HALIFAX REGIONAL MUNICIPALITY

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Environmental & Sustainability Standing Committee
April 16, 2012

TO: Chair and Members of the Environment & Sustainability Standing Committee

SUBMITTED BY: ______________________________
Peter Stickings, Planning & Infrastructure

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Ken Reashor, Director, Transportation & Public Works

DATE: March 27, 2012

SUBJECT: **Road Salt Impacts on Lakes**

INFORMATION REPORT

ORIGIN

October 6, 2011, Environment & Sustainability Standing Committee – Item 7.1.4

BACKGROUND

Halifax Regional Municipality (HRM) Energy & Environment (formerly the Sustainable Environment Management Office (SEMO)) was directed to respond to a motion of the HRM Environment and Sustainability Committee (ESSC) that "*staff provide a report outlying the short term policy opportunities for HRM lakes*". On May 19, 2011, SEMO gathered together interested and knowledgeable parties in water resource management to discuss the protection of lake ecosystems within HRM. This first phase of consultation was designed as a Workshop and was called 'Protect Our Lakes'. The initiative was responding to three key concepts:

- Development and encroachment on water resources increases stress to our freshwater ecosystems, in particular our lakes;
- Recent Water Quality Monitoring Data demonstrates the declining health of our lakes; and
- Well-designed policies have the potential to mitigate or eliminate negative ecological impacts. We are fortunate to have many knowledgeable, passionate, and committed residents wishing to protect our water resources.

The Protect Our Lakes Workshop was designed to help establish priority short term actions that would focus HRM's efforts to improve protection of lakes. A report summarizing the process and recommendations developed at that workshop, led to the direction by ESSC staff, in consultation with a water issues advisory group, to work on actions identified therein. Action 9 in this report was the "Development of Best Management Practices around the use of road salt".

This report presents a summary of activities that Staff has taken to address these impacts, both prior to and in response to the Protect Our Lakes workshop report.

DISCUSSION

Road salts are used as de-icing and anti-icing chemicals for winter road maintenance. They are used across Canada and around the world to maintain public safety in winter conditions, and their effectiveness is undisputed. Although road salts do contribute to public safety, their use also has negative environmental implications. A comprehensive five-year scientific assessment by Environment Canada, published in 2001, determined that in sufficient concentrations road salts pose a risk to plants, animals and the aquatic environment, and deemed them toxic.

Because public safety cannot be compromised and road salt application does not have negative human health impacts, the Government of Canada has not banned them but rather developed a system designed to help municipalities and other road authorities better manage their use of road salts in a way that reduces harm they cause to the environment while maintaining road safety. This system was published as a Code of Practice for the Environmental Management of Road Salts in 2004.

The Code was developed in consultation with a Multi-Stakeholder Working Group for Road Salts. Voluntary, active and ongoing participation in this Working Group marks one of HRM's earliest actions towards addressing the environmental impacts of road salts. In fulfillment of the Code of Practice, HRM has worked steadily to create a salt management plan, identify best management practices and apply innovations to winter works operations where they make sense. Transportation and Public Works are currently developing a new Winter Works Management Plan to reflect recent upgrades in policies and practice.

On a broader level, HRM recognized the need for watershed planning in the Regional Municipal Planning Strategy (2006) in which it expressed a desire that lakes, watercourses and coastal waters not be further degraded. A program of water quality monitoring began in 2006, to identify the status and trends in lake water quality for selected watercourses across the municipality; this program included the collection of chloride data (chloride is the primary toxic component of road salts).

In October of 2011, the Municipal Operations Winter Works Staff initiated and piloted the application of brine (Direct Liquid Brine Application) to HRM roads to achieve enhancements to public safety and a reduction in overall salt usage. A summary of this practice is posted on this HRM website: http://www.halifax.ca/snow/SaltManagementStrategies.html.

In addition, Energy & Environment Staff have received two consulting reports regarding road salts in the HRM.

The first report, a summary of Best Management Practices (BMP) (see Attachment 1) including recommendations for local application, confirmed that HRM has been proactive in its road salt management and already employs a number of BMPs. Cost estimates provided in this report are considered inaccurate by HRM staff.

The second report, a review of lake water quality relevant to road salts (see Attachment 2), revealed that eleven lakes monitored by HRM staff had measured chloride concentrations above the maximum Canadian Council of Ministers of the Environment (CCME) guideline concentration for long-term exposure to Chloride (120 mg/L), for the majority of observations. Several recommendations were provided for HRM's consideration on how to proceed in light of these findings. Staff is committed to proceeding with all recommendations as resource availability permits.

BUDGET IMPLICATIONS

None

FINANCIAL MANAGEMENT POLICIES / BUSINESS PLAN

This report complies with the Municipality's Multi-Year Financial Strategy, the approved Operating, Project and Reserve budgets, policies and procedures regarding withdrawals from the utilization of Project and Operating reserves, as well as any relevant legislation.

COMMUNITY ENGAGEMENT

Approximately ten members of the watershed advisory boards and local environmental organizations participated in the public information meeting that originated successive staff activities reported here.

ATTACHMENTS

Attachment 1: Stantec Report: Road Salt Best Management Practices
Attachment 2: Stantec Report: Lake Water Quality Review

A copy of this report can be obtained online at http://www.halifax.ca/commcoun/cc.html then choose the appropriate Community Council and meeting date, or by contacting the Office of the Municipal Clerk at 490-4210, or Fax 490-4208.

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Report Approved by: ______________________________
Richard MacLellan, Manager, Energy & Environment, 490-6056

Attachment 1

Stantec

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DRAFT REPORT: Road Salt – Review of Best Management Practices

Report Prepared for:
Halifax Regional Municipality
Sustainable Environment Management Office
PO Box 1749
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File: 121411639

Date: November 7, 2011

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1.0 Introduction

1.1 SCOPE OF WORK

Stantec Consulting Limited (Stantec) is pleased to present the results of our review of Best Management Practices (BMPs) relative to Road Salt Application, to Halifax Regional Municipality (HRM) Sustainable Environment Management Office (SEMO). To undertake the BMP review, we completed the following tasks, as outlined in our email dated August 26, 2011:

- reviewed current practices within HRM;
- identified information sources, including, but not limited to: regulatory guidance, scientific papers, BMPs for municipalities within Canada and the US, and experts within academia and the consulting industry;
- performed document review and expert interviews of the identified information sources; and
- consolidated data and prepared this report.

HRM indicated that the driver for this document review was to identify BMPs related to road salt management that may result in lower chloride levels in HRM surface waters. This document provides a starting point for discussion and evaluation of BMPs by a working group formed under the direction of SEMO.

1.2 WINTER MAINTENANCE

Prior to developing an understanding of the impacts of road salt on the environment, an understanding of the need for winter maintenance is required. The Transportation Association of Canada (TAC, 1999) indicated that direct benefits from winter maintenance include fewer accidents, improved travel time, and reduced travel cost, with a number of indirect benefits including: economic productivity, maintenance of social activities, provision of emergency services and reductions in accident claims. The success of our economy relies directly on the delivery and movement of people, resources and goods. Jurisdictions outside of winter zones have a perceived advantage because they do not have down time related to winter storms or icy road conditions.

The costs of winter maintenance are also well documented and a number of studies have estimated direct and indirect costs for winter maintenance. The direct costs are the labour and material costs to conduct winter maintenance. The indirect costs can be linked to human health (traffic accidents, salinity in water), natural environment, road infrastructure (corrosion to bridges), and vehicles (corrosion). The indirect costs to the natural environment would include damage to roadside vegetation, and impacts to surface water and groundwater quality. Global or macro estimates of these costs have been reported. TAC (1999) reported that at the broadest level the application of road salt can have benefit/cost ratios ranging between 2.0:1 and 6.5:1. Research to date has provided justification for winter maintenance based on social and economic benefits. However, the need to better manage the application of road salt as part of winter maintenance has become clear as the environmental impact of road salt is better understood.

1.3 SCIENCE OF SALT – THE BASICS

Maintaining safe roads in the winter consists of providing traction between a vehicle's tires and the road. Slippery conditions result from moisture from fog, rain or snow freezing on the road when the road temperatures are below freezing. Sodium chloride (road salt) is the most popular chemical de-icer, because it is reliable, inexpensive, and easy to handle, store, and apply. Salt prevents freezing by lowering the temperature at which water freezes. Three key elements must be considered when assessing the use of salt to prevent freezing: temperature, moisture, and time.

Because heat is required to break the bond between the sodium and chloride ions to allow the ions to go into solution, this reaction can only occur at certain temperatures. Depending on the temperature of the pavement, one kilogram of salt can melt 46 kilograms (kg) of ice at –1 degree Celsius (°C) and 6.3 kg of ice at –9°C. Therefore the colder the road temperature, the more salt that needs to be applied. In general, application of salt works best at temperatures above -11°C (Stantec, 2002).

Application of road salt only works when the salt forms a brine solution that inhibits snow and ice from adhering to the road surface. Therefore, moisture is critical to the effectiveness of road salt. Moisture can be introduced via precipitation, humidity or pre-wetting. Too much precipitation can dilute the brine and make it less effective.

The amount of moisture present and the road surface temperature impact the amount of time needed for the salt to go into solution and for melting to occur. As salt goes into solution, it must be dispersed across the road surface to create a protective layer over the pavement to prevent formation of a bond between ice/snow and the road surface. If ice and snow bond with the road surface, it becomes very difficult to remove the material by mechanical means without damaging the roadway. Therefore, it is far more effective to anti-ice than to de-ice, as actual melting of formed ice requires significantly more salt than to prevent ice formation through creating a brine layer over the pavement.

1.4 HISTORY OF ROAD SALT APPLICATION

Since the 1940s road salt has been applied by various methods and means to roads (Stantec, 2002). Initially, road salt was applied by shoveling from the back of trucks at icy locations. The first mass applications of salt were as an additive to sand to eliminate freezing in the storage piles and to reduce clumping in the sand trucks. As the benefits of salt for melting snow and ice on the pavement began to be understood, the percentage of salt within the sand was increased to mixtures ranging from 2:1 to 5:1 sand to salt. Between the mid-1960s and early 1970s most urban centers realized that the application of road salt directly to the roadway provided several short term benefits which included:

- the faster elimination of snowpack and the corresponding improved driving conditions/level of service;
- better road-riding performance (less snowpack bumps and uneven bare pavement conditions);
- a reduction in the effort to maintain the roadways through less plowing and winter maintenance; and
- a reduction in the need to conduct a massive spring/summer cleanup of the sand after the winter maintenance activities.

The public has come to expect bare pavement conditions shortly after storm events, and as a result the amount of salt applied to roads increased substantially from the mid-1970s. For the remainder of the 1970s and 1980s all roads within most urban jurisdictions received straight road salt. The impetus on the road salt truck operators was to ensure that enough (or more than enough) road salt was applied to provide an optimum level of service. With the rising cost for the supply of road salt, jurisdictions began to review the roads receiving road salt in efforts to reduce annual operating costs. However, the implementation of road salt reduction measures is commonly faced with addressing risk and liability issues, which can sidetrack the reduction measure or prevent them altogether.

1.5 ROAD SALT USAGE REGULATORY GUIDANCE

Due to the concerns about the large quantities of chlorides being released to the environment as a result of road salt usage, road salt underwent a comprehensive five-year scientific assessment under the *Canadian Environmental Protection Act (CEPA)*, 1999, beginning in 1995.

On December 1, 2001, Environment Canada released an assessment report that concluded that road salts are entering the environment in large amounts and are having an adverse effect on freshwater ecosystems, soil, vegetation and wildlife. Based on the assessment, Environment Canada declared road salt to be “toxic” under CEPA. ***It must be noted that Health Canada stated that road salts are not harmful to humans.***

The final *Code of Practice for the Environmental Management of Road Salts* (the Code) was published in the Canada Gazette, Part I, on April 3, 2004. The Code applies to any organizations that use more than 500 tonnes of road salt per year (five-year rolling average); and organizations that have vulnerable areas in their territory. This includes HRM. The Code states that any agency that meets this criteria should consider implementing the best management practices that are relevant to its local conditions in order to protect the environment from negative impacts of road salts.

Recommendations in the Code do not replace nor supercede any laws or regulations adopted by federal, provincial, territorial, or municipal authorities in relation to, among other things, environmental protection, road safety or use of road salts. Nothing in the Code should be construed as a recommendation to take action to the detriment of road safety.

The Code is not the sole guidance available to users of road salts in Canada, and is intended to be used in conjunction with the *Salt Management Guide and Syntheses of Best Practices* developed by TAC and any federal, provincial, territorial, or municipal maintenance standards. It is noted that Gordon Hayward, HRM Winter Works Superintendent, was a contributor to the TAC document. *The Syntheses of Best Practices* are outlined as follows:

1.0 Salt Management Plans
2.0 Training
3.0 Road and Bridge Design
4.0 Drainage and Stormwater Management
5.0 Pavements and Salt Management
6.0 Vegetation Management
7.0 Design and Operation of Road Maintenance Yards
8.0 Snow Storage and Disposal
9.0 Winter Maintenance Equipment and Technologies

In September 2004, Environment Canada released an *Implementation Guide for the Code of Practice for the Environmental Management of Road Salts*. The appendices in the Guide provide useful information and resources to assist organizations with the development of their salt management plan.

2.0 Road Salt in HRM

2.1 CHALLENGES TO ROAD SALT USAGE IN HRM

The location of HRM close to the Atlantic Ocean creates a more moderate climate than in many parts of Canada, therefore increasing the effectiveness of road salt. However, the proximity to the Atlantic Ocean also decreases the predictability of the weather and can result in more severe winter storms. In addition, HRM includes a large land area with diverse geographical and climatic conditions, making uniform decisions regarding salt application difficult. During any particular storm event, certain areas of the region may be experiencing snow, while others are experiencing rain, sleet, or freezing rain. The numerous and steep hills located throughout HRM are an added challenge to maintaining safe roadways. Although an urban municipality with a municipal water supply, areas of HRM are serviced by private water supply wells, which are potential receptors of road salt impacts. Finally, HRM contains an extensive surface water network, including the municipal water supply source(s). Although the final destination of the surface water systems is the salt water of the Atlantic Ocean, road salt traveling through these surface water bodies has the potential to impact freshwater ecosystems along the way.

2.2 CURRENT PRACTICES IN HRM

Stantec reviewed current salt management practices within HRM and this section summarizes the results of this review. Please note that it was not within the scope of work to perform a more thorough assessment of current practices. Data was gathered through interviews with relevant HRM personnel, in particular Gordon Hayward, Winter Works Superintendent, and a review of existing documents made available by HRM. Documents reviewed included:

- Halifax Regional Municipality, Salt Management Plan, March 2007; and
- Halifax Regional Municipality, Winter Works Management Plan, DRAFT – not yet published.

2.2.1 Roadway and Sidewalk Classification and Levels of Service

The HRM roadway system consists of approximately 3,750 lane kilometers (km) of roads (HRM, 2007). The roadways are prioritized, with Priority 1 roads including main arterials, transit routes, collector roads, and residential streets with a greater than 10% slopes and Priority 2 roads including residential streets and gravel roads. It is noted that snow removal is not discussed in detail in this report. Snow/ice removal service standards (and corresponding salt usage) vary based on roadway classification and are outlined below:

Table 1 Road Classification Salting Guidelines

Road Classification	End Service Level	De-Icer	Application Rate Kg/Lane Km	Start Time And Frequency	Time To Completion From End Of Snowfall
Main Arterials	bare pavement driving lanes	salt pre-wetting	90/125/150 (see Table 2)	after 2 cm of snow, 3 hour turnaround times	8 hours to full driving lanes
Transit Routes Collector Roads	10 ft centerline bare	salt pre-wetting salt/sand under extreme conditions	90/125/150 (see Table 2)	after 2 cm of snow, 3 hour turnaround times	12 hours to full driving lanes
Residential Streets with greater than 10% slope	centerline bare	salt salt/sand under extreme conditions	90/125 (see Table 2)	after 2 cm of snow, 3 hour turnaround times	12 hours to 2 lane widths
Residential Streets	snow covered, passable	sand salt under favorable conditions	90/125 (see Table 2)	after plowing operations are complete	24 hours to 2 lane widths
Gravel Roads	snow covered, passable	sand for traction	800	after plowing operations are complete	24 hours to 2 lane widths

There are also vulnerable areas identified (generally related to private water supplies) where salt use is restricted and in some cases only sand is applied.

Each storm event must be assessed individually to determine the best approach. However, the following table outlines general salt application rates used for common snow and ice events.

Table 2 General Salt Application Rates

Condition	Temperature (°C)	Salt Application Rates (kg/lane km)
dry, light snow (0-2cm) daytime	0 to -5	125
dry, light snow (0-2cm) night time	-4 to -8	150
wet snow (0-2cm) followed by temp drop	0 to -10	150
bare, wet pavement with rapid temp drop	0 to -5	125
refreeze of wet roads	-2 to -5	125
spot salting	0 to -10	90
frost coming out	0 to + 2	90
blowing snow/ squalls	below -12	sand
freezing rain	-1	150

HRM also contains 815 km of sidewalk, of which 720 kms are designated for winter service. The sidewalks are classified similar to the roadways, however, sidewalks cannot be serviced until the roadway levels of service have been achieved. As such, and due to sidewalk construction and pedestrian usage, there is greater probability of ice build-up that cannot effectively be removed with salting. In these cases, sand or sand/salt mix is applied to improve traction. The following table outlines the sidewalk classification and corresponding levels of service.

Table 3 Sidewalk Classification and Levels of Service

Sidewalk Classification	End Service Level	Start Time and Frequency	Time to Completion from End of Snowfall
Main Arterials Capital Districts	Bare or with salt/sand for traction	After 15 cms of snowfall	12 hours
Transit Routes	Bare or with salt/sand for traction	After 15 cms of snowfall	18 hours
School Routes	Bare or with salt/sand for traction	After 15 cms of snowfall	18 hours
Residential Streets and Walkways (not on bus route)	Bare or with salt/sand for traction	After end of snowfall	36 hours

2.2.2 Snow Disposal

HRM has the benefit of being able to dispose of snow in an empty lot beside the Fairview Container Pier, which allows excess salt from the melting snow to be deposited in the Bedford

Basin. As such, snow disposal in HRM is not considered to pose a significant risk to the freshwater ecosystems in question. However, the melting snow may contain other contaminants, such as cyanide (from ferrocyanide), petroleum hydrocarbons, and metals, as well as significant quantities of litter. Although HRM snow disposal will not be discussed further in this report as it is not relevant to concerns regarding road salt impacts to freshwater bodies within HRM, additional evaluation of snow disposal methods and location may be warranted.

2.2.3 Material Storage and Equipment

HRM is divided into three service regions: West, East, and Central. These regions are further divided into areas (four in West, three each in East and Central).

There are three operational depots:

1) Macintosh Street (West streets);
2) Sackville Street (West sidewalks); and
3) Turner Drive (East and Central streets and sidewalks)

There are three material storage bases:

1) MacIntosh Street (West);
2) Bayers Lake (Central); and
3) Turner Drive (East).

The following table summarizes material storage at each facility.

Table 4 Material Storage

	West	Central	East
Salt storage	6000-tonne dome	6000-tonne dome	6000-tonne dome
Sand storage	outside on impervious surface	outside on impervious surface	2000-tonne dome
Brine production and storage	yes	no	yes

Salt is purchased from the mine in Pugwash, NS. Ferrocyanide is added at the mine to reduce caking.

Salt is added to sand (5% mix) to reduce freezing. Our experience with other agencies has shown that this percentage may be as high at 10%.

Salt, sand, and brine loading is conducted outdoors. Unloading of un-used salt is also conducted outdoors.

The brine produced contains 23% sodium chloride (NaCl) and is used to pre-wet salt before it is applied to the roadway. Pre-wetting salt increases its effectiveness by adding moisture to assist in creating a brine, which promotes ice melting. Pre-wet salt is also more likely to stay on the road, rather than bounce off during application or as a result of traffic. Excess brine not used during salt application remains in the tanks on the trucks for the next use.

HRM has approximately 150 pieces of equipment assigned to Winter Works. HRM also employs about 200 pieces of contractor equipment for streets work and 15 pieces of equipment assigned for internal servicing of the sidewalk program. Another 50 pieces of equipment are provided by performance-based contracts for the sidewalk program.

HRM equipment includes 40 trucks equipped with a two-way snowplow and salt spreaders. Thirty-one trucks are equipped with pre-wet systems. Contractors are also encouraged to install pre-wet systems; six contracted units are currently so equipped. All HRM spreaders have electronic rate control that takes into account groundspeed. Twenty trucks have left front discharge; ten trucks have dual front discharge, and ten trucks have rear discharge. Spreaders are calibrated annually, and when any irregularities are noted by the Operator.

Vehicles are washed following service to limit salt corrosion. Vehicle wash water is treated in an oil-water separator before being collected and transported to an appropriate off-site disposal facility.

There are 45 Roadwatch™ infrared temperature (IRT) sensors used between supervisor trucks and tandem salt trucks. The IRT sensors measure the temperature of the road surface to assist in decision-making regarding salt application.

In addition to IRT sensors, Winter Works Superintendents receive detailed weather forecasts based on information gathered from the provincial Road Weather Information System (RWIS). Nova Scotia Transportation and Infrastructure Renewal (NSTIR) has 44 RWIS stations located throughout the province (Kidson, 2011, interview). RWIS stations provide data such as air temperature, wind direction and velocity, humidity, road temperature, sub-road temperature, freeze point (which is impacted by residual salt), and temperature trends.

2.2.4 Winter Event Planning

At the start of each event, a planning session is initiated and the following steps are taken:

1) review weather forecast from several credible sources (see RWIS and IRT information, above);
2) review in-house equipment and human resource availability;
3) evaluate how weather forecast and environmental factors including current road surface temperatures will affect roadway conditions;
4) determine anti-icing strategies;
5) evaluate timing and duration of storm and its relationship to traffic patterns, the initial use of in-house resources along with the requirement for additional equipment/contractors to meet P1 service standards;

6) determine forecasted requirement for resource allocation and timing for P2 streets to meet service standards;
7) determine forecasted requirement for resource allocation for sidewalks in coordination with street operations and service standards; and
8) communicate to all stakeholders.

2.2.5 Training

Beginning in 2008/09, salt management training (SMT) has been provided to supervisors by Eco-Plans Limited (Eco-Plans). Refreshers are conducted annually. Operators also receive individual in-house coaching sessions. As of 2009/10, contractors receive SMT from Eco-Plans. Eco-Plans is a TAC-sponsored SMT provider.

2.2.6 Salt Tracking/Accounting

Salt/Sand Report Forms are completed by Supervisors each day during winter works even if no materials are used. The reports identify usage by vehicle. Salt usage and accountability are reviewed internally for budget projections and inventory control with necessary HRM operation and finance staff. Annual salt usage reports are submitted to Environment Canada.

2.2.7 Public Education and Communication

Public education, including councillor education, and communication is an on-going process. HRM provides information to the public regarding snow clearing efforts, service delivery standards, winter parking bans and all winter safety operations through the following methods:

- www.halifax.ca/snow
- Public Service Announcements (PSAs)
- News releases
- HRM Call Centre (490-4000)
- Print ads
- Radio ads/interviews
- TV ads/interviews
- Posters
- E-mail distribution contact list (Mayor, Council and Business Improvement Districts)
- Social media sites (Twitter)
- HRM's mayor and councillors
- HRM libraries and customer service centres

2.2.8 Alternative De-Icers

In 2005/06 HRM trialed the use of GeoMelt® and Fusion™, liquid organic de-icer solutions made from sugar beets. According to John Sibbald, Halifax Regional Water Commission, the influx of organics to the stormwater system created elevated biological oxygen demand (BOD) and overloaded treatment plants. Elevated BOD is not desirable in surface water bodies.

2.2.9 Proposed Changes

In 2011/12 and beyond, HRM is installing scales at the salt storage depots to better track salt usage per operator/vehicle. This will allow for checks between ideal and actual spreading rates and will show if spreader calibration or additional operator training is needed. In addition, liquid anti-icing using pure brine with no solid salt is being trialed.

2.3 ANNUAL ROAD SALT VOLUME USAGE IN HRM

The following table provides annual salt usage by HRM from the 2000/01 winter season to the 2009/10 winter season. The 2003/04 season (*) was the first year that salt management initiatives were implemented.

Table 5 Road Salt Usage Per Winter Season in HRM

Year	Total Road Salt Usage (tonnes)	Five-Year Rolling Average (tonnes)
2000/01	43,735	-
2001/02	42,506	-
2002/03	62,574	-
2003/04*	26,501*	-
2004/05	28,565	40,776
2005/06	21,800	36,389
2006/07	23,000 (estimate)	32,488
2007/08	62,000	32,373
2008/09	53,000	37,673
2009/10	36,500	37,260

When considering salt usage, the winter severity index must be considered. Therefore, this table does not provide a complete picture of the effectiveness of salt management initiatives in HRM.

It should be noted that Nova Scotia is the third largest consumer of road salt in Canada, behind Quebec and Ontario (Environment Canada, 2001). This may be at least partly attributed to the climate, which is moderated by the Atlantic Ocean. Winter temperatures are often above -10°C, making application of road salt highly effective in preventing icy roads. In addition, Nova Scotia is prone to wet snow, freezing rain, and sleet, as well as freeze-thaw events, which require de-icing to maintain safe roadways. In addition, salt is relatively cheap to purchase due to the presence of a salt-producing mine in the province.

3.0 The Environmental Impact of Road Salt

There are numerous publications outlining the impact of road salt on vegetation, wildlife, freshwater aquatic life, and groundwater. To be effective, sodium chloride (NaCl) molecules must go into solution, mobilizing Na^+ and Cl^- ions. Sodium is retained by soil particles and does not travel far from the source; however, this ion exchange can result in the release of other ions (including metals) into groundwater. Chloride is non-reactive and highly mobile and readily makes its way to surface water bodies and groundwater aquifers.

Ferrocyanide is added to road salt to prevent caking. In the absence of direct sunlight, ferrocyanide complex is stable and low in toxicity. However, exposure to sunlight results in dissociation and release of free cyanide, which can be hydrated to hydrogen cyanide; both compounds are toxic.

3.1 DRINKING WATER GUIDELINES

Health Canada has applied aesthetic objectives to sodium (200 milligrams per litre (mg/L)) and chloride (250 mg/L) in drinking water. Sodium in drinking water can be a health problem for individuals on low-sodium diets due to hypertension.

Health Canada has a Maximum Acceptable Concentration (MAC) of 0.2 mg/L for cyanide in drinking water.

3.2 FRESHWATER GUIDELINES

The focus of this document review is protection of freshwater ecosystems. Canadian Council of Ministers of the Environment (CCME) does not currently have water quality guidelines for the protection of freshwater aquatic life for either sodium or chloride. However, chloride effects on aquatic species such as bacteria, yeast, and bivalves can occur at concentrations between 5 and 200 mg/L (TAC, 1999). A review of chloride toxicity studies suggests that a chloride concentration of 1,000 mg/L is the general threshold beyond which direct adverse effects on aquatic species can occur (TAC,1999). Studies have shown that low-flow environments are most impacted and that sudden increases in chloride concentrations are more destructive than long-term elevated chloride. In January 2010, British Columbia Ministry of the Environment (BCMOE) established ambient water quality guidelines for chloride of 600 mg/L (acute) and 150 mg/L (chronic, 30-day average). The United States Environmental Protection Agency (USEPA) has established chloride water quality standards of 860 mg/L (acute) and 230 mg/L (chronic).

CCME has a cyanide water quality guideline of 5 µg/L for the protection of aquatic life.

3.3 LAKE MONITORING IN HRM

Stantec reviewed a 2007 Department of Fisheries and Oceans (DFO) publication entitled Synoptic Water Quality Survey of Selected Halifax Regional Municipality Lakes on 28-29 March 2000. The report summarizes results for lake water sampling and analysis conducted in 1980, 1991, and 2000 at 52 lakes within HRM. Sodium was the most abundant cation detected and chloride was the most abundant anion detected. A substantial increase in both sodium and chloride concentrations was observed from 1980 to 1991. Sodium concentrations increased on average by approximately two times. From 1991 to 2000, sodium concentrations increased in some lakes but decreased in others, while chloride concentrations showed slight increases. There was high correlation between sodium and chloride concentrations. Increases were not uniform across all lakes sampled and increases were greatest in lakes located in well-developed watersheds and lowest in lakes whose watersheds maintain a higher percentage of undeveloped terrain. The report concluded that road salt is the most likely source of sodium and chloride in the lakes. The ten lakes with the highest concentrations of both ions were: Whimsical, Bissett, Cranberry, Penhorn, Russell, Frog Pond, Chocolate, Oathill, Settle, and Frenchman.

The maximum sodium concentration detected in 2000 was 91.6 mg/L and the maximum chloride concentration detected was 160 mg/L. These concentrations do not likely pose a threat to aquatic life. However, the presence of denser salt-containing water could impact lake water quality by inhibiting spring and fall mixing events. Although corrective action was not recommended, preventative action to limit the use of road salt was advised.

HRM collects water quality data from lakes in the spring, summer and fall of each year. Data from 2006 through 2010 is available for review on the HRM website. Review of 2010 data indicated that the maximum sodium and chloride concentrations detected during both the spring and summer sampling rounds were in samples collected from the mouth of Nine Mile River in Shad Bay, with concentrations as high as 3,710 mg/L sodium and 5,060 mg/L chloride. These concentrations are approximately 10 times higher than the next highest concentrations detected and are likely due to the proximity to the Atlantic Ocean. However, the sample collected from this location during the Fall 2010 sampling event did not exhibit elevated sodium and chloride concentrations (11.2 mg/L sodium and 19 mg/L chloride). This may be a tidal influence, but additional assessment would be required to accurately assess the sodium and chloride source. Excluding the Nine Mile River/Shad Bay samples, Upper Porter's Lake consistently exhibited the highest sodium and chloride concentrations, with sodium ranging from 213 to 266 mg/L and chloride ranging from 373 to 557 mg/L over the three 2010 sampling events. Sodium and chloride concentrations detected in other lake samples ranged up to 135 mg/L sodium (detected at Dent's Punch Bowl, Cowie Hill, Summer 2010 sampling event) and 308 mg/L chloride (detected at Penhorn Lake, Dartmouth, Spring 2010). Based on the data reviewed, many lakes in HRM contain low, apparently naturally-occurring sodium and chloride concentrations (<10 to 20 mg/L), while many other lakes in HRM contain sodium and chloride at concentrations approximately 10 times higher. The data suggests that road salt is impacting surface waters in HRM and may be severe enough to result in a negative impact to aquatic species.

It should be noted that when testing lakes for sodium and chloride content, samples should be collected from the bottom of the lake to ensure accurate worst-case data due to the greater density of saline water.

4.0 Review of BMPs

HRM Winter Works has been proactive in their approach to road salt and has a number of BMPs in place to reduce salt usage. A Salt Management Plan was created in 2003 and is updated annually. A Winter Work Management Plan is currently in progress. Mr. Hayward has indicated that the BMPs outlined in TAC's Salt Management Guide are generally followed, including storage of materials and proper housekeeping. Employees and contractors receive SMT training and annual refreshers. Salt usage is tracked and reported and this system is being improved upon. RWIS and IRT sensors are part of the weather and road condition data collected when planning the response to a winter weather event. Each winter weather event is analyzed and a strategy for clearing the roads is established and relayed to the Operators, with a focus on anti-icing, rather than de-icing, whenever possible. Technologies, such as electronic spreader rate controls that take into account groundspeed and pre-wetting of road salt prior to application, are implemented. Alternatives to road salt application have been considered, and this year liquid brine application will be trialed for anti-icing.

With this in mind, Stantec focused on BMPs, new technologies, and alternatives that have been successfully implemented in other jurisdictions, which, based on our review of available documents and discussions with HRM staff, appear to have not yet been explored or may require additional consideration. It should be noted that a more thorough assessment of the existing program, including inspections of the salt storage depots and review of salt usage records, would be required to fully address potential areas for improvement. In addition, it was not within the scope of this project to prepare cost-benefit analyses regarding implementation of the reviewed BMPs, technologies, and alternatives.

4.1 IDENTIFICATION OF VULNERABLE AREAS

Establishment of Vulnerable Areas is an integral component of any Salt Management Plan, as outlined in Annex B of the CEPA Code of Practice and in TAC's Syntheses of Best Management Practices. HRM has indicated that environmentally-sensitive areas have been identified, but that this portion of the salt management program is currently under review. The focus appears to have been areas that are serviced by private water supply wells. Some of these areas are designated for sand-only treatment and no road salt is applied.

Although sources of drinking water are potential salt vulnerable areas, other areas must also be assessed, such as:

- groundwater recharge areas:
- areas with exposed or shallow water tables and medium to high permeability soil;

- salt-sensitive vegetative communities;
- salt-sensitive wetlands;
- small ponds and lakes;
- rivers with low flows;
- salt-sensitive agricultural areas; and
- salt-sensitive habitats for species at risk.

Salt vulnerable areas can be defined as areas where the combination of hydrogeology and drainage is such that immediate or long term releases of sodium and chloride from highway de-icing activities or from a salt and/or sand storage facility could adversely impact the environment. Salt vulnerable areas should be taken into consideration when locating salt storage areas and snow disposal areas. In addition, salt vulnerable areas may require additional mitigative and protective measures and should be considered for targeted monitoring programs.

Applied specifically to HRM, the data reviewed for this report strongly suggests that identification of surface water features vulnerable to road salt impacts is critical to the successful implementation of the salt management plan. Once vulnerable areas have been identified, salt reduction and/or mitigation strategies can be developed and implemented and a monitoring program can be established to assess their effectiveness. More comprehensive identification of salt vulnerable areas would allow HRM to focus its efforts and resources in the locations most likely to benefit.

Identification of salt vulnerable areas can be difficult and data-intensive. However, in 2006, Jacques Whitford Environment Limited (JWEL, now Stantec) developed a tool that can quickly assess an individual site, group of sites, or an entire map area for salt vulnerability and can prioritize sites for further investigation, mitigative action, or possible relocation. The tool can be implemented as a comprehensive Geographical Information System (GIS) or as simple worksheets.

4.2 DESIGN AND OPERATION OF ROAD MAINTENANCE YARDS

The proper design and operation of road maintenance yards is an important component of the salt management plan. As stated previously, the scope of work for this project did not include an assessment of the existing HRM facilities. However, information gathered suggests that HRM maintenance yards are well-designed and generally operate in accordance with TAC BMPs. Three items were identified for additional review:

1) sand storage;
2) salt loading; and
3) disposal of vehicle wash water.

Sand is stored within a 2,000-tonned dome at the East Maintenance Yard (Turner Drive). However, there is no interior sand storage at the West and Central Maintenance Yards. Sand at these locations is stored outside on an impervious surface (asphalt) and is not covered. Construction of interior sand storage structures should be considered at these yards. The sand contains 5% salt, which can be dissolved during precipitation events when stored outside. Studies of leachate from sand/salt piles have shown an approximate 50% loss of salt when stored outside. (NBDOT, 1978). In addition, salt and sand can be blown away. Finally, the sand itself can be carried in runoff to catch basins, adding sediment load to the stormwater system. There are financial as well as environmental costs to storing sand outside.

Salt is currently stored in dome structures at each of the three maintenance yards. Dome structures do not readily allow for interior salt loading. When loading salt outdoors, infrastructure should be in place to collect and treat salt runoff. Loading/unloading should be carried out on an asphalt or concrete apron that is sloped toward a catch basin that directs the runoff to an underground storage tank (UST); the collected runoff can be disposed of at an appropriate facility. During periods of inactivity, provision should be made to prevent runoff from discharging to the catch basin and consequently to the UST. In addition, any materials spilled on the apron should be swept back into the storage facility immediately after the storm. This requirement can be removed if salt is loaded indoors and good housekeeping practices are conducted. Retrofitting the existing salt domes with load-out additions should be considered as an interim step, with construction of more suitable facilities considered when building replacement is scheduled.

Salt-laden wash water generated during washing of snow removal/salting trucks is currently collected and directed to an oil-water separator prior to being transferred to an approved disposal facility. In addition to offering a long-term, economical disposal solution, reusing vehicle wash water could reduce overall water consumption and salt usage. Salt recovered from the wash water would be reused in the brine solution. The equipment required for making brine solution from recycled vehicle wash water includes a wash water collection system, oil/water separator, sedimentation/retention tank for wash water, brine making tank, brine storage tank(s), and pumps. Typically, wash water would flow through a floor grate and be pumped through an oil-water separator and then gravity discharged to a UST for collection of treated salt water for reuse. From here the wash water would be pumped to a brine-making tank. Additional salt could be added as needed. The HRM facilities have the advantage of already having brine-making capabilities in place as well as an oil-water separator for treating wash water. Cape Breton Highlands National Park (CBHNP) has such a system at their truck wash facility in Ingonish.

Stantec has compared recycling of wash water with off-site disposal for other clients and found recycling to be a more cost-effective alternative. In addition, Indiana Department of Transportation (INDOT) and Virgina DOT have implemented wash water recycling processes at their facilities (Salt Institute, 2010). In addition to wash water, floor drains and sumps collect any salt/brine spillage and recycle it to the brine maker. In Virginia, a cost analysis compared off-site disposal of wash water with reusing wash water to make brine; it excluded any savings resulting from less salt consumption. The results of the cost-benefit analysis indicated that recycling the wash water was the most cost-effective option and estimated capital costs would be recovered within four years. The amount of wash water generated can be reduced by using high pressure, low volume washing facilities.

4.3 SALT APPLICATION

HRM Winter Operations staff recognize the importance of pre-wetting solid salt with brine and are exploring the use of brine-only as an anti-icing strategy. Increasing the amount of HRM and contractor trucks with pre-wetting capabilities should continue to be a priority. If the brine-only trial proves successful, acquisition of additional tanker trucks should be considered. NSTIR are currently trialing liquid application of a brine solution in Antigonish County.

Consideration should be given to use of zero-velocity spreaders on highway routes where trucks are spreading salt at greater speeds. With zero-velocity spreaders, road salt is applied in a rearward direction at the same speed that the vehicle is moving forward. The two velocities cancel each other, thus minimizing salt bounce.

4.4 MATERIAL USAGE MONITORING

As discussed previously, scales will be installed at the HRM depots this year to more accurately track salt volume used by each vehicle. This will greatly improve salt accountability. It will allow for comparison between the logged quantity and the actual quantity used per operator and event, as well as for reconciliation of the total salt volume used from beginning to end of the season.

Salt accountability could be further enhanced by the use of automatic vehicle location (AVL) technology to map salt usage by individual truck and route. The AVL system includes a control box connected to the electronic spreader control and an antenna. The control box records when and what is being applied and GPS is used to track the location of the salt truck and download data records. This information is provided in real time format through an internet website to the operations staff. Another consideration is bucket loader monitors that accurately measure the amount of salt per bucket and prevent overloading of trucks and subsequent spillage during travel, as well as preventing spillage during loading.

4.5 MECHANICAL REMOVAL

4.5.1 Design Considerations

The more effective the mechanical removal of snow and ice is, the less there is need for chemical (salt) removal. Plowing should therefore be the first line of defense and any potential improvements in plowing capability should be explored. HRM currently employs anti-icing by applying salt before a storm, which impedes snow and ice adhering to the pavement surface, thereby making plowing more effective. Other methods of improving mechanical removal of snow and ice should be considered. This begins with roadway construction and maintenance.

During design of new roadways, consideration should be given to drainage, orientation to sun, wind control, snow fencing, and vegetation, to minimize snow and ice build-up. Pavement surfaces should be repaired so as to maintain smoothness and allow for optimal plowing. New developments should construct roadways of adequate width to enable effective plowing and to minimize build-up of snow and ice. TAC outlines design considerations in the Syntheses of Best Practices:

3.0 Road and Bridge Design;
4.0 Drainage and Stormwater Management;
5.0 Pavements and Salt Management; and
6.0 Vegetation Management.

Consideration should be given to reviewing the design recommendations and including those deemed relevant in permit approval requirements for new construction in HRM, particularly in vulnerable areas.

4.5.2 Plows

HRM currently uses two-way plows. Different plow and blade types should be considered. For instance, underbody plows (or downward-pressure plows) have gained recognition as being better able to scrape roadways free of remaining snow and ice, particularly at the end of a storm. They also work well in crowded urban streets. The underbody plow is limited to clearing snow accumulations up to 30 cm (the depth of snow that will pass under the front axle), but are effective in removing highly compacted snow and ice. A variable downward pressure is applied using the truck's compressed air system (TAC, 1999).The underbody plow can be used in conjunction with other plows on the same vehicle. In addition, flexible snow plow blades contact the road surface and remove more snow than conventional plow blades. Multiple blade designs include a scarifying blade to break up the ice or snow pack and a squeegee blade to remove excess moisture/slush (NHDES, 2011).

4.6 WINTER WEATHER/CONDITIONS MONITORING EQUIPMENT

RWIS sensors (owned and operated by NSTIR) are used in the twice-daily weather reports received by HRM. RWIS collect a variety of data including road temperature, sub-road temperature, air temperature, and, if moisture is present, calculated freeze point (which takes into account residual salt on the road). In general, the more RWIS sensors in use, the better the data. Therefore, HRM could consider installation of additional RWIS sensors within HRM; this could be done as a joint effort with NSTIR.

In addition, HRM has 45 IRTs mounted to supervisor trucks and spreaders. IRTs measure road temperature. Addition of IRTs to the HRM fleet will increase forecasting and decision-making ability. If IRTs are combined with automatic vehicle location (AVL) technology, the road surface can be thermally mapped. Data gathered from RWIS can then be used to predict night-icing potential. Prediction of night-icing potential can help prevent unnecessary application of salt and enable resources to be focused on areas forecasted to have significant build-ups of ice. NSTIR currently uses this technology to predict night-icing potential along sections of roadway to a resolution of 1km (Siegel, 2011).

RWIS can also be combined with Fixed Automated Spray Technology (FAST) for more efficient anti-icing, particularly on bridges and ramps. A FAST system monitors road surface conditions and deploys adequate anti-icing chemicals just in advance of freezing conditions. The benefits of the automatic features of the system include: an immediate response time, enhanced roadway safety, reduced chemical wastage and reduced salt damage to the structure. The technology is particularly useful on surfaces that tend to freeze in advance of main roadways, such as bridges and ramps. NSTIR and HRM indicated that FAST technology is not currently employed within Nova Scotia. In 2000, a FAST system was installed on an interchange ramp of Highway 401/416 near Prescott, Ontario in response to 14 traffic accidents the previous year (McCormick Rankin and EcoPlans Limited, 2003). Cost-benefit analysis conducted by Ministry of Transportation of Ontario (MTO) indicated that the cost of the $300,000 system was recovered in the first year, due in large part to 100% reduction in traffic accidents and resulting travel delays.

4.7 ALTERNATIVE DE-ICERS AND ABRASIVES

To date, HRM has not successfully implemented alternative de-icing chemicals. As discussed in previous section, the use of liquid organic de-icers derived from sugar beets caused concern over elevated BOD. Sodium chloride remains the de-icing agent of choice and is by far the most cost-effective. Common alternatives to road salt are outlined below:

Table 6 Winter Maintenance Chemicals

Chemical	Description	Practical Working Temperature/ Eutectic* Temperature (°C)	Benefits	Drawbacks	Cost Compared to NaCl
Sodium Chloride (NaCL)	A naturally occurring mineral, Rock Salt	-9.4/-21	Highly Effective Easy to handle Inexpensive	Environmentally toxic Highly corrosive	1:1
Calcium Chloride (CaCl)	A synthetic brine converted to flakes or pellets that give off heat as moisture is absorbed	-31.6/-51.1	More effective than NaCl Less harmful to concrete than NaCl	Negative environmental effects More corrosive to steel than NaCl	10:1
Potassium Chloride (KCl)	A naturally occurring mineral used as fertilizer	-3.8/-11.1	Less environmentally toxic than NaCl Similar cost to NaCl	Less active than other chlorides Highly corrosive	1:1
Magnesium Chloride (MgCl)	A synthetic brine converted to flakes or pellets that give off heat as moisture is absorbed	-15/-33.6	More effective than NaCl	Environmentally toxic Highly corrosive Only 48% active requiring double application rate	-
Calcium Magnesium Acetate (CMA)	A synthetic mixture of dolomite lime and acetic acid, available as liquid or granulated solid	-6/-27	Similar temperature performance range as NaCl Biodegradable	Performance characteristics require plowing or traffic activity Handling and storage difficulties	40:1

Table 6 Winter Maintenance Chemicals

Chemical	Description	Practical Working Temperature/ Eutectic* Temperature (°C)	Benefits	Drawbacks	Cost Compared to NaCl
Potassium Acetate	A synthetic liquid similar to CMA, used primarily as a runway de-icer	-26/-60	More effective than NaCl Biodegradable Generally non-corrosive	Toxic to fish at elevated concentrations Creates a Biological Oxygen Demand (BOD) Storage difficulties More expensive than NaCl	-
Sodium Acetate (NaAc)	An anhydrous synthetic solid designed as a runway de-icer gives off heat as it degrades at low temperatures	Not Applicable	Less corrosive to metals than NaCl	Upper respiratory tract irritation Handling and storage difficulties More expensive than NaCl	-
Urea ($CO(NH_2)_2$)	A synthetic mixture of ammonia and carbon dioxide in liquid or solid form used as fertilizer	-3.8/-11.6	May improve soil quality Less corrosive to metals than NaCl	Less active than NaCl Toxic to aquatic life May cause vegetative burn, contamination to drinking water, and odours Causes concrete spalling	12:1
Glycols	Dihydroxy alcohols similar to anti-freeze typically used as a runway de-icer	Not Applicable	More effective than NaCl Non-corrosive	Short active life Toxic to humans/animals Creates high BOD Requires liquid application equipment More expensive than NaCl	-
Methanol	Liquid Methyl alcohol can be used as an anti-freeze, or as a fuel source	NS/-125	More effective than NaCl Faster than NaCl	Short active life, requires frequent re-application Highly volatile, flammable and toxic Lethal to humans and animals Contributes to zone pollution Deleterious effects on asphalt concrete Handling and storage difficulties	5:1
Sodium Formate	A chemical waste product	NA/-18	Similar de-icing results to NaCl Non-corrosive to steel Applied with conventional equipment	Similar environmental effect to NaCl	13:1

1. Information obtained from the Salt Management Guide, T.A.C.
2. "-" = information not available.
3. Eutectic Temperature: The lowest temperature at which the de-icer can suppress the freezing point of water.

4.7.1 Potassium Formate

The Finnish Environment Institute (SKYE) has recently recommended the use of potassium formate (KFo) for the deicing of roads in salt-sensitive areas. (SKYE, 2010). Potassium formate is widely used in Finnish airports and studies have shown that formate biodegrades rapidly, even at low temperatures. SKYE compared potassium formate, sodium chloride (road salt), calcium chloride, magnesium chloride, calcium magnesium acetate (CMA), and potassium acetate in a six-year bench-scale study. Results indicated that KFo was the most promising candidate for groundwater-friendly de-icing due to the following:

- KFo contains no chloride;
- KFo caused the least dissolution of trace metals into water;
- formate degraded to carbon dioxide at 3-6 °C;
- the rapid biodegradation of KFo was found to significantly lower its toxicity on plants; and
- oxygen consumption by KFo was significantly lower than that of potassium acetate (lower BOD)

Full-scale studies conducted between 2002 and 2010 provided additional evidence that formate rapidly biodegrades to carbon dioxide and water in the environment even at low temperatures (-2 °to +1°C), resulting in low load of organic carbon in surface water bodies and preventing formate infiltration to groundwater. Topsoil rich in organic matter and with high microbial activity greatly assists the biodegradation of KFo. Potassium formate was found to be more effective than sodium chloride in removing black ice, but less effective in removing packed snow. It was estimated that if KFo was used instead of road salt on 800 km of roads in salt-sensitive areas, winter maintenance costs would increase by 5 to 10%.

4.7.2 EcoTraction™

In 2011, the City of Ottawa agreed to a trial run of EcoTraction™, an abrasive made from a natural volcanic material (zeolite) that sticks to ice to prevent slipping (Centretown News, 2011), on city-owned parking lots, sidewalks, and walkways. According to product information (www.ecotraction.com), EcoTraction™ offers 35% better traction than sand due to its structure, which contains microscopic channels that absorb the slippery layer of water found on ice and which allow it to embed into ice and snow, creating a sand paper effect. Additional benefits cited include:

- it is safe (if accidentally ingested) for children, pets and wildlife;
- it will not damage grass or plants;
- it will actually improve soil condition by promoting aeration, releasing nutrients and minerals, and retaining water;
- it will not corrode or damage brick, stone, uncured concrete;
- it will not rust metal;
- it will not stain clothing or carpets; and
- it does not contain chloride or carcinogenic silica dust.

In addition, although four times more expensive (per 10 kg bag) than salt or sand/salt mix on a per volume basis, the manufacturer estimates that EcoTraction™ is up to 9 times more effective (i.e. 1/9 of the amount is needed for the same results), resulting in an overall cost savings.

4.8 ENGAGING AND EDUCATING THE PUBLIC

Several municipalities and organizations have taken an aggressive approach to engaging and educating the public on the implications of road salt usage.

4.8.1 New Hampshire

In 2008, New Hampshire Department of Environmental Services (NHDES) listed 19 surface water bodies as chloride-impaired and in 2010 the number increased to 40; the source of chloride has been determined to be road salt. Stantec interviewed Eric Williams, NHDES, regarding the New Hampshire Road Salt Reduction Initiative. As part of the environmental assessment undertaken for widening of I-93 in New Hampshire (NH), a water quality monitoring program was carried out from 2002 to 2005 by NHDES, NH Department of Transportation (NHDOT) and USEPA. Violations in chloride concentrations of the USEPA Clean Water Act triggered the need for a total maximum daily load (TDML) study for chlorides in the affected watersheds. A TDML refers to the calculated maximum amount of a pollutant that a waterbody can receive and attain or maintain water quality standards for its designated use.

As part of the TDML study, the Center for the Environment at Plymouth State University performed a thorough assessment of private salt loading (Sassan and Kahl, 2007). Results indicated that 43% of salt load from de-icing was attributable to the private sector (parking lots and private roads), with the remainder attributable to state and municipal roadways. Average application rates were determined to be 6.4 tons/acre/year (14.5 tonnes/hectare/year) on parking lots and associated driveways (residential driveways were excluded) and 17.8 tons/lane mile/year (10 tonnes/lane km/year) on public and private roads. Although salt application rate on parking lots was lower than that of roadways, a high percentage of paved surfaces (57%) were found to be represented by parking lots. While this southern NH study area likely has an above-average parking lot-to-road ratio, it does bring forth the importance of considering private sector salt usage in protecting surface water bodies.

The findings of the study lead to development of a salt accounting system for the private sector by the University of New Hampshire (UNH), Technology Transfer Center (T2C) (http://t2.unh.edu). The municipalities encouraged private sector participation in the program. Under their Road Scholars Program, UNH T2C also developed a training program for private plow and salt truck operators regarding salt reduction for parking lots and private roads. Attendees who successfully complete the course and written exam become a NH Certified Green SnowPro and receive a certificate of completion. An obstacle to reduced salt usage on private property is liability concerns. NHDES is promoting legislation that will provide liability protection for private owners if they have a winter maintenance plan and it is implemented with Certified Green SnowPro operators.

A social marketing campaign is also underway in NH that uses specific motivating messages and tools to get past barriers to changing expectations or behaviours related to surface treatment and winter driving. (NHDES, 2011). Key goals of the project include:

1. altering public perception that bare pavement is necessary during storm events and educating the driving public about the issues surrounding excessive salt use and the environment; and
2. building support for such behavioral changes as snow speed limits, decreased winter speed limits, and incorporating winter driving safety into public and commercial driver education programs.

NHDOT is planning an Intelligent Travel System for the I-93 corridor that will bring real-time road condition information to drivers and promote lower vehicle speed to encourage safer driving habits. Encouraging use of winter snow tires (rather than all-season tires) is also being explored.

4.8.2 Waterloo

The Regional Municipality of Waterloo (Waterloo) has also implemented public awareness campaigns as part of its efforts to reduce road salt usage and the corresponding impact on its public water supply wells. The Smart About Salt (SAS) Council (www.smartaboutsalt.com) is a not-for-profit organization dedicated to the protection of drinking water and the environment through programs that improve management of winter salt used to control ice on sidewalks, parking lots, and roadways. Similar to T2C in NH, they have developed and administer an accreditation program that is designed to teach private contractors and property managers the best practices of salt management. As Waterloo renews its snow and ice removal contracts, all contractors that apply salt on its building properties must be registered in the SAS Program. Property owners are encouraged to become SAS-certified sites to reduce winter maintenance costs, reduce infrastructure damage, and demonstrate commitment to environmental stewardship. Insurance premium costs can also be reduced as the insurance broker, Marsh Canada, offers a liability premium discount for members who are SAS-certified.

5.0 Summary of Findings

Stantec completed a broad, high-level evaluation of the best management practices reviewed. Consideration was given to:

- relative capital cost;
- effort to implement;
- salt reduction to surface water bodies; and
- positive service delivery potential (i.e. the likelihood of a positive response from the public after implementation).

The following table summarizes the results of the evaluation with the BMPs listed in order of ranking. Those listed at the top (green) are options that HRM should consider for implementation in the short term as they give the “biggest bang for the buck”. Those shaded orange involve more significant capital spending or effort and may be considered as mid-term strategies. BMPs listed near the bottom (blue) may be part of a long-term salt reduction strategy based on higher capital costs or greater effort required to implement. The "positive service delivery potential" was also considered with respect to visibility by the general public.

It is noted that assessment of the potential impact of implementing BMPs at salt storage facilities depends on whether the facilities are located within a salt vulnerable area, an assessment that has not yet been completed. Determination of salt vulnerable areas is critical if HRM is to effectively focus salt-reduction efforts and financial resources effectively.

Table 7 Evaluation of BMPs

BMP	Relative Capital Cost (low, moderate, high)	Effort to Implement (low, moderate, high)	Salt Reduction (minor, intermediate, major)	Positive Service Delivery Potential (low, moderate, high)	Comments
Install weigh scales at salt depots	Low to moderate	Low	Major	Low	Planned for 2011/12 season.
Determine salt vulnerable areas	Low	Moderate	Major	Low	Prioritize salt vulnerable areas.
Contractors to implement pre-wetting	Low	Low	Major	High	Capital cost and effort for HRM is low but there is significant cost and effort for contractors.
Apply KFo in salt vulnerable areas	Low	Low	Major	High	If KFo is effective in treating roadways, public response will be positive.
Install additional IRT	Low	Low	Intermediate	Moderate	Likely part of existing HRM strategy.
Trial Eco-Traction	Low	Low	Low to intermediate	Moderate to high	Potential for significant positive public response.
Trial zero-velocity spreaders	Moderate	Low	Low to intermediate	Moderate	Visibility to public and effect are relative to lower spread rates achieved.
Trial new plow types	Moderate	Low	Intermediate	Low	Visibility to public and effect are relative to plowing results.
Trial bucket loader monitors	Moderate	Moderate	Low to Intermediate	Low	Redundant if scales are installed and salt accounting improvements made.
Recycle vehicle wash water	Moderate*	Moderate	Low	Low	*May be overall cost savings in reduced disposal cost. Benefits include water and salt usage reductions.
Incorporate snow/ice removal considerations into building design requirements for new	Low	High	Major	High	There may be negative response from certain groups (e.g. developers).

Table 7 Evaluation of BMPs

BMP	Relative Capital Cost (low, moderate, high)	Effort to Implement (low, moderate, high)	Salt Reduction (minor, intermediate, major)	Positive Service Delivery Potential (low, moderate, high)	Comments
construction in vulnerable areas					
Training program for private contractors	Moderate to High	High	Major	High	Expect positive public response.
Winter-driving public awareness campaign	Moderate to High	High	Intermediate	High	Increase in driver preparedness and decrease in level of service expectations could lower salt usage requirements without compromising safety.
Install AVL to track salt usage	High	Moderate	Intermediate	Moderate	Effort related to training.
Store sand indoors	High	Moderate	Intermediate	Low	Salt impacts will be reduced at storage bases.
Load materials indoors	High	Moderate	Intermediate	Low	Salt impacts will be reduced at storage bases.
Install FAST on bridges and ramps.	High	High	Intermediate to major	High	New construction and high-priority areas.
AVL/IRT Thermal Mapping	High	High	Intermediate to major	Low	Effort includes training. Can be combined with RWIS to predict night-icing potential.
Install RWIS in salt vulnerable areas	High	High	Major	Low	May be opportunity to partner with NSTIR.

5.1 SALT REDUCTION PLAN

Data suggests that HRM concerns regarding road salt impacts to freshwater surface bodies are valid. Therefore, implementation of a Salt Reduction Plan, which would incorporate recommendations outlined in this report, may be appropriate. Steps to consider when creating the plan include:

1) **Establish where you are** – this includes identification of vulnerable/salt sensitive areas; collection of surface water chemistry data within vulnerable areas and other areas of concern; detailed assessment of current practices and salt usage for both private and public entities
2) **Determine where you want to be** – set measurable goals regarding surface water quality, reduction of salt usage, levels of service achieved, and financial cost/gain, including timeline

3) **Assess salt reduction strategies and develop timeline** –rank salt reduction strategies according to potential effectiveness, feasibility, and cost; create an implementation timeline based on this analysis; develop monitoring program

4) **Implement, monitor, analyze, revise** – implement strategies as outlined in #3, perform routine monitoring to assess effectiveness, analyze the effectiveness, and revise the plan as appropriate (at least annually)

6.0 CLOSURE

This report is prepared for the sole benefit of HRM. The report may not be relied upon by any other person or entity without the express written consent of Stantec Consulting Ltd. and HRM.

Any use which a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices at the time the work was performed. The conclusions presented herein represent the best technical judgment of Stantec Consulting Ltd. based on the information available.

Should additional information become available, Stantec requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

We look forward to working with HRM-SEMO further on this project and on other projects in the future. Please do not hesitate to contact the undersigned should you have any questions or concerns or require additional information.

Yours very truly,

STANTEC CONSULTING LTD.

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Maylia K. Parker, B.Sc., P.G.
Project Manager

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Interviews

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Olga Kidson, Nova Scotia Transportation and Infrastructure Renewal
John Sibbald, Halifax Regional Water Commission
Eric Williams, New Hampshire Department of Environmental Services

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January 20, 2012
File: 121411639

Halifax Regional Municipality
Sustainable Environment Management Office
PO Box 1749
Halifax, NS B3J 3A5

Attention: Mr. Richard MacLellan

Dear Mr. MacLellan:

Reference: Review of Lake Water Quality
Halifax Regional Municipality, Nova Scotia

Stantec Consulting Limited (Stantec) is pleased to present the results of our review of lake water quality with respect to potential road salt impacts to Halifax Regional Municipality – Sustainable Environment Management Office (HRM-SEMO). To undertake the lake water quality review, we completed the following tasks as outlined in our email proposal dated December 22, 2012:

- reviewed lake water quality data from 2006 to 2010 available on the HRM website;
- analyzed the chemistry data for evidence of road salt impacts;
- based on the results prepared GIS maps showing impacted lakes within HRM; and
- prepared this letter report.

The work was conducted as the second-phase of a road salt best management practices (BMP) review completed in November 2011. This study identifies lakes where road salt is impacting lake water quality within HRM to assist HRM-SEMO in determining areas where salt-reduction efforts should be focused.

Regulatory Framework

The Canadian Council of Ministers of the Environment (CCME) *Canadian Environmental Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FAL)* (accessed on-line) were considered when analyzing the data. CCME recently established an acute chloride FAL guideline of 640 mg/L and a chronic FAL guideline of 120 mg/L. The lake sample data was also compared to the FAL guideline for pH of 6.5 to 9.0.

Data Analysis

As part of the lake water quality review, the following parameters were considered (and are explained below):

- potassium;
- chloride;

- pH; and
- sulphate.

It is important to note that Stantec was not involved in sample collection and analysis and therefore, no comment is made regarding the quality of the data. This study assumed that the available HRM data is reliable.

Potassium

Road salt is predominantly composed of the salt sodium chloride, which is also a major component of sea salt. Therefore, water bodies that are under tidal influence could have high concentrations of chloride that are not derived from a road salt source. However, sea salt also contains other cations, particularly potassium, which can be used to screen and identify lakes that may be influenced by the marine environment.

Potassium concentrations in freshwater environments tend to be quite low. Based upon a preliminary screening of the HRM data, average potassium concentrations greater than 4 milligrams per litre (mg/L) were considered an indication of potential tidal influence. Lakes exhibiting tidal influence were not included in the data review as road salt impact is not a concern for brackish water. Other potential sources of potassium that could influence water quality could include but are not limited to fertilizers (e.g., potash) and wood ash, which is also a rich source of potassium.

Chloride

Chloride concentrations were particularly focused upon because they are a primary component of road salt, and because the CCME guideline focuses on the chloride component as a potential environmental stressor for aquatic life. Chloride is considered to be a conservative ion in surface water and groundwater, meaning that it interacts weakly with soils and tends to be highly mobile, making its way to surface water bodies and groundwater aquifers. Lakes having detected chloride concentrations in water higher that the CCME chronic FAL guideline of 120 mg/L are considered to be impacted.

Annex A of the *Code of Practice for Environmental Management of Road Salts*, released by Environment Canada in April 2004, indicates that background chloride concentrations for Atlantic Canada range from <10 mg/L to 20 mg/L. The lakes and streams within HRM are generally located within an urban area, and therefore, few, if any, may reflect a genuine "background" level for chloride. Some level of change in water chemistry is inevitable, and the role of road salt application in ensuring public safety cannot be overstated. Therefore, to enable a clear focus on lakes most likely to be impacted, Stantec calculated the median and 75th percentile values for reported chloride concentrations, which were 51 mg/L and 101 mg/L, respectively. These values are below the CCME chronic FAL guideline of 120 mg/L. Lakes that contain chloride concentrations in excess of 120 mg/L were identified as being impacted by road salt. Lakes having average road salt concentrations greater than 50 mg/L were identified as being influenced by road salt application, and potentially benefiting from management actions to reduce their exposure to road salt.

pH

The data set contains information on the pH of lakes, and there are CCME guidelines respecting the pH of streams and lakes, which ideally should lie between pH 6.5 and 9.0. However, salt loadings to watersheds can exacerbate acidification caused by other processes (Heath et.al, 1992; Wright et.al., 1988), and therefore some consideration was given to surface water pH in the course of this data review.

High salt (sodium chloride) loadings to watershed soils can exacerbate acidification of lake and stream water resulting from acidic precipitation, which is regional or continental in scale. The sodium cation participates in ion exchange reactions in watershed soils. In acidified soils, incoming sodium ions can undergo ion exchange reactions with soils, causing the release of other cations, including, but not limited to, hydrogen, aluminum, iron and calcium (Heath et.al, 1992; Wright et.al., 1988). When sodium ions liberate hydrogen ions, this has an immediate acidifying effect on groundwater, which can subsequently be transmitted to streams and lakes. Aluminum and iron ions in water can also act as virtual acids, since the precipitation of these minerals removes base (OH^-) ions from the water, shifting the pH balance towards acidity.

Although evaluation of calcium concentrations was not included in this study, it is also a potential consideration when assessing existing and future lake water quality with respect to road salt. Low calcium concentrations can be limiting to the diversity and productivity of aquatic life (Jeziorski et.al, 2008), and some of the watersheds within HRM are based on granitic terrain which is very resistant to weathering and produces water that is extremely soft (low in calcium and magnesium) and sensitive to acidification. Sodium can exchange for calcium in watershed soils, a process which, while increasing calcium concentrations in lake water in the short term, will eventually lead to calcium depletion as the exchangeable reservoir of soil calcium becomes depleted. Such depletion has been shown to be occurring in sensitive lakes throughout eastern North America, including lakes in Nova Scotia (Jeziorski et.al, 2008).

Therefore, pH was considered in conjunction with chloride to assess whether road salt may be causing acidification of the lakes and to further assess the vulnerability of the lakes with respect to road salt. Lakes with average pH values below the lower CCME FAL guideline of pH 6.5 were flagged as potentially impacted by anthropogenic effects. Lakes with pH below 5.6 (the pH at which the bicarbonate buffering capacity of water becomes exhausted) were considered to be severely impacted (Stephenson et.al., 1994).

<u>Sulphate</u>

Two main causes of lake acidification within HRM include acid precipitation (a regional issue originating with air pollution in eastern North America generally) and acid rock drainage (a local issue caused by disturbance of sulfide-containing bedrock and leading to the oxidation of sulfide minerals to release sulfuric acid). Elevated concentrations of sulfate would be a primary indicator of acid rock drainage, whereas low pH in the absence of elevated sulfate concentrations would be an indicator of the effects of acid deposition on sensitive watersheds, such as those on granitic terrain, with thin soils.

Sulphate was therefore considered in conjunction with pH in an effort to assess the possible cause of lake acidification. Low pH lakes with low sulphate concentrations (<5 mg/L) may simply be sensitive to acid precipitation. Low pH lakes with elevated sulphate concentrations (>10 mg/L) may be influenced by acid rock drainage, particularly if they are located in areas of known sulphide mineralization, such as areas where the bedrock consists of of sulphide-bearing Halifax Slate.

Results

<u>Potassium</u>

Analytical data collected from a total of 77 lakes and watercourses was initially considered; this was reduced to 75 as chloride data was not available for two of the locations (Sackville River at Highway 102 and Sullivan's Pond). Average potassium concentrations greater than 4 mg/L suggested that four of the lakes may be tidally-influenced: Nine Mile River at Mouth, Rocky Lake, Russell Lake and Upper Porter's Lake. Based on their location, Rocky Lake and Russell Lake are not believed to be tidally-influenced and so were not removed from the study. Further investigation would be required to ascertain the likely source of elevated potassium in these lakes. In addition, MacIntosh Run at Mouth was considered to be tidally-influenced due to its location, and the identification of two elevated potassium concentrations (10 mg/L in the fall 2008 sample and 7.6 mg/L in the summer 2009 sample). MacIntosh Run at Mouth was also removed from the database for potential impacts of road salt.

A summary of the chemistry analysis (chloride, pH, and sulphate) of the remaining 72 lakes is provided below.

<u>Chloride</u>

No chloride concentrations in excess of the acute FAL guideline of 640 mg/L were detected. Samples collected from 23 lakes (32% of sampled lakes) contained chloride concentrations in excess of the 120 mg/L FAL guideline during at least one sampling event. The lakes with elevated chloride concentrations are plotted on the attached maps. On Figure 1, these lakes are shown in red and on Figures 2 through 4, these lakes are displayed with pie charts reflecting the relative percentage of samples with chloride concentrations in excess of the chronic FAL guideline at that location. In addition, Table 1 outlines the frequency of chloride concentrations greater than the chronic FAL guideline for the 23 impacted lakes.

Table 1: Percentage of Samples with Chloride Concentrations >120 mg/L

1 – 20%	21 – 40%	41 – 60%	61-80%	81 – 100%
Duck Lake, Beaverbank (8%)	Cranberry Lake, Dartmouth (23%)	Frog Pond, Halifax (45%)	**First Chain Lake, Halifax (64%)**	**Dent's Punch Bowl, Cowie Hill (91%)**
Little Albro Lake, Dartmouth (15%)	Oathill Lake, Dartmouth (23%)	Bissett Lake, Cole Harbour (46%)	**First Lake, Lower Sackville (69%)**	
	Red Bridge Pond, Dartmouth (27%)	Settle Lake, Dartmouth (46%)	**Lake Micmac, Dartmouth (69%)**	
	Half Mile Lake, Timberlea (27%)	**Governor's Lake, Timberlea (54%)**	**Lovett Lake, Lakeside (73%)**	
	Frenchman Lake, Dartmouth (36%)	**Black Duck Pond, Lakeside (55%)**	**Chocolate Lake, Halifax (77%)**	
	Albro Lake, Dartmouth (38%)		**Lake Banook, Dartmouth (77%)**	
	Whimsical Lake, Halifax (38%)		**Penhorn Lake, Dartmouth (77%)**	
			Russell Lake, Dartmouth (77%)	

Note: **Bold** indicates lake exhibits chloride concentrations in excess of chronic FAL guideline (>120 mg/L) in the majority of samples analyzed from this location (>50%).

Reference: Review of Lake Water Quality
Halifax Regional Municipality, Nova Scotia

As can be seen in Table 1, eleven lakes, or about 15% of the non-tidal lakes considered as part of this study, display chloride concentrations >120 mg/L the majority of the time (>50%). Upon review of the location of these lakes, three general areas of concern were identified (and are designated Areas 1 through 3 for the remainder of this report):

- Area 1: Dartmouth/Cole Harbour (containing 12 lakes);
- Area 2: Halifax Mainland South extending along St. Margaret's Bay Road to Timberlea (containing 9 lakes); and
- Area 3: Beaverbank/Sackville (containing 2 lakes).

Figure 1 also indicates lakes with average chloride concentrations >50 mg/L, but where none of the detected concentrations has exceeded the FAL guideline of 120 mg/L. These lakes are coloured orange. These lakes (listed in Table 2) are generally located in highly developed urbanized areas and/or adjacent to major arteries and should be considered for on-going assessment. Remaining lakes that are included in the sampling program, but have average chloride concentrations <50 mg/L and no samples with chloride detected above 120 mg/L are coloured dark blue.

Table 2: Lakes with Average Chloride Concentrations Above Median (>50 mg/L) but with No Samples Above FAL Guideline (<120 mg/L)

Lake	Average Chloride Concentration (mg/L)
Drain Lake, Route 101, Middle Sackville	59
Kearney Lake, Bedford	60
Lake Charles, Dartmouth	55
Long Lake, Halifax	74
MacIntosh Run at Roach's Pond, Spryfield	61
Maynard Lake, Dartmouth	85
Morris Lake (North and South Basin), Dartmouth	82
Paper Mill Lake, Bedford	55
Rocky Lake, Bedford	74
Williams Lake, Halifax	57

Of the ten additional lakes identified in Table 2, three are located in Area 1, three are located in Area 2, and one is located in Area 3. The remaining three lakes are located in Bedford. It is noted that although Rocky Lake is technically located in Bedford, it is closer to the Area 3 lakes than the other two lakes in Bedford.

<u>pH and Sulphate</u>

Analytical data for three of the 72 non-tidal lakes did not include pH. Review of pH data indicates that the majority of the remaining 69 non-tidal lakes contain neutral water that meets the CCME guideline of pH

6.5 to 9.0. The median pH for the lakes was calculated to be 7.2 and the average pH was 6.9. Seventeen (17) of the lakes (25%) display average pH that is less than 6.5, indicating potential sensitivity of the surface water body to acidification, and seven of the lakes display average pH less than 5.6, indicating acute acidification. The lowest average pH was calculated for First Chain Lake (pH 4.71).

Average sulphate values were considered for those lakes exhibiting low pH to assess whether acid-rock drainage (ARD) is the likely cause of acidification. Those lakes where sulphate concentrations exceed 10 mg/L are considered likely to be impacted by ARD, as for example from the disturbance of sulphide-bearing Halifax Slate or other sulphide-containing bedrock. ARD is not a probable source of acidification in those lakes where sulphate concentrations are less than 5 mg/L. In these cases, larger-scale sources, such as acid rain, are suspected, and in addition the lake is likely sensitive to acidification, having little or no natural buffering capacity derived from watershed soils or underlying geology. Lakes where average sulphate concentrations lie between 5 and 10 mg/L would require further investigation to assess potential sources of acidity.

Table 3 summarizes the pH and sulphate data for those lakes where average pH does not meet the CCME guideline. Two of the seventeen identified lakes (Eagle Lake and Juniper Lake Outlet) were excluded due to limited data (Spring 2007 only). Of the fifteen lakes listed, three are considered likely to be impacted by ARD, and seven are considered not likely to be impacted by ARD, based on the average sulphate values. Results for the remaining five lakes are inconclusive and require additional analysis.

Table 3: Low-pH Lakes and Sulphate Concentrations

Lake	Average pH	Average Sulphate	ARD Source?
Black Duck Pond, Beechville	5.43	28.36	Likely
Black Point Lake, Hubley	5.27	3.63	Not Likely
Chocolate Lake, Halifax	5.61	33.82	Likely
First Chain Lake, Halifax	4.71	16.45	Likely
Hubley Big Lake, Hubley	5.13	3.25	Not Likely
Lake Echo, Eastern Shore	5.61	4.00	Not Likely
Long Lake, Halifax	5.99	9.36	Inconclusive
Long Pond, Herring Cove	5.90	3.88	Not Likely
McCabe Lake, Lucasville	6.35	3.63	Not Likely
MacIntosh Run At Roach's Pond, Spryfield	5.84	8.75	Inconclusive
Moody Lake, Williamswood	5.37	5.00	Inconclusive
Nine Mile River At Hwy 103, Timberlea	6.46	7.30	Inconclusive
Sheldrake Lake, Hubley	5.25	5.20	Inconclusive
Stillwater Lake, Upper Tantallon	5.73	2.90	Not Likely
The Mill Pond (Three Mile Pond), Timberlea	6.16	4.09	Not Likely

Three of the lakes that exhibited chloride concentrations in excess of the chronic FAL guideline also exhibit low pH: Black Duck Pond, Chocolate Lake and First Chain Lake. These lakes are also the three lakes that exhibit elevated sulphate concentration as evidence of potential ARD impacts. These three lakes are located within approximately 5 kilometres (km) of each other in Area 2. It is noted that Long Lake and MacIntosh Run at Roach's Pond, which exhibit average chloride concentrations >50 mg/L (refer to Table 2), also contain average sulphate concentrations near 10 mg/L and may also be influenced by sulphide mineral weathering. As with the other three lakes, these lakes are located in Area 2; bedrock geology in the area consists of granitic rocks (monzogranite and granodiorite) and Halifax Formation slate/siltstone (Keppie, 2000). The Halifax Formation is broadly known to contain sulphide-bearing minerals. Other lakes having low pH, but also having low sulphate concentrations, are likely to be situated on granitic terrain that is highly resistant to weathering, and low in sulfide mineralization, such as the terrain underlying the Woodens River watershed, where Hubley Big Lake and Sheldrake Lake are located.

Conclusions

Based on our review of available HRM lake water quality data collected between 2006 and 2010, Stantec offers the following conclusions with respect to potential road salt impacts:

- none of the samples contained chloride concentrations in excess of the acute FAL guideline (640 mg/L);
- 23 (32%) of the 72 lakes included in the study contained chloride concentrations in excess of the chronic FAL guideline (120 mg/L) during at least on sampling event;
- most lakes exhibiting evidence of road salt impact are located in Area 1 (Dartmouth/Cole Harbour) or Area 2 (Halifax Mainland South extending towards Timberlea);
- secondary areas of concern include Sackville/Beaverbank (Area 3) and Bedford;
- lakes that exhibit both elevated chloride and low pH include Black Duck Pond, Chocolate Lake, First Chain Lake, Long Lake, and MacIntosh Run at Roach's Pond (all located in Area 2), and elevated sulphate concentrations in these lakes suggest the sulphide mineral weathering within these watersheds may account for the low pH; and
- lakes that exhibit low pH and low sulphate concentrations, including Black Point Lake, Hubley Big Lake and Sheldrake Lake in the Woodens River watershed, McCabe Lake in Lucasville, and Moody Lake in Williamswood, may be susceptible to road salt effects that exacerbate watershed acidification and calcium depletion.

Recommendations

A road salt reduction plan should be prepared and implemented by HRM as outlined in the *Road Salt – Review of Best Management Practices* report, prepared by Stantec and dated November 14, 2011. Table 7 of the November 2011 report offers a weighted evaluation of best management practices that can assist in road salt reduction and this report has identified Areas 1 and 2 as critical regions to focus salt reduction efforts and resources.

The five lakes in Area 2 where low-pH conditions and road salt influence have been noted, as well as the acid-sensitive lakes in the Woodens River watershed, may require particular attention as road salt is known to exacerbate acidification of surface waters leading to more severe damage to the freshwater ecosystem. Coordination with Nova Scotia Transportation and Infrastructure Renewal (NSTIR) may be required as some major arteries within HRM fall under provincial jurisdiction.

Although application of road salt along HRM roadways is the primary source of road salt to HRM lakes (via the municipal stormwater system), consideration should also be given to private sources of road salt (e.g., large commercial parking lots).

Reference: **Review of Lake Water Quality**
Halifax Regional Municipality, Nova Scotia

On-going monitoring is an important aspect of any salt reduction program, to assess the effectiveness of actions taken. As was discussed in the November 2011 report, future lake monitoring for road salt impacts should include collection of samples from the bottom of selected lakes to ensure accurate worst-case data due to the greater density of saline water, which can sink, and can also cause stagnation of bottom water. The November 2011 report also discussed the addition of the anti-caking agent ferrocyanide to road salt, which breaks down to form cyanide when exposed to sunlight. Based on this information, cyanide should be considered as part of the monitoring program.

Closure

This report is prepared for the sole benefit of HRM. The report may not be relied upon by any other person or entity without the express written consent of Stantec Consulting Ltd. and HRM.

Any use which a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices at the time the work was performed. The conclusions presented herein represent the best technical judgment of Stantec Consulting Ltd. based on the information available.

Should additional information become available, Stantec requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

We look forward to working with HRM-SEMO further on this project and on other projects in the future. Please do not hesitate to contact the undersigned should you have any questions or concerns or require additional information.

This report was prepared by Maylia Parker, B.Sc., P.Geo., and reviewed by Malcolm Stephenson, Ph.D.

Sincerely,

STANTEC CONSULTING LTD.

Maylia K. Parker, B.Sc., P.Geo.
Project Manager, Environmental Services
maylia.parker@stantec.com

Attachments: Figures 1 through 4

Reference: **Review of Lake Water Quality**
Halifax Regional Municipality, Nova Scotia

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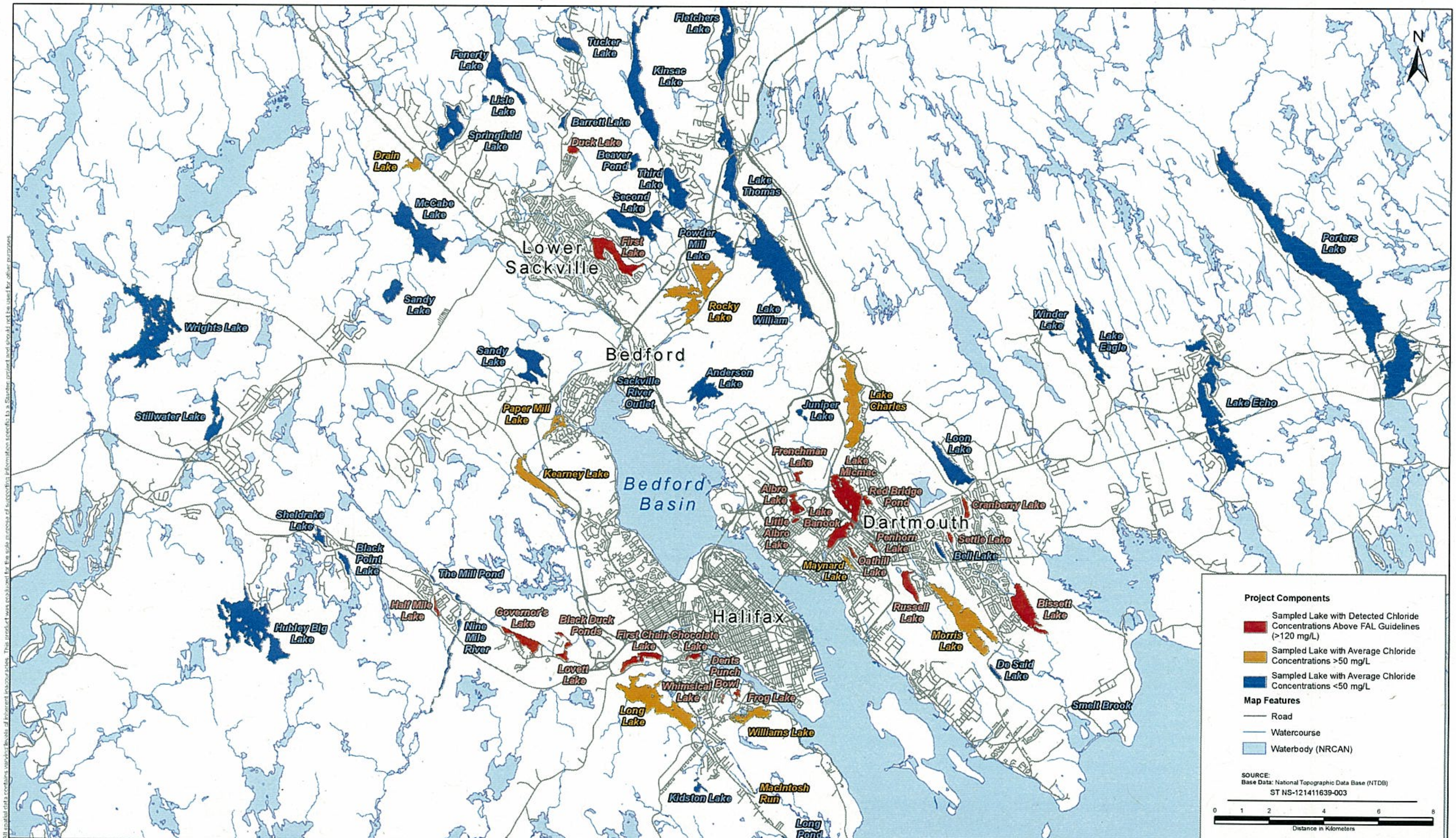

PREPARED BY: M. Huskins-Shupe	HRM Lakes - Road Salt Impact Analysis	FIGURE NO.: 1
REVIEWED BY: M. Parker	**Chloride Concentrations**	DATE: Jan 19, 2012
HALIFAX REGIONAL MUNICIPALITY Sustainable Environment Management Office		Stantec

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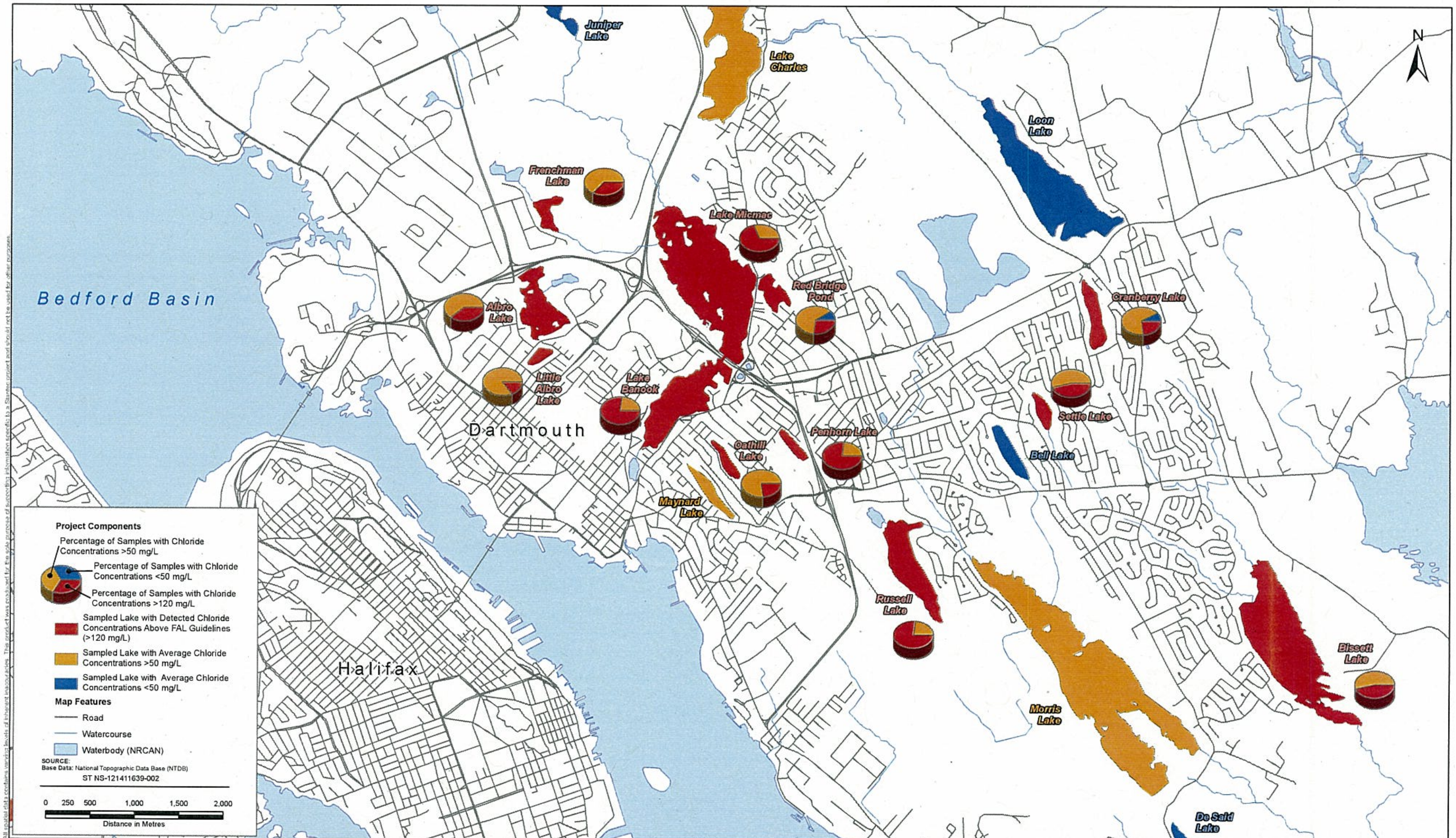

PREPARED BY: M. Huskins-Shupe	HRM Lakes - Road Salt Impact Analysis	FIGURE NO.: 2
REVIEWED BY: M. Parker	**Area 1 Chloride Concentrations**	DATE: Jan 20, 2012
HALIFAX Regional Municipality, Sustainable Environment Management Office		Stantec

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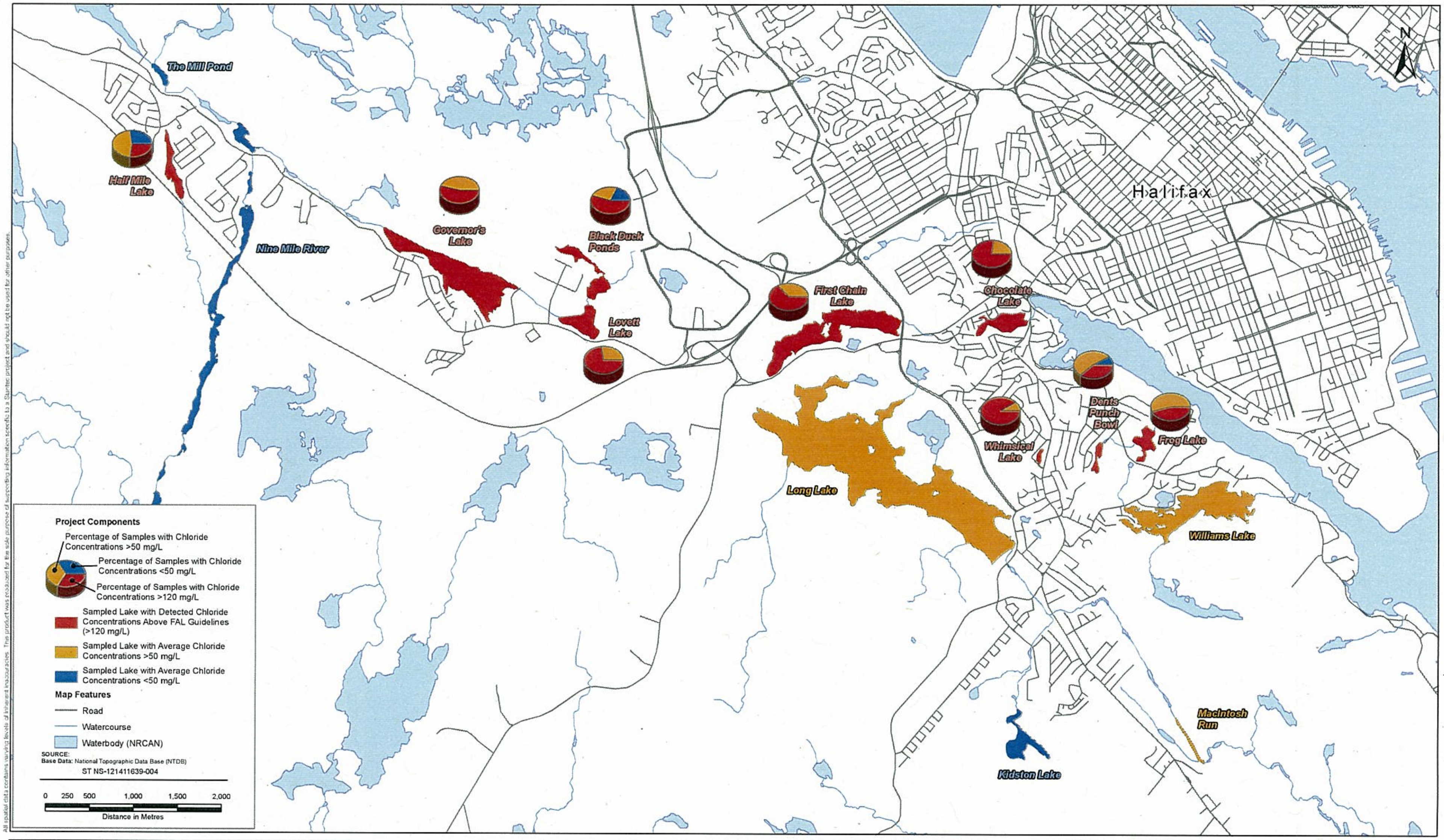

PREPARED BY: M. Huskins-Shupe	HRM Lakes - Road Salt Impact Analysis	FIGURE NO.: 3
REVIEWED BY: M. Parker	**Area 2 Chloride Concentrations**	DATE: Jan 20, 2012
HALIFAX REGIONAL MUNICIPALITY Sustainable Environment Management Office		Stantec

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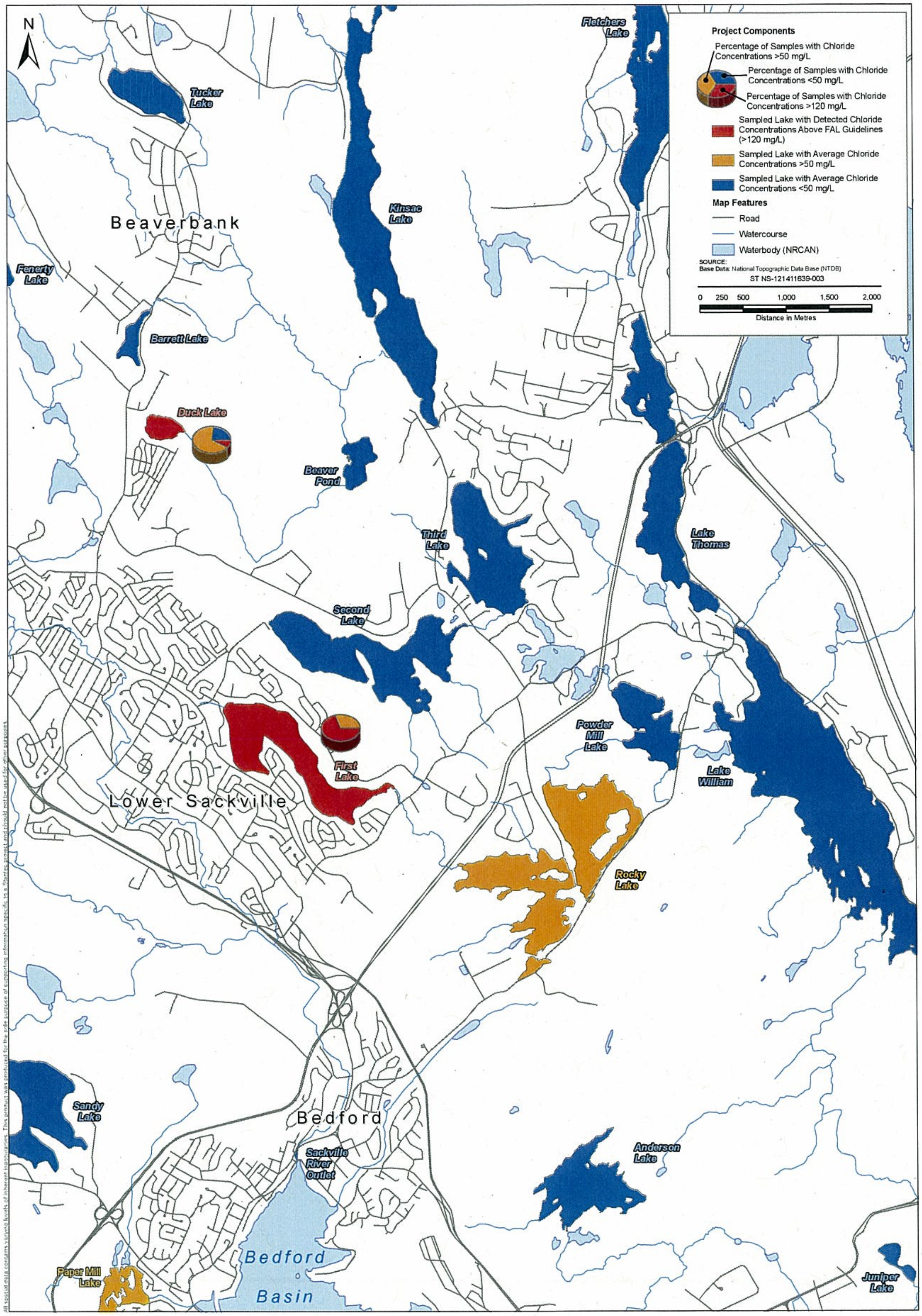

PREPARED BY: M. Huskins-Shupe	HRM Lakes - Road Salt Impact Analysis	FIGURE NO.: 4
REVIEWED BY: M. Parker		DATE: Jan 20, 2012
HALIFAX Regional Municipality Sustainable Environment Management Office	**Area 3 Chloride Concentrations**	Stantec