	33
17/Apr/2006	13.2	1.6	7.4	10.6	0	0	0	0	0		<31
18/Apr/2006	17.1	4.4	10.8	7.2	0	0	0	0	0		<31
19/Apr/2006	19.8	6.7	13.3	4.7	0	0	0	0	0		<31
20/Apr/2006	22.7	8.3	15.5	2.5	0	0	0	0	0		<31
21/Apr/2006	19.3	10.9	15.1	2.9	0	0.2	0	0.2	0	11	44
22/Apr/2006	11.4	6.6	9	9	0	7.2	0	7.2	0	9	33
23/Apr/2006	7.2	4.7	6	12	0	22	0	22	0	8	35
24/Apr/2006	13.9	4.7	9.3	8.7	0	2.6	0	2.6	0	29	46
25/Apr/2006	11.4	0.3	5.9	12.1	0	0.6	T	0.6	T	34	61
26/Apr/2006	17.2	-1.6	7.8	10.2	0	0	0	0	0	27	63
27/Apr/2006	12.5	1.9	7.2	10.8	0	0	0	0	0	1	35
28/Apr/2006	10.7	-0.1	5.3	12.7	0	0	0	0	0		<31
29/Apr/2006	15.1	-0.2	7.5	10.5	0	0	0	0	0	11	37
30/Apr/2006	18.9	4.2	11.6	6.4	0	0	0	0	0	9	37

Daily Data Report for Winter 2006-2007

Environment Canada			National Climate Data and Information Archive					www climate weatheroffice gc ca			
Day	Max Temp	Min Temp	Mean Temp	Heat Deg Days	Cool Deg Days	Total Rain	Total Snow	Total Precip	Snow on Grnd	Dir of Max Gust	Spd of Max Gust
	°C	°C	°C	°C	°C	mm	cm	mm	cm	10's Deg	km/h
31/Oct/2006	16 5	3 5	9 9	8	0	0 2	0	0 2	0	24	46
01/Nov/2006	8 9	-0 7	4 1	13 9	0	0	0	0	0	26	37
02/Nov/2006	4 6	-1 9	1 4	16 6	0	0	T	T	0	27	46
03/Nov/2006	5	-2 6	1 2	16 8	0	0	0	0	0	27	50
04/Nov/2006	5 7	-3 8	1	17	0	0	0	0	0		<31
05/Nov/2006	10 7	3 7	7 2	10 8	0	T	0	T	0		<31
06/Nov/2006	14 4	-0 5	7	11	0	0	0	0	0		<31
07/Nov/2006	10 9	7 2	9 1	8 9	0	12	0	12	0		<31
08/Nov/2006	11 3	7 7	9 5	8 5	0	0 3	0	0 3	0		<31
09/Nov/2006	15 2	4 6	9 9	8 1	0	T	0	T	0	30	50
10/Nov/2006	7 8	3 4	5 6	12 4	0	0	0	0	0	31	35
11/Nov/2006	7 2	1 7	4 5	13 5	0	6	0	6	0	36	39
12/Nov/2006	4 4	0 7	2 6	15 4	0	0	0	0	0	36	32
13/Nov/2006	5 6	3 2	4 4	13 6	0	0 2	0	0 2	0		<31
14/Nov/2006	6 8	3 1	5	13	0	0	0	0	0		<31
15/Nov/2006	10	3 4	6 7	11 3	0	5 8	0	5 8	0		<31
16/Nov/2006	13 7	6 6	10 2	7 8	0	25 4	0	25 4	0	7	33
17/Nov/2006	6 7	2 3	4 5	13 5	0	4 2	0	4 2	0	29	48
18/Nov/2006	6	1 3	3 7	14 3	0	0	0	0	0		<31
19/Nov/2006	2 1	-1	0 6	17 4	0	0	T	T	0		<31
20/Nov/2006	1 8	-0 8	0 5	17 5	0	0	T	T	T	35	32
21/Nov/2006	6 5	-2 6	2	16	0	0	0	0	0		<31
22/Nov/2006	8 1	-3 1	2 5	15 5	0	0	0	0	0		<31
23/Nov/2006	7 2	-3	2 1	15 9	0	0	0	0	0		<31
24/Nov/2006	8 3	-0 7	3 8	14 2	0	0	0	0	0		<31
25/Nov/2006	6 7	-2	2 4	15 6	0	0	0	0	0		<31
26/Nov/2006	14	2 7	8 4	9 6	0	0	0	0	0		<31
27/Nov/2006	14 3	5 6	10	8	0	0	0	0	0		<31
28/Nov/2006	9 8	5 5	7 7	10 3	0	0	0	0	0	9	32
29/Nov/2006	16 1	5 6	10 9	7 1	0	0 2	0	0 2	0	20	37
30/Nov/2006	15 9	2 7	9 3	8 7	0	17 6	0	17 6	0	35	50
01/Dec/2006	4 6	0 5	2 6	15 4	0	28 2	T	28 2	0	26	83
02/Dec/2006	2 4	-1 5	0 5	17 5	0	0	T	T	0	27	74
03/Dec/2006	0 3	-5 3	-2 5	20 5	0	0	T	T	0	27	39
04/Dec/2006	-0 2	-6 4	-3 3	21 3	0	0	0 4	0 4	T	30	39
05/Dec/2006	0	-7 1	-3 6	21 6	0	0	0	0	T	28	37
06/Dec/2006	3 4	-2	0 7	17 3	0	0 6	0 2	0 8	T	24	48
07/Dec/2006	0 6	-11 5	5 5	23 5	0	0	T	T	0	34	50
08/Dec/2006	-1 2	-12 4	-6 8	24 8	0	0	T	T	T	26	46
09/Dec/2006	3 9	-4 2	-0 2	18 2	0	0	0	0	0	24	52
10/Dec/2006	8 6	-0 1	4 3	13 7	0	0 2	0	0 2	0	25	44
11/Dec/2006	5 1	2 3	3 7	14 3	0	2	0	2	0		<31
12/Dec/2006	10	4 4	7 2	10 8	0	0 2	0	0 2	0	17	33
13/Dec/2006	9 7	1 3	5 5	12 5	0	2	0	2	0	22	46
14/Dec/2006	12 4	1 6	7	11	0	T	0	T	0	23	65

15/Dec/2006	10.4	2.1	6.3	11.7	0	T	0	T	0	25	52
16/Dec/2006	6.6	2.5	4.6	13.4	0	T	0	T	0		<31
17/Dec/2006	12.7	4.4	8.6	9.4	0	0	0	0	0		<31
18/Dec/2006	5.8	1.7	3.8	14.2	0	0	0	0	0	32	48
19/Dec/2006	4.7	-2	1.4	16.6	0	0	0	0	0	29	37
20/Dec/2006	7.7	-2.2	2.8	15.2	0	0	0	0	0	26	57
21/Dec/2006	7	1.7	4.4	13.6	0	T	0	T	0		<31
22/Dec/2006	7.6	3	5.3	12.7	0	15.2	0	15.2	0	9	44
23/Dec/2006	7.4	2.7	5.1	12.9	0	1.4	0	1.4	0	25	57
24/Dec/2006	6.4	-0.9	2.8	15.2	0	T	0	T	0	25	48
25/Dec/2006	4.9	-0.8	2.1	15.9	0	1.4	0	1.4	0		<31
26/Dec/2006	3.8	-1.7	1.1	16.9	0	1	0	1	0	35	41
27/Dec/2006	1.8	-1.7	0.1	17.9	0	0	T	T	T	26	35
28/Dec/2006	4.9	-1.1	1.9	16.1	0	0.2	0.6	1	0		<31
29/Dec/2006	0.2	-3.6	-1.7	19.7	0	0	T	T	T		<31
30/Dec/2006	2.5	-4.2	-0.9	18.9	0	T	0.4	0.4	T		<31
31/Dec/2006	5.2	-4.8	0.2	17.8	0	8.2	0	8.2	0	11	46
01/Jan/2007	9.2	1.2	5.2	12.8	0	T	0	T	0	25	56
02/Jan/2007	5.8	-2.5	1.7	16.3	0	0	0	0	0	30	50
03/Jan/2007	8	0	4	14	0	0	0	0	0	24	52
04/Jan/2007	11.9	4.4	8.2	9.8	0	2.8	0	2.8	0	22	48
05/Jan/2007	11.1	7.4	9.3	8.7	0	6	0	6	0		<31
06/Jan/2007	9	1.1	5.1	12.9	0	3.4	0	3.4	0	30	46
07/Jan/2007	4.7	1.4	3.1	14.9	0	0.8	T	0.8	0	12	46
08/Jan/2007	4.1	-2	1.1	16.9	0	3.2	T	3.2	0	26	78
09/Jan/2007	1.2	-5.2	-2	20	0	0	T	T	T	29	52
10/Jan/2007	-2.6	-7.8	-5.2	23.2	0	0	T	T	T	31	50
11/Jan/2007	6.7	-6.9	-0.1	18.1	0	T	0	T	0	22	54
12/Jan/2007	7.6	1.9	4.8	13.2	0	2.6	0	2.6	0	34	35
13/Jan/2007	3.8	-3.5	0.2	17.8	0	T	0.2	0.2	T	35	46
14/Jan/2007	-0.8	-2.6	-1.7	19.7	0	0	1.4	1.8	T		<31
15/Jan/2007	-1.1	-6.6	-3.9	21.9	0	3	5.8	8.8	2	36	39
16/Jan/2007	-6.5	-12.5	-9.5	27.5	0	0	T	T	4	30	48
17/Jan/2007	-3.2	-11.1	-7.2	25.2	0	0	T	T	4		<31
18/Jan/2007	0.8	-4.4	-1.8	19.8	0	0	0.2	0.2	3	22	32
19/Jan/2007	0.3	-6.3	-3	21	0	0	0.2	0.2	3	28	56
20/Jan/2007	-5.8	-12.2	-9	27	0	0	T	T	3	31	48
21/Jan/2007	-3.8	-12.8	-8.3	26.3	0	0	T	T	2	11	32
22/Jan/2007	-3.8	-8.6	-6.2	24.2	0	0	1	1	3		<31
23/Jan/2007	-0.2	-6.8	-3.5	21.5	0	0	T	T	3	23	41
24/Jan/2007	-2.1	-10.9	-6.5	24.5	0	0	0.2	0.2	3		<31
25/Jan/2007	-10.7	-17.5	-14.1	32.1	0	0	T	T	3	34	52
26/Jan/2007	-5.1	-13.1	-9.1	27.1	0	T	2.8	2.6	3	13	37
27/Jan/2007	-1	-5.3	-3.2	21.2	0	1.6	0.8	2	5		<31
28/Jan/2007	-2.6	-13.2	-7.9	25.9	0	0	2.6	2.2	5		<31
29/Jan/2007	-5.9	-16.8	-11.4	29.4	0	0	T	T	7	25	44
30/Jan/2007	-5.8	-12.6	-9.2	27.2	0	0	0.6	0.6	7		<31
31/Jan/2007	-5	-13	-9	27	0	0	T	T	7	27	57
01/Feb/2007	-2.1	-8.3	-5.2	23.2	0	0	0.2	0.2	7	22	46
02/Feb/2007	-2.4	-11	-6.7	24.7	0	0	T	T	7	26	57
03/Feb/2007	-7.3	-14.2	-10.8	28.8	0	0	0.4	0.2	7	26	63
04/Feb/2007	-13.9	-16.5	-15.2	33.2	0	0	T	T	7	26	57
05/Feb/2007	-10.3	-16.8	-13.6	31.6	0	0	2.6	2.6	7	26	67
06/Feb/2007	-10	-15.7	-12.9	30.9	0	0	0	0	9	25	56
07/Feb/2007	-8.3	-16	-12.2	30.2	0	0	T	T	9	24	59

08/Feb/2007	-4.8	-10.9	-7.9	25.9	0	0	0.2	0.2	9	25	56
09/Feb/2007	-3.6	-15	-9.3	27.3	0	0	T	T	9	29	44
10/Feb/2007	-4.6	-10.9	-7.8	25.8	0	0	T	T	9	28	54
11/Feb/2007	-5.6	-11.8	-8.7	26.7	0	0	T	T	9	24	56
12/Feb/2007	-5.9	-15.6	-10.8	28.8	0	0	T	T	9	35	37
13/Feb/2007	-13.7	-17.5	-15.6	33.6	0	0	3.6	3.6	9	5	39
14/Feb/2007	-10.6	-16.5	-13.6	31.6	0	0	6.6	4.6	16	31	52
15/Feb/2007	-9.4	-21	-15.2	33.2	0	0	T	T	19	30	52
16/Feb/2007	-5.2	-11.6	-8.4	26.4	0	0	0.2	0.2	18	27	50
17/Feb/2007	-5.2	-11.8	-8.5	26.5	0	0	T	T	18	25	32
18/Feb/2007	-8.5	-18.1	-13.3	31.3	0	0	T	T	17	32	54
19/Feb/2007	0.1	-16	-8	26	0	0	T	T	17	13	39
20/Feb/2007	4.3	-4.6	-0.2	18.2	0	0	0	0	16		<31
21/Feb/2007	3.8	-6.5	-1.4	19.4	0	0	0	0	9		<31
22/Feb/2007	3.9	-7.1	-1.6	19.6	0	T	3.6	3.6	5	32	76
23/Feb/2007	-5.7	-11.8	-8.8	26.8	0	0	T	T	3	34	56
24/Feb/2007	-2.8	-12.3	-7.6	25.6	0	0	0	0	3	35	46
25/Feb/2007	-1.2	-8.8	-5	23	0	0	3.8	3.6	2	8	57
26/Feb/2007	-1.7	-4.2	-3	21	0	0	6	5.8	6	8	33
27/Feb/2007	0.3	-4.2	-2	20	0	0	T	T	11		<31
28/Feb/2007	1.5	-7.1	-2.8	20.8	0	0	0	0	11		<31
01/Mar/2007	-0.4	-7.7	-4.1	22.1	0	2.8	5.7	9.2	9	9	63
02/Mar/2007	3.2	-1.4	0.9	17.1	0	4.6	1	6	10	M	M
03/Mar/2007	0.1	-3.4	-1.7	19.7	0	0	T	T	6	23	52
04/Mar/2007	-1.2	-4.1	-2.7	20.7	0	0	T	T	6	28	57
05/Mar/2007	-2.7	-18.3	-10.5	28.5	0	0	1	1	6	30	70
06/Mar/2007	-12.3	-22.1	-17.2	35.2	0	0	0.8	0.8	7	34	44
07/Mar/2007	-6.1	-15.4	-10.8	28.8	0	0	0.4	0.4	8	27	37
08/Mar/2007	-3.4	-10.7	-7.1	25.1	0	0	T	T	8	26	37
09/Mar/2007	0.2	-6.7	-3.3	21.3	0	0	0	0	8	14	37
10/Mar/2007	5.8	-2.8	1.5	16.5	0	1.2	0	1.2	5	28	39
11/Mar/2007	5.7	-2	1.9	16.1	0	0	0	0	2	34	33
12/Mar/2007	7	-1.6	2.7	15.3	0	T	0	T	T		<31
13/Mar/2007	15.8	3.4	9.6	8.4	0	0	0	0	T	24	50
14/Mar/2007	14.4	4.4	9.4	8.6	0	0.2	0	0.2	T	32	46
15/Mar/2007	4.7	-4.3	0.2	17.8	0	0	0	0	0	34	50
16/Mar/2007	-2.1	-6.7	-4.4	22.4	0	0	1.6	2	0	8	41
17/Mar/2007	0.5	-7.3	-3.4	21.4	0	0	2	1.8	4	31	52
18/Mar/2007	2.4	-6.2	-1.9	19.9	0	0	0	0	1	30	57
19/Mar/2007	2.6	-4.2	-0.8	18.8	0	T	0.8	0.8	T	18	50
20/Mar/2007	-1.5	-10	-5.8	23.8	0	0	T	T	T	30	61
21/Mar/2007	4.1	-7.8	-1.9	19.9	0	0.2	0	0.2	T		<31
22/Mar/2007	14.9	-0.6	7.2	10.8	0	2.2	0	2.2	T	24	59
23/Mar/2007	11.7	-1.6	5.1	12.9	0	0	0	0	0		<31
24/Mar/2007	7.6	-0.5	3.6	14.4	0	2.2	0	2.2	0		<31
25/Mar/2007	3	0	1.5	16.5	0	0	0	0	0		<31
26/Mar/2007	20.3	2.6	11.5	6.5	0	5.4	0	5.4	0	33	52
27/Mar/2007	18.9	6.5	12.7	5.3	0	0	0	0	0	1	46
28/Mar/2007	9.6	1.6	5.6	12.4	0	0	0	0	0	7	33
29/Mar/2007	8.3	-2.8	2.8	15.2	0	0	0	0	0		<31
30/Mar/2007	12.2	-1	5.6	12.4	0	0	0	0	0	36	32
31/Mar/2007	7.9	2.2	5.1	12.9	0	0	0	0	0	8	32
01/Apr/2007	7.8	4.1	6	12	0	5.6	0	5.6	0		<31
02/Apr/2007	12.4	2.9	7.7	10.3	0	0.2	0	0.2	0	25	57
03/Apr/2007	9.6	0.7	5.2	12.8	0	10.6	0	10.6	0	9	37

04/Apr/2007	9.9	-3.9	3	15	0	8	T	8	0	26	59
05/Apr/2007	-2.1	-6.6	-4.4	22.4	0	0	0.6	0.6	T	28	59
06/Apr/2007	-2.2	-7.2	-4.7	22.7	0	0	0.2	0.2	T	29	48
07/Apr/2007	-0.7	-6.9	-3.8	21.8	0	0	T	T	T	29	44
08/Apr/2007	1.3	-5.1	-1.9	19.9	0	0	0.2	0.2	T	28	39
09/Apr/2007	3	-3.9	-0.5	18.5	0	0	T	T	0	28	33
10/Apr/2007	5.8	-4.2	0.8	17.2	0	0	0	0	0	29	32
11/Apr/2007	5.1	-4.7	0.2	17.8	0	5.4	T	5.4	0	8	63
12/Apr/2007	9.3	1.7	5.5	12.5	0	4.6	T	4.6	0	9	54
13/Apr/2007	5.2	-1.1	2.1	15.9	0	0.4	0.6	1	0	28	61
14/Apr/2007	6.7	-1.9	2.4	15.6	0	0.2	T	0.2	0		<31
15/Apr/2007	7.2	1	4.1	13.9	0	0.8	0.8	1.6	0	34	52
16/Apr/2007	5.3	2.8	4.1	13.9	0	1.8	0	1.8	0	34	74
17/Apr/2007	8.7	3.5	6.1	11.9	0	T	0	T	0	35	35
18/Apr/2007	10	3.9	7	11	0	0	0	0	0	6	32
19/Apr/2007	14.7	3.4	9.1	8.9	0	0	0	0	0	M	M
20/Apr/2007	22.3	5.3	13.8	4.2	0	0	0	0	0		<31
21/Apr/2007	22.6	5.3	14	4	0	0	0	0	0		<31
22/Apr/2007	25.4	9.3	17.4	0.6	0	0	0	0	0	23	39
23/Apr/2007	23.7	8.5	16.1	1.9	0	8.4	0	8.4	0	27	95
24/Apr/2007	15.8	5.5	10.7	7.3	0	0	0	0	0		<31
25/Apr/2007	11.9	6.7	9.3	8.7	0	0	0	0	0		<31
26/Apr/2007	10	6.4	8.2	9.8	0	10.4	0	10.4	0	8	50
27/Apr/2007	17.5	8	12.8	5.2	0	1.6	0	1.6	0	23	46
28/Apr/2007	11.5	5.8	8.7	9.3	0	0.4	0	0.4	0	29	46
29/Apr/2007	21.4	4.6	13	5	0	T	0	T	0	23	52
30/Apr/2007	16.4	6.8	11.6	6.4	0	0	0	0	0	34	48

Daily Data Report for Winter 2007-2008

Environment Canada	National Climate Data and Information Archive	www climate weatheroffice gc ca

Day	Max Temp	Min Temp	Mean Temp	Heat Deg Days	Cool Deg Days	Total Rain	Total Snow	Total Precip	Snow on Grnd	Dir of Max Gust	Spd of Max Gust
	°C	°C	°C	°C	°C	mm	cm	mm	cm	10's Deg	km/h
31/Oct/2007	18 8	7 1	9 9	5	0	1	0	1	0	27	63
01/Nov/2007	10 6	0 4	5 5	12 5	0	0	0	0	0	28	46
02/Nov/2007	9 9	-2	4	14	0	0	0	0	0		<31
03/Nov/2007	14 3	0 7	6 8	11 2	0	0	0	0	0		<31
04/Nov/2007	11 4	1 3	6 4	11 6	0	0	0	0	0		<31
05/Nov/2007	9 6	-0 2	4 7	13 3	0	5 6	0	5 6	0	15	44
06/Nov/2007	6	1 7	3 9	14 1	0	T	0	T	0	29	63
07/Nov/2007	3 2	-0 4	1 4	16 6	0	0	0	0	0	29	41
08/Nov/2007	4 9	0 4	2 7	15 3	0	5 8	T	5 8	0		<31
09/Nov/2007	7 7	2 3	5	13	0	3 6	0	3 6	0		<31
10/Nov/2007	7 2	-0 9	3 2	14 8	0	0 4	T	0 4	T	6	32
11/Nov/2007	8 3	-2 5	2 9	15 1	0	0 4	0	0 4	0		<31
12/Nov/2007	12	5 9	9	9	0	4 6	0	4 6	0		<31
13/Nov/2007	13 1	2 8	8	10	0	0	0	0	0		<31
14/Nov/2007	15 7	5 3	10 5	7 5	0	0 4	0	0 4	0	27	57
15/Nov/2007	8 5	1	4 8	13 2	0	0 6	T	0 6	0	32	46
16/Nov/2007	2 7	-0 9	0 9	17 1	0	T	T	T	T	31	48
17/Nov/2007	3 5	-3 7	-0 1	18 1	0	0	0	0	0		<31
18/Nov/2007	4 3	-7 3	1 5	19 5	0	0	0	0	0		<31
19/Nov/2007	5 3	-3 7	0 8	17 2	0	5 8	0	5 8	0		<31
20/Nov/2007	11 8	4 7	8 3	9 7	0	3 6	0	3 6	0		<31
21/Nov/2007	5	0 8	2 9	15 1	0	29 2	0 4	32 6	0	5	39
22/Nov/2007	1 1	-6 9	2 9	20 9	0	2 6	7 6	10 4	2	2	50
23/Nov/2007	-4 1	-9 9	-7	25	0	0	0	0	5		<31
24/Nov/2007	2 1	8	-3	21	0	0	0	0	4	24	48
25/Nov/2007	5 1	1 9	1 6	16 4	0	0	0	0	2	24	44
26/Nov/2007	4 1	0 4	2 3	15 7	0	8 8	2 2	11	T		<31
27/Nov/2007	4 3	-3 6	0 4	17 6	0	1	0 4	1 4	T	27	80
28/Nov/2007	3	-7 7	-2 4	20 4	0	0	T	T	T	13	32
29/Nov/2007	5	-4 8	0 1	17 9	0	1 2	T	1 2	0	28	65
30/Nov/2007	2 6	-6	-1 7	19 7	0	0	0 4	0 4	0	28	67
01/Dec/2007	-5 4	-11	8 2	26 2	0	0	3 2	3 2	T	12	39
02/Dec/2007	3	-6 5	-1 8	19 8	0	14 6	9 2	23 8	11	11	50
03/Dec/2007	3 6	-4 8	-0 6	18 6	0	1 6	1 2	2 8	3	29	74
04/Dec/2007	-2 1	-7 5	-4 8	22 8	0	0	T	T	3	30	57
05/Dec/2007	-7 3	-11 1	9 2	27 2	0	0	0	0	3		<31
06/Dec/2007	-2 9	-8 6	-5 8	23 8	0	0	T	T	3	25	41
07/Dec/2007	0 3	-4 5	2 1	20 1	0	0	0 2	0 2	3		<31
08/Dec/2007	0 3	-3 2	-1 5	19 5	0	0	0	0	3	31	35
09/Dec/2007	-2 8	-4 3	-3 6	21 6	0	0	0 2	0 2	3		<31
10/Dec/2007	1 3	-3 9	-1 3	19 3	0	0	0 4	0 4	3		<31
11/Dec/2007	2	-4 6	-1 3	19 3	0	6 6	1 2	7 8	2		<31
12/Dec/2007	2 4	-6 9	-2 3	20 3	0	0	0	0	T	30	57
13/Dec/2007	2 1	-6 3	-2 1	20 1	0	0	3	2 4	T	25	33
14/Dec/2007	2 1	-11 6	-4 8	22 8	0	0	T	T	3	31	56

15/Dec/2007	-3.5	-13.2	-8.4	26.4	0	0	3.2	2.8	2	11	54
16/Dec/2007	-2.8	-10.3	-6.6	24.6	0	T	16.8	17.1	7	35	57
17/Dec/2007	-3.1	-10.8	-7	25	0	0	T	T	21	31	37
18/Dec/2007	1.3	-7.3	-3	21	0	0	0	0	21		<31
19/Dec/2007	3.3	0.2	1.8	16.2	0	T	0	T	20		<31
20/Dec/2007	1.9	-2.5	-0.3	18.3	0	0	0	0	12		<31
21/Dec/2007	2.7	-2.5	0.1	17.9	0	0	0	0	12	10	37
22/Dec/2007	4.7	2.4	3.6	14.4	0	0	0	0	8		<31
23/Dec/2007	7.9	-4.8	1.6	16.4	0	20.2	T	20.2	4	24	65
24/Dec/2007	-1.5	-5.1	-3.3	21.3	0	0	0.4	0.4	1	25	61
25/Dec/2007	-0.6	-2.8	-1.7	19.7	0	0	T	T	1	25	33
26/Dec/2007	1.1	-5	-2	20	0	0	0	0	1		<31
27/Dec/2007	2.5	-0.8	0.9	17.1	0	0	2.8	2.6	1		<31
28/Dec/2007	3.4	-0.8	1.3	16.7	0	6.2	0.4	6.6	1	10	65
29/Dec/2007	4.1	-0.8	1.7	16.3	0	T	T	T	T	23	61
30/Dec/2007	0.4	-0.9	-0.3	18.3	0	0	0.2	0.2	T		<31
31/Dec/2007	0	-3.4	-1.7	19.7	0	0	2	2	2		<31
01/Jan/2008	1	-8.4	-3.7	21.7	0	0	9.4	10.2	5	34	48
02/Jan/2008	-8.4	-15.4	-11.9	29.9	0	0	0	0	11	25	44
03/Jan/2008	-4.7	-17.7	-11.2	29.2	0	0	0	0	11	25	57
04/Jan/2008	-1.7	-5.5	-3.6	21.6	0	0	0	0	11	23	56
05/Jan/2008	3.4	-3.6	-0.1	18.1	0	T	T	T	11		<31
06/Jan/2008	7.2	1.4	4.3	13.7	0	0.8	0	0.8	2		<31
07/Jan/2008	14.9	6.9	10.9	7.1	0	2.2	0	2.2	T		<31
08/Jan/2008	15.5	11.3	13.4	4.6	0	4.2	0	4.2	0	21	54
09/Jan/2008	11.6	0.8	6.2	11.8	0	13.4	0	13.4	0	26	107
10/Jan/2008	3.8	-1.8	1	17	0	1.2	T	1.2	0	10	52
11/Jan/2008	8.4	1.7	5.1	12.9	0	2.8	0	2.8	0	23	69
12/Jan/2008	3.9	-0.7	1.6	16.4	0	0	0	0	0	25	33
13/Jan/2008	2.7	-1.9	0.4	17.6	0	2.4	0.8	3.2	0	10	39
14/Jan/2008	3.2	-0.7	1.3	16.7	0	0.4	1.6	2.2	T		<31
15/Jan/2008	-0.2	-3.1	-1.7	19.7	0	0	3	2.8	1		<31
16/Jan/2008	-0.1	-7.7	-3.9	21.9	0	0	0	0	2		<31
17/Jan/2008	2.6	-0.9	0.9	17.1	0	0.4	0.4	0.8	2	19	35
18/Jan/2008	2.6	-5	-1.2	19.2	0	0.6	T	0.6	T	26	83
19/Jan/2008	-3.2	-12.2	-7.7	25.7	0	0	T	T	T	27	57
20/Jan/2008	-8.2	-13.5	-10.9	28.9	0	0	T	T	T	26	69
21/Jan/2008	-6.7	-12.4	-9.6	27.6	0	0	T	T	T	26	48
22/Jan/2008	-0.2	-8.2	-4.2	22.2	0	0	4	3.4	T	30	57
23/Jan/2008	-6.1	-9.1	-7.6	25.6	0	0	T	T	2	27	43
24/Jan/2008	-5.7	-11.3	-8.5	26.5	0	0	0.4	0.4	2	31	37
25/Jan/2008	-5.4	-10.7	-8.1	26.1	0	0	0	0	2	28	50
26/Jan/2008	-2.8	-9.2	-6	24	0	0	2.6	2.2	2		<31
27/Jan/2008	-0.6	-7.1	-3.9	21.9	0	0	0.4	0.4	4		<31
28/Jan/2008	1.7	-7.6	-3	21	0	0.2	0	0.2	4		<31
29/Jan/2008	8.2	1.1	4.7	13.3	0	5.8	0	5.8	T	21	35
30/Jan/2008	8.5	-9.7	-0.6	18.6	0	1.2	0.2	1.4	0	25	93
31/Jan/2008	-4.6	-11.1	-7.9	25.9	0	0	0	0	T	7	32
01/Feb/2008	-0.3	-4.7	-2.5	20.5	0	0	16.4	16.4	4	10	61
02/Feb/2008	0.1	-4.1	-2	20	0	0	T	T	16	28	32
03/Feb/2008	1.4	-2.2	-0.4	18.4	0	0	T	T	15		<31
04/Feb/2008	2.8	-1.8	0.5	17.5	0	10	0.4	10.4	13	10	41
05/Feb/2008	6.6	-0.2	3.2	14.8	0	3.4	0.4	3.8	5	2	39
06/Feb/2008	0.2	-5.9	-2.9	20.9	0	T	30.4	31.4	18	6	54
07/Feb/2008	-2.1	-8.7	-5.4	23.4	0	0	1.4	1.4	33	1	39

08/Feb/2008	-0.5	-5	-2.8	20.8	0	0	0.4	0.4	33		<31
09/Feb/2008	2.4	-1.1	0.7	17.3	0	0.6	6.2	7.4	33	23	50
10/Feb/2008	-0.5	-16.6	-8.6	26.6	0	0	0.4	0.4	35	28	80
11/Feb/2008	-9.1	-18.2	-13.7	31.7	0	0	T	T	35	24	50
12/Feb/2008	-3.3	-14.5	-8.9	26.9	0	0	12.6	10.8	35	6	35
13/Feb/2008	-4	-9.4	-6.7	24.7	0	0	0.4	0.4	48		<31
14/Feb/2008	-0.3	-6.4	-3.4	21.4	0	0	T	T	48	21	33
15/Feb/2008	-0.5	-9.7	-5.1	23.1	0	0	T	T	48	26	37
16/Feb/2008	-4.5	-12	-8.3	26.3	0	0	0	0	48		<31
17/Feb/2008	5.5	-12.6	-3.6	21.6	0	14.8	0	14.8	45	30	35
18/Feb/2008	6.5	-5.6	0.5	17.5	0	1.8	0.2	2	18	24	80
19/Feb/2008	-5.2	-9.3	-7.3	25.3	0	0	0.2	0.2	17	27	56
20/Feb/2008	-6.4	-13.6	-10	28	0	0	T	T	17	26	37
21/Feb/2008	-5.6	-13.3	-9.5	27.5	0	0	0	0	17	28	32
22/Feb/2008	-1.9	-8.1	-5	23	0	0	0.4	0.4	17		<31
23/Feb/2008	-0.7	-11.9	-6.3	24.3	0	0	0	0	17		<31
24/Feb/2008	0.9	-9.9	-4.5	22.5	0	0	0	0	15		<31
25/Feb/2008	1.1	-7.3	-3.1	21.1	0	0	0	0	14		<31
26/Feb/2008	0.4	-8.6	-4.1	22.1	0	0	2.2	2.2	10	34	52
27/Feb/2008	-8.6	-15.7	-12.2	30.2	0	0	0	0	12	34	54
28/Feb/2008	-9.7	-18	-13.9	31.9	0	0	0	0	12		<31
29/Feb/2008	0.7	-15.5	-7.4	25.4	0	T	4.8	5.2	12	11	39
01/Mar/2008	0.4	-5.1	-2.4	20.4	0	0	T	T	16	30	59
02/Mar/2008	0.8	-7.4	-3.3	21.3	0	T	0	T	14	12	33
03/Mar/2008	12.8	-0.4	6.2	11.8	0	3	0	3	12	22	50
04/Mar/2008	-0.4	-4.7	-2.6	20.6	0	0	6.8	7.4	4	31	44
05/Mar/2008	-0.1	-6.7	-3.4	21.4	0	0.4	8.4	8.8	16	4	46
06/Mar/2008	3.6	-4.7	-0.6	18.6	0	0	T	T	18	22	33
07/Mar/2008	-0.7	-6.4	-3.6	21.6	0	0	4.2	4.2	16	36	39
08/Mar/2008	-5.7	-8.5	-7.1	25.1	0	0	11.2	11.2	20	35	65
09/Mar/2008	-4.2	-13.6	-8.9	26.9	0	0	0.2	0.2	30	27	46
10/Mar/2008	-0.6	-16.2	-8.4	26.4	0	0	0	0	28		<31
11/Mar/2008	0.8	-11.8	-5.5	23.5	0	0	T	T	26	21	37
12/Mar/2008	0.6	-7.4	-3.4	21.4	0	0	0.4	0.2	25	34	46
13/Mar/2008	3.4	-8.7	-2.7	20.7	0	0	0.2	0.2	23	10	44
14/Mar/2008	6	-3	1.5	16.5	0	T	0	T	22		<31
15/Mar/2008	4.8	-1	1.9	16.1	0	0	0	0	16		<31
16/Mar/2008	-0.5	-5.7	-3.1	21.1	0	0	0	0	8	34	50
17/Mar/2008	-0.7	-8.3	-4.5	22.5	0	0	0	0	5		<31
18/Mar/2008	3.2	-0.7	1.3	16.7	0	5.4	T	5.4	5		<31
19/Mar/2008	3.3	2	2.7	15.3	0	5.2	T	5.2	3	34	48
20/Mar/2008	2.7	-2.8	-0.1	18.1	0	0	0	0	2	31	70
21/Mar/2008	0.6	-4.8	-2.1	20.1	0	0	0	0	2	33	41
22/Mar/2008	0.9	-7.5	-3.3	21.3	0	0	0	0	2	33	37
23/Mar/2008	0.8	-6.6	-2.9	20.9	0	0	0.2	0.2	2		<31
24/Mar/2008	0	-9.3	-4.7	22.7	0	0	1.4	1.4	3		<31
25/Mar/2008	3.7	-6.1	-1.2	19.2	0	0.4	5	5.4	3	21	61
26/Mar/2008	5	-0.7	2.2	15.8	0	0	0	0	3	31	50
27/Mar/2008	5.9	-1.7	2.1	15.9	0	0	0	0	2		<31
28/Mar/2008	3.8	-3.7	0.1	17.9	0	0	T	T	1	34	37
29/Mar/2008	1.9	-5.7	-1.9	19.9	0	0	0	0	T		<31
30/Mar/2008	4.2	-3.1	0.6	17.4	0	T	0	T	T	10	48
31/Mar/2008	7.2	2.5	4.9	13.1	0	8.8	0	8.8	T		<31
01/Apr/2008	15.3	-0.9	7.2	10.8	0	1.2	0	1.2	T	28	83
02/Apr/2008	4.6	-4.5	0.1	17.9	0	0	0	0	T	33	33

03/Apr/2008	9.8	-2.4	3.7	14.3	0	0	0	0	0		<31
04/Apr/2008	5.5	1.3	3.4	14.6	0	7.6	1	8.6	0		<31
05/Apr/2008	12	-0.2	5.9	12.1	0	0	0	0	0		<31
06/Apr/2008	13	0.6	6.8	11.2	0	0	0	0	0	9	41
07/Apr/2008	12.5	4.7	8.6	9.4	0	0	0	0	0	10	33
08/Apr/2008	16.7	6.9	11.8	6.2	0	0	0	0	0		<31
09/Apr/2008	19.5	5	12.3	5.7	0	2.6	0	2.6	0	27	57
10/Apr/2008	11.6	2.3	7	11	0	0.4	0	0.4	0	8	44
11/Apr/2008	6	2.3	4.2	13.8	0	24.2	0	24.2	0	10	57
12/Apr/2008	9.3	2.7	6	12	0	4.2	0	4.2	0	29	35
13/Apr/2008	7.3	0.9	4.1	13.9	0	T	T	T	0	33	41
14/Apr/2008	10.3	0.5	5.4	12.6	0	0	0	0	0	36	35
15/Apr/2008	13.5	-2.3	5.6	12.4	0	0	0	0	0		<31
16/Apr/2008	18.9	3.8	11.4	6.6	0	0	0	0	0	21	41
17/Apr/2008	23.3	5.6	14.5	3.5	0	0	0	0	0	23	37
18/Apr/2008	23.2	10	16.6	1.4	0	0	0	0	0		<31
19/Apr/2008	24.3	7.9	16.1	1.9	0	0	0	0	0	10	46
20/Apr/2008	23.5	9.5	16.5	1.5	0	0	0	0	0		<31
21/Apr/2008	20.9	12.7	16.8	1.2	0	0	0	0	0		<31
22/Apr/2008	20.9	10.3	15.6	2.4	0	0	0	0	0		<31
23/Apr/2008	23.7	9.5	16.6	1.4	0	1.8	0	1.8	0	30	52
24/Apr/2008	18.6	5.6	12.1	5.9	0	0	0	0	0		<31
25/Apr/2008	17.4	11	14.2	3.8	0	0	0	0	0		<31
26/Apr/2008	23.8	8.4	16.1	1.9	0	0	0	0	0	23	57
27/Apr/2008	19.6	7.1	13.4	4.6	0	0	0	0	0	16	37
28/Apr/2008	9.1	0.9	5	13	0	11.6	0	11.6	0	36	44
29/Apr/2008	10.3	-2	4.2	13.8	0	0	0	0	0	32	41
30/Apr/2008	11.6	-1.9	4.9	13.1	0	0	0	0	0	28	44

Daily Data Report for Winter 2008-2009											
Environment Canada			National Climate Data and Information Archive					www.climate.weatheroffice.gc.ca			
Day	Max Temp	Min Temp	Mean Temp	Heat Deg Days	Cool Deg Days	Total Rain	Total Snow	Total Precip	Snow on Grnd	Dir of Max Gust	Spd of Max Gust
	°C	°C	°C	°C	°C	mm	cm	mm	cm	10's Deg	km/h
31/Oct/2008	19.5	6.8	9.9	4.8	0	0	0	0	0	25	39
01/Nov/2008	9.1	-0.6	4.3	13.7	0	0	0	0	0	36	32
02/Nov/2008	6.8	-2.5	2.2	15.8	0	0	0	0	0	12	32
03/Nov/2008	16	2.5	9.3	8.7	0	8.2	0	8.2	0		<31
04/Nov/2008	18.1	6.8	12.5	5.5	0	0	0	0	0		<31
05/Nov/2008	17.6	6.7	12.2	5.8	0	0	0	0	0		<31
06/Nov/2008	17.8	3.4	10.6	7.4	0	0	0	0	0		<31
07/Nov/2008	17	5.1	11.1	6.9	0	4.4	0	4.4	0		<31
08/Nov/2008	11.2	2.7	7	11	0	0.8	0	0.8	0	21	46
09/Nov/2008	7.3	0.2	3.8	14.2	0	T	0	T	0	25	44
10/Nov/2008	4.6	-0.7	2	16	0	T	T	T	0	26	54
11/Nov/2008	5.8	0	2.9	15.1	0	0	0	0	0	27	33
12/Nov/2008	7.4	0.9	4.2	13.8	0	0	0	0	0		<31
13/Nov/2008	11.9	5.9	8.9	9.1	0	8.4	0	8.4	0	22	37
14/Nov/2008	14.6	8.2	11.4	6.6	0	2.6	0	2.6	0	20	35
15/Nov/2008	9.4	0.9	5.2	12.8	0	28.4	T	28.4	0	35	78
16/Nov/2008	4.2	-1.1	1.6	16.4	0	1.2	T	1.2	0	30	54
17/Nov/2008	2.1	-4.4	-1.2	19.2	0	0	T	T	0	36	37
18/Nov/2008	0.1	-6.7	-3.3	21.3	0	0	T	T	T	35	32
19/Nov/2008	-1.2	-8.6	-4.9	22.9	0	0	6.2	3	0		<31
20/Nov/2008	-0.3	-6.1	-3.2	21.2	0	0	0.4	0.4	7		<31
21/Nov/2008	-3.8	-10.6	-7.2	25.2	0	0	0	0	2	32	35
22/Nov/2008	-3.5	-10.6	-7.1	25.1	0	0	0	0	2		<31
23/Nov/2008	0.5	-9.7	-4.6	22.6	0	0	0	0	2		<31
24/Nov/2008	3.9	-1.3	1.3	16.7	0	5.8	0.4	6.2	1	12	37
25/Nov/2008	4.5	0.9	2.7	15.3	0	1.2	T	1.2	0	22	32
26/Nov/2008	3.1	0.3	1.7	16.3	0	0.4	0.2	0.6	T	27	48
27/Nov/2008	3.1	0.6	1.9	16.1	0	0	T	T	0	25	39
28/Nov/2008	3.8	-0.1	1.9	16.1	0	0.4	0.4	0.8	T	26	56
29/Nov/2008	4.8	-2.2	1.3	16.7	0	0	0	0	0	24	32
30/Nov/2008	3.8	-4	-0.1	18.1	0	8.1	5.5	13.6	0	10	57
01/Dec/2008	3.4	-0.9	1.3	16.7	0	3.2	0.4	3.6	0	21	46
02/Dec/2008	0.6	-1.6	-0.5	18.5	0	0	T	T	T	26	44
03/Dec/2008	6.4	-1	2.7	15.3	0	0.4	0	0.4	0	20	44
04/Dec/2008	4.8	-4.3	0.3	17.7	0	1	T	1	0	27	56
05/Dec/2008	-2.2	-8	-5.1	23.1	0	0	T	T	0	26	52
06/Dec/2008	-1.7	-6.6	-4.2	22.2	0	0	2.2	1.8	T	19	37
07/Dec/2008	-2.1	-12.7	-7.4	25.4	0	0	T	T	2	30	63
08/Dec/2008	-2.6	-11.2	-6.9	24.9	0	0	3.4	1.4	2		<31
09/Dec/2008	3.7	-3.4	0.2	17.8	0	6.4	6	12.4	6		<31
10/Dec/2008	2.6	-9.6	-3.5	21.5	0	3.6	0.4	4.2	1	34	44
11/Dec/2008	-1.8	-10.1	-6	24	0	0	0	0	1		<31
12/Dec/2008	-1.4	-11.9	-6.7	24.7	0	0	T	T	1	29	41
13/Dec/2008	1.1	-12.9	-5.9	23.9	0	0	0.2	0.2	1	20	39
14/Dec/2008	5.1	0.6	2.9	15.1	0	1	T	1	1	22	37

15/Dec/2008	10.6	-7.3	1.7	16.3	0	3.8	T	3.8	0	24	74
16/Dec/2008	-3.3	-7.6	-5.5	23.5	0	0	4.4	4	T		<31
17/Dec/2008	-0.1	-5.8	-3	21	0	0	5.4	4.6	8	28	39
18/Dec/2008	-2.2	-8.4	-5.3	23.3	0	0	0	0	7	26	33
19/Dec/2008	-4.2	-14.5	-9.4	27.4	0	0	16	15.2	7	3	57
20/Dec/2008	-10.4	-17.7	-14.1	32.1	0	0	0.4	0.2	22	7	32
21/Dec/2008	-3.6	-13.7	-8.7	26.7	0	0	5.4	5.4	24	25	69
22/Dec/2008	-7.1	-13.5	-10.3	28.3	0	0	T	T	24	30	59
23/Dec/2008	-1.4	-11.7	-6.6	24.6	0	0	11	11.6	23	18	35
24/Dec/2008	6.1	-1.5	2.3	15.7	0	10.8	1.8	12.6	36	27	93
25/Dec/2008	1.2	-4.6	-1.7	19.7	0	0	0.2	0.2	31	28	74
26/Dec/2008	2.5	-4.9	-1.2	19.2	0	T	2.2	1.8	30		<31
27/Dec/2008	14.2	1.4	7.8	10.2	0	9	0	9	22	20	39
28/Dec/2008	15.9	0.1	8	10	0	0.8	0	0.8	2	25	93
29/Dec/2008	5.1	-2.2	1.5	16.5	0	T	T	T	T	30	85
30/Dec/2008	-0.5	-5.9	-3.2	21.2	0	0	3.8	3.4	T	29	72
31/Dec/2008	-5.8	-14.3	-10.1	28.1	0	0	1.6	1.2	5	31	57
01/Jan/2009	-3.8	-15.6	-9.7	27.7	0	0	0	0	2		<31
02/Jan/2009	0.7	-4.7	-2	20	0	0	1.2	0.6	2	28	48
03/Jan/2009	-1.9	-11.8	-6.9	24.9	0	0	0	0	2	28	35
04/Jan/2009	-0.7	-12.2	-6.5	24.5	0	T	0	T	2		<31
05/Jan/2009	0.6	-7.7	-3.6	21.6	0	T	0	T	1	27	44
06/Jan/2009	-0.6	-10	-5.3	23.3	0	T	3.6	3.4	1	11	33
07/Jan/2009	0.7	-2.8	-1.1	19.1	0	1	9	10	5	25	46
08/Jan/2009	-2.8	-12	-7.4	25.4	0	0	0.2	0.2	11	30	48
09/Jan/2009	-6	-12.2	-9.1	27.1	0	0	T	T	11		<31
10/Jan/2009	-6.8	-14.9	-10.9	28.9	0	0	3.8	3.4	11	1	39
11/Jan/2009	-6.3	-12.8	-9.6	27.6	0	0	0.2	0.2	14	36	33
12/Jan/2009	-3.5	-10.6	-7.1	25.1	0	0	0	0	14	27	35
13/Jan/2009	1.1	-16.9	-7.9	25.9	0	0	4	4.6	15	31	65
14/Jan/2009	-13.1	-22.1	-17.6	35.6	0	0	0.8	0.8	18		<31
15/Jan/2009	-10.8	-19.3	-15.1	33.1	0	0	0.6	0.6	18	26	33
16/Jan/2009	-12.7	-18	-15.4	33.4	0	0	0	0	18	26	50
17/Jan/2009	-6.9	-20	-13.5	31.5	0	0	4.8	4	18	14	37
18/Jan/2009	-3	-8.6	-5.8	23.8	0	0	2.8	2.8	21	14	33
19/Jan/2009	-5.6	-11.6	-8.6	26.6	0	0	0.8	0.8	24		<31
20/Jan/2009	-10.2	-17.5	-13.9	31.9	0	0	T	T	24	36	44
21/Jan/2009	-5.5	-19	-12.3	30.3	0	0	T	T	24	27	41
22/Jan/2009	-1.9	-6	-4	22	0	0	T	T	24		<31
23/Jan/2009	3.6	-6.8	-1.6	19.6	0	0	T	T	24	30	63
24/Jan/2009	-6.7	-19.2	-13	31	0	0	0	0	21	31	46
25/Jan/2009	-8.9	-15.6	-12.3	30.3	0	0	0	0	21	25	37
26/Jan/2009	-8.8	-16.9	-12.9	30.9	0	0	0	0	21	26	33
27/Jan/2009	-4	-13.8	-8.9	26.9	0	0	T	T	21	11	33
28/Jan/2009	-3.4	-8.2	-5.8	23.8	0	0	13.4	12.6	23	M	M
29/Jan/2009	-3.1	-10.2	-6.7	24.7	0	0	0.4	0.4	32	22	35
30/Jan/2009	-3.2	-10.8	-7	25	0	0	T	T	32	27	48
31/Jan/2009	-4.7	-16.7	-10.7	28.7	0	0	0.4	T	32	23	37
01/Feb/2009	4.4	-4.8	-0.2	18.2	0	0	0	0	32	26	52
02/Feb/2009	2	-7.9	-3	21	0	0	0	0	28		<31
03/Feb/2009	-3.8	-10.5	-7.2	25.2	0	0	7.4	6.2	27	8	37
04/Feb/2009	-10.2	-18	-14.1	32.1	0	0	1.6	1	35	35	35
05/Feb/2009	-9	-22.2	-15.6	33.6	0	0	T	T	35		<31
06/Feb/2009	-2	-11.8	-6.9	24.9	0	0	0	0	35		<31
07/Feb/2009	7.9	-8.3	-0.2	18.2	0	0	0	0	32	24	70

08/Feb/2009	4	-4.8	-0.4	18.4	0	0	0	0	9	30	57
09/Feb/2009	3.2	-6.2	-1.5	19.5	0	0	0	0	6		<31
10/Feb/2009	9.3	-0.1	4.6	13.4	0	T	0	T	3	22	35
11/Feb/2009	8.9	6.5	7.7	10.3	0	25.8	0	25.8	1		<31
12/Feb/2009	7.8	-2.1	2.9	15.1	0	11.8	T	11.8	T	29	85
13/Feb/2009	-0.9	-7.4	-4.2	22.2	0	0	0	0	T	35	32
14/Feb/2009	-1.8	-8.2	-5	23	0	0	0	0	T		<31
15/Feb/2009	1.3	-8.9	-3.8	21.8	0	0	0	0	T		<31
16/Feb/2009	0.7	-7.5	-3.4	21.4	0	0	0	0	T		<31
17/Feb/2009	2.2	-6.8	-2.3	20.3	0	0	0	0	T	22	32
18/Feb/2009	1	-0.8	0.1	17.9	0	0	8.2	12.4	T		<31
19/Feb/2009	1.3	-7.9	-3.3	21.3	0	0	0.4	0.4	3	27	59
20/Feb/2009	-2.6	-8.8	-5.7	23.7	0	0	T	T	3	29	70
21/Feb/2009	-0.5	-11.2	-5.9	23.9	0	0	4.6	3.6	2	12	37
22/Feb/2009	-2	-8.3	-5.2	23.2	0	0	T	T	5	25	54
23/Feb/2009	-6	-11.4	-8.7	26.7	0	0	0	0	4	34	59
24/Feb/2009	-3.2	-15.1	-9.2	27.2	0	0	0	0	4		<31
25/Feb/2009	2.8	-6.9	-2.1	20.1	0	0.8	2.2	2.8	3		<31
26/Feb/2009	6.5	-0.5	3	15	0	3.8	0	3.8	1		<31
27/Feb/2009	9.4	-12	-1.3	19.3	0	5.8	T	5.8	T	35	59
28/Feb/2009	-6.5	-16.4	-11.5	29.5	0	0	0	0	T	36	35
01/Mar/2009	-4.2	-12.5	-8.4	26.4	0	0	0	0	T	34	52
02/Mar/2009	-9.5	-15.4	-12.5	30.5	0	0	0	0	T	35	52
03/Mar/2009	-3.9	-15.7	-9.8	27.8	0	0	0	0	T		<31
04/Mar/2009	1.6	-12.5	-5.5	23.5	0	0	0	0	T		<31
05/Mar/2009	5.6	-7.1	-0.8	18.8	0	T	0	T	T		<31
06/Mar/2009	18.9	1.3	10.1	7.9	0	0	0	0	T	24	61
07/Mar/2009	4.6	-2	1.3	16.7	0	19.8	0	19.8	T		<31
08/Mar/2009	5.5	1.1	3.3	14.7	0	9.8	T	9.8	0	9	59
09/Mar/2009	4.4	-0.5	2	16	0	1.4	0.6	2.2	T	33	48
10/Mar/2009	3.7	0.2	2	16	0	6.4	0	6.4	0	11	32
11/Mar/2009	9.5	-5.2	2.2	15.8	0	5.4	T	5.4	0	33	82
12/Mar/2009	-2.1	-9.5	-5.8	23.8	0	0	T	T	0	31	41
13/Mar/2009	-0.7	-10.3	-5.5	23.5	0	0	0	0	0		<31
14/Mar/2009	6.9	-6.1	0.4	17.6	0	0	0	0	0		<31
15/Mar/2009	9.6	-3.8	2.9	15.1	0	0	0	0	0		<31
16/Mar/2009	10	-2.4	3.8	14.2	0	0	0	0	0		<31
17/Mar/2009	11.8	-1.8	5	13	0	0	0	0	0		<31
18/Mar/2009	15	2.5	8.8	9.2	0	T	0	T	0	28	76
19/Mar/2009	4.3	-3.6	0.4	17.6	0	0	0	0	0	33	41
20/Mar/2009	2.8	-6.4	-1.8	19.8	0	0	0	0	0		<31
21/Mar/2009	5.9	-5.7	0.1	17.9	0	0	0	0	0		<31
22/Mar/2009	5.8	-4.3	0.8	17.2	0	0	0	0	0	1	41
23/Mar/2009	2.6	-6.4	-1.9	19.9	0	0	0	0	0	2	32
24/Mar/2009	4	-2.9	0.6	17.4	0	0	0	0	0	11	44
25/Mar/2009	8.6	1.9	5.3	12.7	0	2.6	0	2.6	0	10	33
26/Mar/2009	10.4	2	6.2	11.8	0	T	0	T	0	30	35
27/Mar/2009	12.3	-3	4.7	13.3	0	0	0	0	0		<31
28/Mar/2009	13.2	0.3	6.8	11.2	0	0	0	0	0	9	50
29/Mar/2009	10.8	2.6	6.7	11.3	0	22.6	0	22.6	0	23	61
30/Mar/2009	5.6	-2.7	1.5	16.5	0	0	0	0	0	30	54
31/Mar/2009	5.6	-3.1	1.3	16.7	0	T	0	T	0	9	44
01/Apr/2009	14	2.5	8.3	9.7	0	1.8	0	1.8	0	24	70
02/Apr/2009	15.1	1.3	8.2	9.8	0	0.2	0	0.2	0	10	48
03/Apr/2009	10	3.1	6.6	11.4	0	40.2	0	40.2	0	29	74

04/Apr/2009	5.6	2.5	4.1	13.9	0	T	0	T	0	30	80
05/Apr/2009	12.1	0.3	6.2	11.8	0	0.2	0	0.2	0	34	37
06/Apr/2009	4.8	-3.3	0.8	17.2	0	13.8	3.8	17.8	T	33	65
07/Apr/2009	-0.1	-3.9	-2	20	0	0	T	T	1	30	56
08/Apr/2009	8.3	-1.7	3.3	14.7	0	0	T	T	T	27	63
09/Apr/2009	11.7	-1.7	5	13	0	0	0	0	0	30	52
10/Apr/2009	10.7	-0.6	5.1	12.9	0	0	0	0	0	2	33
11/Apr/2009	8.9	-0.8	4.1	13.9	0	0	0	0	0	33	56
12/Apr/2009	6.7	-2.5	2.1	15.9	0	0	0	0	0	35	46
13/Apr/2009	6.8	-3.9	1.5	16.5	0	0	0	0	0		<31
14/Apr/2009	11.8	3.9	7.9	10.1	0	0	0	0	0	8	57
15/Apr/2009	14.5	3.6	9.1	8.9	0	0	0	0	0	7	33
16/Apr/2009	14.5	2.5	8.5	9.5	0	0	0	0	0		<31
17/Apr/2009	20.9	3.9	12.4	5.6	0	0	0	0	0	31	41
18/Apr/2009	21.2	8	14.6	3.4	0	0	0	0	0		<31
19/Apr/2009	12.4	5.2	8.8	9.2	0	T	0	T	0	9	59
20/Apr/2009	9.3	4.3	6.8	11.2	0	25.8	0	25.8	0	9	57
21/Apr/2009	12	3.9	8	10	0	1	0	1	0	17	39
22/Apr/2009	8	3.5	5.8	12.2	0	T	0	T	0	30	48
23/Apr/2009	12	3.6	7.8	10.2	0	T	0	T	0	34	56
24/Apr/2009	19.8	4.8	12.3	5.7	0	0	0	0	0	13	32
25/Apr/2009	27.9	10.5	19.2	0	1.2	9.8	0	9.8	0	26	115
26/Apr/2009	16.2	8.1	12.2	5.8	0	3	0	3	0	36	33
27/Apr/2009	27.5	7	17.3	0.7	0	0	0	0	0	23	69
28/Apr/2009	17.3	4.4	10.9	7.1	0	10.4	0	10.4	0	35	59
29/Apr/2009	12.5	3.6	8.1	9.9	0	0	0	0	0	13	37
30/Apr/2009	17.5	7.3	12.4	5.6	0	23.4	0	23.4	0	22	48

Daily Data Report for Winter 2009-2010

Environment Canada			National Climate Data and Information Archive					www.climate.weatheroffice.gc.ca			
Day	Max Temp	Min Temp	Mean Temp	Heat Deg Days	Cool Deg Days	Total Rain	Total Snow	Total Precip	Snow on Grnd	Dir of Max Gust	Spd of Max Gust
	°C	°C	°C	°C	°C	mm	cm	mm	cm	10's Deg	km/h
01/Nov/2009	10.7	4.1	9.9	10.6	0	0	0	0	0	28	32
02/Nov/2009	10.4	1.1	5.8	12.2	0	1.6	0	1.6	0		<31
03/Nov/2009	8.9	0.9	4.9	13.1	0	T	0	T	0	33	50
04/Nov/2009	6.2	-1.2	2.5	15.5	0	1.8	0	1.8	0		<31
05/Nov/2009	7.5	1.3	4.4	13.6	0	1.6	0	1.6	0	32	69
06/Nov/2009	4.9	-1.1	1.9	16.1	0	0	0	0	0		<31
07/Nov/2009	16.1	4.5	10.3	7.7	0	0	0	0	0	21	41
08/Nov/2009	18.1	4.7	11.4	6.6	0	0	0	0	0		<31
09/Nov/2009	19.1	3.9	11.5	6.5	0	0	0	0	0		<31
10/Nov/2009	13.5	3.3	8.4	9.6	0	0	0	0	0	M	M
11/Nov/2009	9	-0.5	4.3	13.7	0	0	0	0	0		<31
12/Nov/2009	9.6	-1.8	3.9	14.1	0	0	0	0	0		<31
13/Nov/2009	11.1	-1.5	4.8	13.2	0	0	0	0	0		<31
14/Nov/2009	15.8	3.6	9.7	8.3	0	0	0	0	0		<31
15/Nov/2009	13.5	2	7.8	10.2	0	0	0	0	0	31	37
16/Nov/2009	8.8	-0.2	4.3	13.7	0	0	0	0	0		<31
17/Nov/2009	7.5	-2.3	2.6	15.4	0	0	0	0	0		<31
18/Nov/2009	11.3	0.1	5.7	12.3	0	0	0	0	0		<31
19/Nov/2009	10.2	2	6.1	11.9	0	12.6	0	12.6	0	25	37
20/Nov/2009	10.4	3.7	7.1	10.9	0	1.2	0	1.2	0	27	50
21/Nov/2009	11.7	3	7.4	10.6	0	0	0	0	0		<31
22/Nov/2009	11	2.8	6.9	11.1	0	0	0	0	0		<31
23/Nov/2009	9.8	2.4	6.1	11.9	0	0	0	0	0		<31
24/Nov/2009	7.8	6.2	7	11	0	1.2	0	1.2	0		<31
25/Nov/2009	10.6	7.5	9.1	8.9	0	6.2	0	6.2	0		<31
26/Nov/2009	9.5	1.3	5.4	12.6	0	0.4	0	0.4	0	23	35
27/Nov/2009	7.1	1.4	4.3	13.7	0	0.4	0	0.4	0	32	56
28/Nov/2009	6.5	0.2	3.4	14.6	0	0	0	0	0	30	33
29/Nov/2009	6.9	-3	2	16	0	4.6	0	4.6	0		<31
30/Nov/2009	5.5	-0.7	2.4	15.6	0	0.6	0	0.6	0	32	35
01/Dec/2009	7	0.3	3.7	14.3	0	0	0.2	0.2	T	24	44
02/Dec/2009	10.2	0.2	5.2	12.8	0	15.6	0	15.6	0	9	46
03/Dec/2009	7.6	-0.6	3.5	14.5	0	5	0	5	0	30	54
04/Dec/2009	3.3	-3.8	-0.3	18.3	0	0	0	0	0	24	50
05/Dec/2009	0.9	-5.7	-2.4	20.4	0	0	0	0	0		<31
06/Dec/2009	2.7	-3.8	-0.6	18.6	0	0	T	T	T	23	41
07/Dec/2009	1.6	-2.7	-0.6	18.6	0	0	T	T	0		<31
08/Dec/2009	2.1	-4.5	-1.2	19.2	0	0	T	T	0	11	61
09/Dec/2009	6.1	-0.9	2.6	15.4	0	10.2	9.6	26.2	5	23	76
10/Dec/2009	-0.8	-9.5	-5.2	23.2	0	0	1.4	1	2	24	74
11/Dec/2009	-6.4	-10.2	-8.3	26.3	0	0	T	T	2	27	63
12/Dec/2009	1.7	-8.5	-3.4	21.4	0	0	T	T	1	26	39
13/Dec/2009	3	-0.4	1.3	16.7	0	0.8	T	0.8	1	19	35
14/Dec/2009	3.8	0.4	2.1	15.9	0	2.6	0	2.6	1		<31
15/Dec/2009	3	-5	-1	19	0	0	0.6	0.6	T	31	50

16/Dec/2009	-3.6	-6.3	-5	23	0	0	0.6	0.4	T	26	41
17/Dec/2009	-4.7	-11.7	-8.2	26.2	0	0	T	T	T		<31
18/Dec/2009	-2.9	-7.1	-5	23	0	0	T	T	T		<31
19/Dec/2009	-3.3	-9.2	-6.3	24.3	0	0	0	0	T		<31
20/Dec/2009	1.1	-5.8	-2.4	20.4	0	0	T	T	T		<31
21/Dec/2009	-1.8	-6.7	-4.3	22.3	0	0	T	T	T		<31
22/Dec/2009	-5.7	-11.7	-8.7	26.7	0	0	T	T	T	34	32
23/Dec/2009	-3.3	-9.9	-6.6	24.6	0	0	T	T	T	33	35
24/Dec/2009	0.5	-7.3	-3.4	21.4	0	0	0.4	0.4	T	10	44
25/Dec/2009	3.7	-0.1	1.8	16.2	0	15.6	0	15.6	T	10	63
26/Dec/2009	4.4	-2.7	0.9	17.1	0	10.6	0	10.6	0	9	44
27/Dec/2009	2	-2.2	-0.1	18.1	0	0	T	T	0	24	32
28/Dec/2009	-1.6	-11.4	-6.5	24.5	0	0	1	0.6	T	31	70
29/Dec/2009	-5.2	-15.7	-10.5	28.5	0	0	0.4	0.2	1	31	56
30/Dec/2009	-1.2	-8.8	-5	23	0	0	0	0	1		<31
31/Dec/2009	2.7	-1.5	0.6	17.4	0	0.6	T	0.6	T		<31
01/Jan/2010	0.9	-10.4	-4.8	22.8	0	0	1.6	1.2	T	32	54
02/Jan/2010	-10.2	-17.6	-13.9	31.9	0	0	T	T	1	31	50
03/Jan/2010	-8.3	-15.5	-11.9	29.9	0	0	2	1.2	1	33	65
04/Jan/2010	-7.1	-12.7	-9.9	27.9	0	0	0.8	0.4	2	34	44
05/Jan/2010	-3.6	-11.1	-7.4	25.4	0	0	3	2	2	33	39
06/Jan/2010	-2.1	-10.3	-6.2	24.2	0	0	T	T	5	33	37
07/Jan/2010	-3	-7.3	-5.2	23.2	0	0	T	T	5		<31
08/Jan/2010	-7.3	-11.7	-9.5	27.5	0	0	1.4	0.8	5	34	46
09/Jan/2010	-8.7	-14.6	-11.7	29.7	0	0	0	0	5	36	46
10/Jan/2010	-3.8	-15.6	-9.7	27.7	0	0	T	T	4	24	46
11/Jan/2010	-4.7	-7.8	-6.3	24.3	0	0	1.4	1.2	3	23	39
12/Jan/2010	-5.7	-9.1	-7.4	25.4	0	0	0	0	4	35	35
13/Jan/2010	0.4	-6.1	-2.9	20.9	0	0	0	0	4	24	44
14/Jan/2010	4.8	-6	-0.6	18.6	0	0	0	0	3	22	33
15/Jan/2010	4.1	1	2.6	15.4	0	T	0	T	T		<31
16/Jan/2010	2	-3.2	-0.6	18.6	0	0	0	0	T	25	33
17/Jan/2010	2.7	-1.6	0.6	17.4	0	0	0	0	0		<31
18/Jan/2010	1	-2.9	-1	19	0	0	0	0	0		<31
19/Jan/2010	2	-3.8	-0.9	18.9	0	0	0.2	0.2	0	35	32
20/Jan/2010	-1.8	-7.7	-4.8	22.8	0	0	0	0	T	34	35
21/Jan/2010	0.9	-8.9	-4	22	0	0	0	0	T	10	37
22/Jan/2010	3.1	-5.3	-1.1	19.1	0	0	0	0	0	9	32
23/Jan/2010	1.5	-3.8	-1.2	19.2	0	0	0	0	0		<31
24/Jan/2010	6	-1.3	2.4	15.6	0	6.2	0	6.2	0	12	32
25/Jan/2010	6.7	0.2	3.5	14.5	0	10.8	0	10.8	0	26	48
26/Jan/2010	0.3	-1.9	-0.8	18.8	0	0	0.2	0.2	0	26	56
27/Jan/2010	-1.9	-5.8	-3.9	21.9	0	0	0.2	0.2	T	25	50
28/Jan/2010	-3.9	-13.7	-8.8	26.8	0	0	T	T	T	32	74
29/Jan/2010	-9.5	-17.7	-13.6	31.6	0	0	T	T	T	31	46
30/Jan/2010	-9.4	-19	-14.2	32.2	0	0	0	0	T		<31
31/Jan/2010	-4.1	-13.5	-8.8	26.8	0	0	T	T	T	31	44
01/Feb/2010	-3.3	-10.9	-7.1	25.1	0	0	T	T	T	27	50
02/Feb/2010	-1.2	-9.9	-5.6	23.6	0	0	2.6	2	T		<31
03/Feb/2010	0.6	-6.1	-2.8	20.8	0	0	0.4	0.4	2	29	48
04/Feb/2010	0.4	-10	-4.8	22.8	0	0	0	0	2		<31
05/Feb/2010	0.1	-6.8	-3.4	21.4	0	0	0	0	1	5	41
06/Feb/2010	-5.4	-12	-8.7	26.7	0	0	0	0	1	4	37
07/Feb/2010	-2.2	-11.9	-7.1	25.1	0	0	0	0	T	35	37
08/Feb/2010	0.9	-11.4	-5.3	23.3	0	0	0	0	T	32	35

09/Feb/2010	-3.8	-8.7	-6.3	24.3	0	0	0.2	0.2	T	7	35
10/Feb/2010	-3.2	-7.6	-5.4	23.4	0	0	4.4	3.2	3	33	54
11/Feb/2010	-1.4	-9.7	-5.6	23.6	0	0	0	0	3	29	37
12/Feb/2010	-0.5	-11.5	-6	24	0	0	0	0	2	28	35
13/Feb/2010	-1.2	-9.6	-5.4	23.4	0	0	0.6	0.6	T	31	37
14/Feb/2010	-1.1	-3.8	-2.5	20.5	0	0	T	T	1	29	44
15/Feb/2010	-1.4	-4.1	-2.8	20.8	0	0	T	T	T		<31
16/Feb/2010	0.6	-4.6	-2	20	0	0	0.2	0.2	T		<31
17/Feb/2010	0.6	-3.6	-1.5	19.5	0	0	2.2	1.8	T	31	50
18/Feb/2010	1.4	-2.4	-0.5	18.5	0	0	0	0	1	32	48
19/Feb/2010	4.1	-2	1.1	16.9	0	0	0	0	T	31	59
20/Feb/2010	4.1	-5.6	-0.8	18.8	0	0	0	0	T	29	33
21/Feb/2010	4.9	-5.7	-0.4	18.4	0	0	0	0	0		<31
22/Feb/2010	0.6	-6.1	-2.8	20.8	0	0	5	5	0	8	41
23/Feb/2010	0.7	-3.8	-1.6	19.6	0	T	0.6	0.6	5		<31
24/Feb/2010	0.9	-5.4	-2.3	20.3	0	0	T	T	5		<31
25/Feb/2010	-0.4	-7.5	-4	22	0	0	3	2.8	3	34	61
26/Feb/2010	-0.1	-6.3	-3.2	21.2	0	0	6.4	6.2	7	34	72
27/Feb/2010	2.2	-0.7	0.8	17.2	0	0	1.8	1.8	8	32	41
28/Feb/2010	3.1	0.2	1.7	16.3	0	0	T	T	4	34	35
01/Mar/2010	2.5	-1.3	0.6	17.4	0	0	0	0	1	34	46
02/Mar/2010	3	-3.4	-0.2	18.2	0	0	0	0	1		<31
03/Mar/2010	4.4	-3.1	0.7	17.3	0	0	0	0	T	36	32
04/Mar/2010	3.8	-4.3	-0.3	18.3	0	0	0	0	T	33	37
05/Mar/2010	3.9	-4.1	-0.1	18.1	0	0	0	0	T	35	35
06/Mar/2010	9	-4	2.5	15.5	0	0	0	0	T		<31
07/Mar/2010	11.3	-2.7	4.3	13.7	0	0	0	0	T	27	41
08/Mar/2010	14.2	-0.2	7	11	0	0	0	0	T	29	46
09/Mar/2010	13	-0.1	6.5	11.5	0	0	0	0	0		<31
10/Mar/2010	9	-1.9	3.6	14.4	0	T	0	T	0	M	M
11/Mar/2010	12.2	5.1	8.7	9.3	0	0	0	0	0	9	44
12/Mar/2010	7.5	5.1	6.3	11.7	0	21.6	0	21.6	0	9	54
13/Mar/2010	6.7	4	5.4	12.6	0	20.6	0	20.6	0	7	78
14/Mar/2010	5.8	3.3	4.6	13.4	0	4	0	4	0	8	70
15/Mar/2010	13.2	3	8.1	9.9	0	T	0	T	0	4	33
16/Mar/2010	16	0.9	8.5	9.5	0	0	0	0	0		<31
17/Mar/2010	17.7	3.5	10.6	7.4	0	0	0	0	0		<31
18/Mar/2010	18.7	3.2	11	7	0	0	0	0	0	27	46
19/Mar/2010	19.1	3.1	11.1	6.9	0	0	0	0	0	24	50
20/Mar/2010	5.3	-1.2	2.1	15.9	0	0	0	0	0	35	32
21/Mar/2010	5.3	-1.6	1.9	16.1	0	0	T	T	T		<31
22/Mar/2010	7.9	-0.8	3.6	14.4	0	4	0	4	0	5	41
23/Mar/2010	3.7	0.2	2	16	0	3.6	0	3.6	0	2	37
24/Mar/2010	15.4	-2	6.7	11.3	0	0	0	0	0	32	33
25/Mar/2010	9	-3.1	3	15	0	0	0	0	0		<31
26/Mar/2010	0.9	-6.7	-2.9	20.9	0	0	0	0	0	2	46
27/Mar/2010	4.6	-6.6	-1	19	0	0	0	0	0		<31
28/Mar/2010	6.9	0.9	3.9	14.1	0	7.8	0	7.8	0		<31
29/Mar/2010	8.8	-0.5	4.2	13.8	0	1	0	1	0	3	39
30/Mar/2010	12.6	-2	5.3	12.7	0	0	0	0	0		<31
31/Mar/2010	14.7	0.3	7.5	10.5	0	0	0	0	0		<31
01/Apr/2010	19.3	6	12.7	5.3	0	0	0	0	0		<31
02/Apr/2010	24.3	7.6	16	2	0	0	0	0	0		<31
03/Apr/2010	21.9	7.2	14.6	3.4	0	T	0	T	0	25	72
04/Apr/2010	18.1	5.8	12	6	0	0	0	0	0	17	44

05/Apr/2010	23.1	9.9	16.5	1.5	0	T	0	T	0	28	59
06/Apr/2010	13.3	8.7	11	7	0	7.2	0	7.2	0	11	32
07/Apr/2010	17.2	8.4	12.8	5.2	0	14.4	0	14.4	0	24	32
08/Apr/2010	11.6	3.7	7.7	10.3	0	10.8	0	10.8	0	26	46
09/Apr/2010	4.1	1.3	2.7	15.3	0	T	T	T	0	27	50
10/Apr/2010	13.3	-0.8	6.3	11.7	0	T	0	T	0	26	44
11/Apr/2010	17.7	3.8	10.8	7.2	0	0	0	0	0	29	46
12/Apr/2010	13.6	3.9	8.8	9.2	0	0	0	0	0	36	37
13/Apr/2010	14.9	4.1	9.5	8.5	0	0	0	0	0		<31
14/Apr/2010	16.5	2.2	9.4	8.6	0	0	0	0	0		<31
15/Apr/2010	19.9	5.6	12.8	5.2	0	0	0	0	0		<31
16/Apr/2010	21.6	4.6	13.1	4.9	0	T	0	T	0	31	63
17/Apr/2010	7.9	3.2	5.6	12.4	0	0.2	T	0.2	0	29	54
18/Apr/2010	14	3.9	9	9	0	T	0	T	0	33	48
19/Apr/2010	16.2	3.4	9.8	8.2	0	0	0	0	0	36	39
20/Apr/2010	18.2	4.4	11.3	6.7	0	0	0	0	0		<31
21/Apr/2010	19.1	3.4	11.3	6.7	0	T	0	T	0	34	48
22/Apr/2010	12.6	1.7	7.2	10.8	0	0	0	0	0	32	33
23/Apr/2010	15	0.9	8	10	0	0	0	0	0		<31
24/Apr/2010	18.1	3	10.6	7.4	0	0	0	0	0		<31
25/Apr/2010	12.7	9.3	11	7	0	3.6	0	3.6	0	8	41
26/Apr/2010	17.5	5.3	11.4	6.6	0	0	0	0	0	36	57
27/Apr/2010	10.6	2.8	6.7	11.3	0	0	0	0	0	33	54
28/Apr/2010	14	4	9	9	0	0	0	0	0	33	54
29/Apr/2010	19.5	3.5	11.5	6.5	0	T	0	T	0	23	32
30/Apr/2010	20.9	10.6	15.8	2.2	0	0	0	0	0		<31

APPENDIX B

Mobilization Data for
Winter Seasons 2004-2005 to 2009-2010

Mobilization Data for Winter 2004-2005 City of Toronto - West District					
Winter Day No.	**Date**	**Mobilization Per Date Totals**	**Units per Day**	**KM Driven per Day**	**Operation**
3	03-Nov-2004	1	1	22.8	Salting
7	07-Nov-2004	2	2	258	Anti-icing
8	08-Nov-2004	2	2	258	Anti-icing
11	11-Nov-2004	2	2	258	Anti-icing
13	13-Nov-2004	2	2	258	Anti-icing
25	25-Nov-2004	17	17	436.2	Salting
26	26-Nov-2004	61	40	1709.34	Salting
28	28-Nov-2004	2	2	258	Anti-icing
31	01-Dec-2004	2	2	258	Anti-icing
33	03-Dec-2004	2	2	258	Anti-icing
34	04-Dec-2004	2	2	258	Anti-icing
36	06-Dec-2004	100	38	2729.2	Salting
37	07-Dec-2004	79	38	2097.12	Salting
41	11-Dec-2004	76	38	2030.19	Salting
43	13-Dec-2004	2	2	271.9	Anti-icing
45	15-Dec-2004	59	38	1593.99	Salting
47	17-Dec-2004	65	38	1751.59	Salting
49	19-Dec-2004	61	38	1645.99	Salting
50	20-Dec-2004	35	26	894.98	Salting
51	21-Dec-2004	83	38	2293	Salting
52	22-Dec-2004	118	38	3187.98	Salting
53	23-Dec-2004	159	38	4242.58	Salting
54	24-Dec-2004	159	38	4241.33	Salting
55	25-Dec-2004	83	38	2293	Salting
56	26-Dec-2004	94	38	2571.6	Salting
57	28-Dec-2004	59	38	1593.99	Salting
62	01-Jan-2005	2	2	271.9	Anti-icing
63	02-Jan-2005	61	38	1659.56	Salting
64	04-Jan-2005	50	29	1576.99	Salting
65	05-Jan-2005	33	20	870.12	Salting
66	06-Jan-2005	173	38	5377.81	Salting

67	07-Jan-2005	50	38	1594.67	Salting
69	08-Jan-2005	59	38	1593.99	Salting
71	10-Jan-2005	2	2	271.9	Anti-icing
73	12-Jan-2005	67	38	2030.87	Salting
74	13-Jan-2005	50	38	1594.67	Salting
75	14-Jan-2005	44	32	1437.07	Salting
76	15-Jan-2005	1	1	164.9	Anti-icing
77	16-Jan-2005	50	38	1594.67	Salting
78	17-Jan-2005	18	18	601.1	Salting
80	19-Jan-2005	200	38	6378.68	Salting
81	20-Jan-2005	40	27	1465.57	Salting
82	21-Jan-2005	1	1	198.9	Anti-icing
83	22-Jan-2005	170	38	5292.41	Salting
84	23-Jan-2005	127	38	3970.95	Salting
85	24-Jan-2005	100	38	3189.34	Salting
86	25-Jan-2005	150	38	4784.41	Salting
87	26-Jan-2005	67	38	2030.87	Salting
88	27-Jan-2005	34	22	1323.37	Salting
90	29-Jan-2005	1	1	27	Salting
92	31-Jan-2005	2	2	271.9	Anti-icing
95	03-Feb-2005	2	2	271.9	Anti-icing
100	08-Feb-2005	19	19	708.1	Salting
101	09-Feb-2005	150	38	4784.01	Salting
102	10-Feb-2005	103	38	3258.54	Salting
105	13-Feb-2005	2	2	271.9	Anti-icing
106	14-Feb-2005	50	38	1594.67	Salting
108	16-Feb-2005	100	38	3189.34	Salting
109	17-Feb-2005	52	38	1644.67	Salting
112	20-Feb-2005	100	38	3189.34	Salting
113	21-Feb-2005	50	38	1594.47	Salting
117	25-Feb-2005	100	38	3189.34	Salting
118	26-Feb-2005	50	38	1594.67	Salting
119	27-Feb-2005	2	2	340.5	Anti-icing
120	28-Feb-2005	106	38	3346.94	Salting
121	01-Mar-2005	117	38	3625.54	Salting
122	02-Mar-2005	100	38	3189.34	Salting
123	03-Mar-2005	33	21	1158.47	Salting

127	07-Mar-2005	50	38	1594.67	Salting
128	08-Mar-2005	1	1	23.6	Salting
129	09-Mar-2005	35	23	977.61	Salting
130	10-Mar-2005	26	26	895.66	Salting
131	11-Mar-2005	50	38	1594.67	Salting
132	12-Mar-2005	59	38	2054.13	Salting
133	13-Mar-2005	97	38	2887.48	Salting
137	17-Mar-2005	37	25	1474.17	Salting
138	18-Mar-2005	2	2	271.9	Anti-icing
139	19-Mar-2005	1	1	25.4	Salting
141	21-Mar-2005	52	40	1866.57	Salting
143	23-Mar-2005	50	38	1594.67	Salting
144	24-Mar-2005	52	40	1866.57	Salting
152	01-Apr-2005	2	2	271.9	Anti-icing
154	03-Apr-2005	12	12	300.8	Salting

Mobilization Data for Winter 2005-2006

City of Toronto - West District

Winter Day No.	Date	Mobilization Per Date Totals	Units per Day	KM Driven per Day	Operation
10	10-Nov-2005	2	1	279.42	Anti-icing
16	16-Nov-2005	2	2	279.42	Anti-icing
17	17-Nov-2005	2	2	279.42	Anti-icing
18	18-Nov-2005	112	38	2357.19	Salting
22	22-Nov-2005	2	2	279.42	Anti-icing
23	23-Nov-2005	106	38	2199.68	Salting
24	24-Nov-2005	354	38	7616.78	Salting
25	25-Nov-2005	244	38	4627.76	Salting
26	26-Nov-2005	95	38	1920.99	Salting
30	30-Nov-2005	1	1	164.9	Anti-icing
32	02-Dec-2005	148	38	3365	Salting
33	03-Dec-2005	31	16	796.73	Salting
34	04-Dec-2005	117	38	2496.02	Salting
39	09-Dec-2005	202	38	4138.98	Salting
43	13-Dec-2005	17	17	436.2	Salting
44	14-Dec-2005	128	37	3096.03	Salting
45	15-Dec-2005	215	38	5353.77	Salting

46	16-Dec-2005	77	38	1920.99	Salting
47	17-Dec-2005	3	2	227.46	Anti-icing
50	20-Dec-2005	77	38	1920.99	Salting
55	25-Dec-2005	77	38	1920.99	Salting
56	26-Dec-2005	26	12	764.58	Salting
57	27-Dec-2005	2	2	279.42	Anti-icing
59	29-Dec-2005	2	2	279.42	Anti-icing
60	30-Dec-2005	4	2	279.42	Anti-icing
61	31-Dec-2005	351	39	8856.66	Salting
62	01-Jan-2006	2	1	54.38	Salting
66	05-Jan-2006	2	2	279.42	Anti-icing
68	07-Jan-2006	120	40	3859.98	Salting
69	08-Jan-2006	1	1	25.4	Salting
70	09-Jan-2006	2	2	279.42	Anti-icing
75	14-Jan-2006	61	40	2025.08	Salting
76	15-Jan-2006	24	15	1039.12	Salting
77	16-Jan-2006	1	1	2	Salting
78	17-Jan-2006	72	40	2219.59	Salting
79	18-Jan-2006	85	40	2635	Salting
80	19-Jan-2006	1	1	24.6	Salting
82	21-Jan-2006	66	42	2284.16	Salting
84	23-Jan-2006	2	2	279.42	Anti-icing
86	25-Jan-2006	67	40	2088.71	Salting
91	30-Jan-2006	2	2	279.42	Anti-icing
92	31-Jan-2006	2	2	279.42	Anti-icing
97	05-Feb-2006	120	40	3855.65	Salting
98	06-Feb-2006	155	40	4831.59	Salting
99	07-Feb-2006	37	23	1021.41	Salting
102	10-Feb-2006	120	40	3867.81	Salting
107	15-Feb-2006	2	2	279.42	Anti-icing
108	16-Feb-2006	256	40	8506.83	Salting
109	17-Feb-2006	61	40	1932.82	Salting
110	18-Feb-2006	96	40	2909.43	Salting
116	24-Feb-2006	2	2	279.42	Anti-icing
117	25-Feb-2006	213	40	6414.84	Salting
118	26-Feb-2006	58	35	1885.36	Salting
130	10-Mar-2006	2	2	279.42	Anti-icing

134	14-Mar-2006	2	2	279.42	Anti-icing
137	17-Mar-2006	2	2	279.42	Anti-icing
140	20-Mar-2006	2	2	279.42	Anti-icing
142	22-Mar-2006	2	2	279.42	Anti-icing
146	26-Mar-2006	2	2	279.42	Anti-icing
152	01-Apr-2006	2	2	279.42	Anti-icing
155	04-Apr-2006	2	2	279.42	Anti-icing
156	05-Apr-2006	10	10	606.22	Salting

Mobilization Data for Winter 2006-2007

City of Toronto - West District

Winter Day No.	Date	Mobilization Per Date Totals	Units per Day	KM Driven per Day	Operation
1	01-Nov-2006	6	4	279.42	Anti-icing
3	03-Nov-2006	6	4	279.42	Anti-icing
18	18-Nov-2006	6	4	279.42	Anti-icing
22	22-Nov-2006	6	4	279.42	Anti-icing
32	02-Dec-2006	37	25	1257.03	Salting
33	03-Dec-2006	7	6	224.64	Salting
34	04-Dec-2006	72	39	2240.24	Salting
35	05-Dec-2006	35	23	977.61	Salting
37	07-Dec-2006	35	23	977.61	Salting
45	15-Dec-2006	2	2	279.42	Anti-icing
49	19-Dec-2006	2	2	279.42	Anti-icing
57	27-Dec-2006	72	38	2261.45	Salting
59	29-Dec-2006	35	23	977.61	Salting
60	30-Dec-2006	59	38	1920.99	Salting
63	02-Jan-2007	2	2	279.42	Anti-icing
67	06-Jan-2007	2	1	279.42	Anti-icing
69	08-Jan-2007	1	1	164.9	Anti-icing
70	09-Jan-2007	1	1	114.52	Anti-icing
71	10-Jan-2007	35	23	977.61	Salting
74	13-Jan-2007	59	38	1920.99	Salting
75	14-Jan-2007	61	40	1925.24	Salting
76	15-Jan-2007	284	40	9107.65	Salting
77	16-Jan-2007	104	40	3460.68	Salting
78	17-Jan-2007	44	23	1496.92	Salting

80	19-Jan-2007	55	34	1775.42	Salting
83	22-Jan-2007	133	40	4143.03	Salting
84	23-Jan-2007	20	5	536.78	Salting
85	24-Jan-2007	26	15	998.18	Salting
87	26-Jan-2007	180	40	5800.79	Salting
88	27-Jan-2007	121	40	3890.28	Salting
89	28-Jan-2007	120	40	3863.23	Salting
91	30-Jan-2007	120	40	3864.65	Salting
95	03-Feb-2007	3	3	80.2	Salting
96	04-Feb-2007	3	2	87.96	Salting
97	05-Feb-2007	218	40	7121.39	Salting
98	06-Feb-2007	61	40	1931.83	Salting
105	13-Feb-2007	120	40	3853.23	Salting
106	14-Feb-2007	148	38	4872.58	Salting
107	15-Feb-2007	61	40	1932.49	Salting
108	16-Feb-2007	97	40	2936.85	Salting
113	21-Feb-2007	2	2	279.42	Anti-icing
114	22-Feb-2007	120	40	3847.73	Salting
117	25-Feb-2007	127	40	4028.23	Salting
118	26-Feb-2007	214	40	7015.45	Salting
119	27-Feb-2007	60	38	1946.39	Salting
121	01-Mar-2007	144	40	4464.53	Salting
122	02-Mar-2007	180	40	5817.75	Salting
125	05-Mar-2007	95	38	2924	Salting
127	07-Mar-2007	120	40	3854.48	Salting
130	10-Mar-2007	2	2	279.42	Anti-icing
131	11-Mar-2007	1	1	24.6	Salting
132	12-Mar-2007	2	2	55.6	Salting
135	15-Mar-2007	2	2	279.42	Anti-icing
136	16-Mar-2007	121	41	3866.13	Salting
137	17-Mar-2007	122	40	3885.48	Salting
142	22-Mar-2007	2	2	279.42	Anti-icing
144	24-Mar-2007	2	2	279.42	Anti-icing
156	05-Apr-2007	76	38	2357.19	Salting

Mobilization Data for Winter 2007-2008 City of Toronto - West District					
Winter Day No.	Date	Mobilization Per Date Totals	Units per Day	KM Driven per Day	Operation
1	01-Nov-2007	2	1	279.42	Anti-icing
7	07-Nov-2007	2	2	279.42	Anti-icing
10	10-Nov-2007	2	2	279.42	Anti-icing
22	22-Nov-2007	246	40	7851.45	Salting
23	23-Nov-2007	57	35	1840.99	Salting
27	27-Nov-2007	37	24	1122.33	Salting
28	28-Nov-2007	9	6	276.11	Salting
29	29-Nov-2007	2	2	279.42	Anti-icing
30	30-Nov-2007	43	31	1141.71	Salting
32	02-Dec-2007	165	40	5006.81	Salting
33	03-Dec-2007	61	40	1921.82	Salting
34	04-Dec-2007	36	24	1015.44	Salting
38	08-Dec-2007	1	1	2	Salting
39	09-Dec-2007	42	30	1176.14	Salting
40	10-Dec-2007	62	41	1974.09	Salting
41	11-Dec-2007	111	41	3666.48	Salting
42	12-Dec-2007	1	1	164.9	Anti-icing
43	13-Dec-2007	116	41	3779.07	Salting
45	15-Dec-2007	183	41	5600.46	Salting
47	17-Dec-2007	140	41	4721.12	Salting
48	18-Dec-2007	62	41	1976.75	Salting
57	20-Dec-2007	2	2	279.42	Anti-icing
58	24-Dec-2007	94	38	2898.6	Salting
59	27-Dec-2007	61	40	1930.9	Salting
60	29-Dec-2007	2	2	279.42	Salting
61	31-Dec-2007	96	40	2912.1	Salting
62	01-Jan-2008	237	40	7691.04	Salting
63	02-Jan-2008	24	12	699.01	Salting
71	10-Jan-2008	2	2	279.42	Anti-icing
72	11-Jan-2008	2	2	279.42	Anti-icing
76	15-Jan-2008	97	40	2939.18	Salting
79	18-Jan-2008	61	40	1929.24	Salting
80	19-Jan-2008	12	9	410.22	Salting

81	20-Jan-2008	1	1	2	Salting
83	22-Jan-2008	180	41	5815.57	Salting
84	23-Jan-2008	44	23	1495.12	Salting
85	24-Jan-2008	72	40	2210	Salting
87	26-Jan-2008	120	40	3854.9	Salting
88	27-Jan-2008	35	26	1221.98	Salting
90	29-Jan-2008	61	40	1932.99	Salting
91	30-Jan-2008	62	41	1971.52	Salting
92	31-Jan-2008	35	23	977.61	Salting
93	01-Feb-2008	176	40	5284.35	Salting
94	02-Feb-2008	61	40	1931.99	Salting
95	03-Feb-2008	35	23	977.61	Salting
96	04-Feb-2008	59	38	1920.99	Salting
98	06-Feb-2008	295	41	9637.5	Salting
99	07-Feb-2008	169	41	5231.98	Salting
100	08-Feb-2008	26	17	951.55	Salting
101	09-Feb-2008	193	41	6192.59	Salting
103	11-Feb-2008	35	23	977.61	Salting
104	12-Feb-2008	182	41	5900.01	Salting
105	13-Feb-2008	155	40	4832.17	Salting
109	17-Feb-2008	120	40	3852.4	Salting
110	18-Feb-2008	61	40	1935.74	Salting
111	19-Feb-2008	105	23	2932.83	Salting
114	22-Feb-2008	59	38	1920.99	Salting
116	24-Feb-2008	11	11	278.6	Salting
118	26-Feb-2008	120	40	3852.32	Salting
119	27-Feb-2008	61	40	1930.74	Salting
121	29-Feb-2008	141	41	4419.81	Salting
122	01-Mar-2008	62	41	1977.67	Salting
124	03-Mar-2008	62	41	1971.92	Salting
125	04-Mar-2008	162	41	5107.3	Salting
126	05-Mar-2008	46	24	1536.51	Salting
128	07-Mar-2008	163	42	5272.69	Salting
129	08-Mar-2008	119	38	3860.38	Salting
130	09-Mar-2008	126	40	4286.38	Salting
131	10-Mar-2008	20	11	803.78	Salting
133	12-Mar-2008	62	41	1970.81	Salting

134	13-Mar-2008	11	11	278.6	Salting
137	16-Mar-2008	39	27	1345.51	Salting
138	17-Mar-2008	39	23	1077.21	Salting
140	19-Mar-2008	2	2	279.42	Anti-icing
141	20-Mar-2008	17	11	441	Salting
142	21-Mar-2008	18	12	488.2	Salting
143	22-Mar-2008	1	1	2	Salting
144	23-Mar-2008	17	12	474.08	Salting
145	24-Mar-2008	123	41	3964.01	Salting
147	26-Mar-2008	36	24	1018.54	Salting

Mobilization Data for Winter 2008-2009

City of Toronto - West District

Winter Day No.	Date	Mobilization Per Date Totals	Units per Day	KM Driven per Day	Operation
10	10-Nov-2008	3	2	221.42	Anti-icing
16	16-Nov-2008	4	4	214.1	Anti-icing
17	17-Nov-2008	2	2	106.9	Anti-icing
19	19-Nov-2008	40	40	2592.16	Salting
20	20-Nov-2008	40	40	1725.03	Salting
28	28-Nov-2008	4	4	214.1	Anti-icing
32	02-Dec-2008	19	19	654.86	Salting
34	04-Dec-2008	4	4	214.1	Anti-icing
36	06-Dec-2008	40	40	2000.47	Salting
37	07-Dec-2008	40	40	1386.38	Salting
38	08-Dec-2008	40	40	1614.95	Salting
39	09-Dec-2008	42	42	4420.75	Salting
40	10-Dec-2008	42	42	2530.96	Salting
42	12-Dec-2008	3	3	181	Salting
44	14-Dec-2008	21	21	633.34	Salting
45	15-Dec-2008	4	4	214.1	Anti-icing
46	16-Dec-2008	21	21	1525.49	Salting
47	17-Dec-2008	21	21	1747.83	Salting
48	18-Dec-2008	1	1	26.67	Salting
49	19-Dec-2008	42	42	3284.08	Salting
50	20-Dec-2008	42	42	2894.32	Salting
51	21-Dec-2008	39	39	2787.25	Salting

52	22-Dec-2008	42	42	2904.68	Salting
53	23-Dec-2008	42	42	2693.35	Salting
55	25-Dec-2008	42	42	1475.54	Salting
56	26-Dec-2008	42	42	1465.74	Salting
59	29-Dec-2008	4	4	214.1	Anti-icing
60	30-Dec-2008	21	21	1284.17	Salting
61	31-Dec-2008	40	40	2604.33	Salting
63	02-Jan-2009	42	42	1465.74	Salting
65	04-Jan-2009	21	21	855.59	Salting
67	06-Jan-2009	21	21	1284.17	Salting
68	07-Jan-2009	42	42	3333.42	Salting
69	08-Jan-2009	42	42	1465.74	Salting
71	10-Jan-2009	42	42	2600.81	Salting
72	11-Jan-2009	32	32	1409.57	Salting
73	12-Jan-2009	32	32	1009.3	Salting
74	13-Jan-2009	42	42	2693.35	Salting
75	14-Jan-2009	39	39	1284.14	Salting
76	15-Jan-2009	39	39	1623.39	Salting
78	17-Jan-2009	42	42	2693.35	Salting
79	18-Jan-2009	42	42	1804.39	Salting
80	19-Jan-2009	39	39	2569.28	Salting
84	23-Jan-2009	6	6	206.59	Salting
85	24-Jan-2009	6	6	206.59	Salting
89	28-Jan-2009	42	42	3363.61	Salting
90	29-Jan-2009	42	42	2750.48	Salting
91	30-Jan-2009	39	39	1284.74	Salting
92	31-Jan-2009	42	42	1465.75	Salting
95	03-Feb-2009	31	31	2063.78	Salting
96	04-Feb-2009	39	39	1284.74	Salting
97	05-Feb-2009	3	3	181	Salting
100	08-Feb-2009	39	39	1371.94	Salting
101	09-Feb-2009	2	2	106.9	Anti-icing
108	16-Feb-2009	11	11	629.57	Salting
109	17-Feb-2009	5	5	241.48	Salting
110	18-Feb-2009	42	42	2309.34	Salting
111	19-Feb-2009	39	39	2569.48	Salting
112	20-Feb-2009	42	42	1465.74	Salting

113	21-Feb-2009	39	39	2236.91	Salting
114	22-Feb-2009	33	33	1175.21	Salting
115	23-Feb-2009	22	22	748.03	Salting
116	24-Feb-2009	3	3	181	Salting
117	25-Feb-2009	21	21	670.65	Salting
118	26-Feb-2009	18	18	614.09	Salting
126	06-Mar-2009	4	4	214.1	Anti-icing
129	09-Mar-2009	46	46	1679.84	Salting
132	12-Mar-2009	35	35	1559.35	Salting
146	26-Mar-2009	4	4	214.1	Anti-icing
157	06-Apr-2009	30	30	994.11	Salting
158	07-Apr-2009	32	32	1030.65	Salting
161	10-Apr-2009	2	2	107.2	Anti-icing
162	11-Apr-2009	2	2	107.2	Anti-icing
163	12-Apr-2009	2	2	107.2	Anti-icing

Mobilization Data for Winter 2009-2010

City of Toronto - West District

Winter Day No.	Date	Mobilization Per Date Totals	Units per Day	KM Driven per Day	Operation
3	03-Nov-2009	4	3	214.1	Anti-icing
5	05-Nov-2009	4	4	214.1	Anti-icing
10	10-Nov-2009	4	4	214.1	Anti-icing
12	12-Nov-2009	4	4	213.48	Anti-icing
16	16-Nov-2009	4	4	214.1	Anti-icing
27	27-Nov-2009	4	4	214.1	Anti-icing
30	30-Nov-2009	4	4	214.1	Anti-icing
33	03-Dec-2009	4	4	214.1	Anti-icing
36	06-Dec-2009	4	4	214.1	Anti-icing
38	08-Dec-2009	1	1	40.84	Salting
39	09-Dec-2009	42	42	3489.37	Salting
40	10-Dec-2009	42	42	2154.76	Salting
44	14-Dec-2009	1	1	40.84	Salting
45	15-Dec-2009	42	42	2136.39	Salting
53	23-Dec-2009	20	20	721.29	Salting
54	24-Dec-2009	39	39	1284.74	Salting
56	26-Dec-2009	25	25	884.75	Salting

57	27-Dec-2009	42	42	1465.76	Salting
58	28-Dec-2009	42	42	1465.74	Salting
59	29-Dec-2009	4	4	134.36	Salting
61	31-Dec-2009	4	4	214.1	Anti-icing
62	01-Jan-2010	42	42	2931.48	Salting
64	03-Jan-2010	42	42	4316.74	Salting
65	04-Jan-2010	42	42	2079.83	Salting
66	05-Jan-2010	42	42	3379.27	Salting
67	06-Jan-2010	42	42	1465.74	Salting
69	08-Jan-2010	42	42	2402.82	Salting
72	11-Jan-2010	39	39	1898.83	Salting
73	12-Jan-2010	4	4	207.6	Salting
76	15-Jan-2010	4	4	214.1	Anti-icing
79	18-Jan-2010	4	4	214.1	Anti-icing
80	19-Jan-2010	18	18	614.09	Salting
81	20-Jan-2010	3	3	181	Salting
82	21-Jan-2010	4	4	214.1	Anti-icing
86	25-Jan-2010	4	4	214.1	Anti-icing
88	27-Jan-2010	39	39	1311.34	Salting
89	28-Jan-2010	33	33	1174.61	Salting
94	02-Feb-2010	39	39	1623.39	Salting
95	03-Feb-2010	42	42	1465.74	Salting
101	09-Feb-2010	39	39	1735.41	Salting
102	10-Feb-2010	42	42	3388.12	Salting
103	11-Feb-2010	3	3	181	Salting
105	13-Feb-2010	18	18	614.09	Salting
108	16-Feb-2010	39	39	1284.74	Salting
109	17-Feb-2010	21	21	795.09	Salting
114	22-Feb-2010	42	42	2693.35	Salting
115	23-Feb-2010	42	42	2136.39	Salting
116	24-Feb-2010	21	21	795.09	Salting
117	25-Feb-2010	42	42	4159.09	Salting
118	26-Feb-2010	42	42	3068.44	Salting
119	27-Feb-2010	1	1	36.04	Salting
120	28-Feb-2010	42	42	2079.83	Salting
128	08-Mar-2010	4	4	214.1	Anti-icing
141	21-Mar-2010	4	4	214.1	Anti-icing