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**Alberta RWIS Network Expansion, Winter Risk
Assessment and Priority List for Advanced Winter
Maintenance Strategies**

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Abstract

In 2003, Alberta Transportation (AT) completed an Advanced Traveller Information System (ATIS) and Advanced Transportation Management System (ATMS) Blueprint project. Part of this project was to determine where Road Weather Information Systems (RWIS) sites should be located on the National Highway System (NHS) to provide the optimal coverage. After deployments it was recognized that coverage solely on the NHS resulted in gaps in the real-time and forecast road condition information throughout the province. These gaps prompted a challenge to AT to respond in a proactive, timely manner to the weather events.

The deployment has been a resounding success with the public. Existing road condition and atmospheric forecast is currently readily available through the province's current ATIS service provider. The increased public access and availability of this information has meant increased pressure on AT to expand the RWIS service to areas previously not covered in the first phase deployment. In 2008, AT undertook an RWIS expansion study to identify the gaps and determine which technology would best provide the relevant road weather information necessary to support winter maintenance activities. The expected outcome of this project is a consistent coverage across the province which will redefine current maintenance levels on a regional basis, reduce priority based maintenance activities, and help in the continued provision of a consistent level of service. AT recognizes their limitations with respect to the level of maintenance that can be economically provided for the majority of the road network. AT also recognizes there are segments which have been identified as being at a higher winter collision risk. Rather than increasing the level of service (across the board) to accommodate these areas, the province has taken the approach of providing advanced winter maintenance practices at specific locations. Having embarked on this tiered approach to maintenance levels of service, AT has been inundated with requests to install advanced winter maintenance technology.

The 2008 study employed the GIS winter road condition model used for locating the original RWIS sites, reviewed collision statistics, and developed algorithms to allow network-wide assessment of winter driving risks. Based on the relative ranking of the risk and a short list of winter risk mitigation strategies, AT was provided with a relative ranking and priority list for deployment of advanced winter maintenance technologies. This paper will discuss the regional and micro level RWIS assessments that were completed. It will also review the risk assessment which identified the locations with a high winter collision risk. Finally, the paper will overview the resulting deployment plan which recommended approximately 20 RWIS sites on the provincial highway system.

1. Background

1.1 Introduction

In 2003, Alberta Transportation (AT) completed an Advanced Traveller Information System (ATIS) and Advanced Transportation Management System (ATMS) Blueprint project. Part of this project was to determine where Road Weather Information Systems (RWIS) sites should be located on the National Highway System (NHS) to provide the optimal coverage. After deployments it was recognized that coverage solely on the NHS resulted in gaps in the real-time and forecast road condition information throughout the province. These gaps prompted a challenge to AT to respond in a proactive, timely manner to the weather events.

While the deployment has been a resounding success with the public, AT was concerned with the utilization of RWIS by their operational and maintenance staff. Currently, select existing road condition information is available to the public. All road condition information and atmospheric forecast is readily available to the AT operational and maintenance staff.

In 2008, AT undertook an RWIS expansion study to identify the gaps and determine which technology would best provide the relevant road weather information necessary to support winter maintenance activities. This study was prompted by the need to provide real-time information and forecasts along major provincial routes to provide assistance to winter maintenance staff. The expected outcome of this project is consistent coverage across the province which will redefine current maintenance levels on a regional basis, reduce priority based maintenance activities, and help in the continued provision of a consistent maintenance level of service.

The maintenance level of service is generally defined in terms of the start and frequency of the snow and ice control treatment response. The response must be appropriate for the weather condition.

Although significant advances in winter maintenance have been made in the last decade, both the travelling public and commercial interests continue to demand more improvements. They desire consistent driving conditions and expect that driving conditions will be restored to normal as quickly as possible after winter weather events.

Rock salt is the component of a maintainer's material cost that has the most potential for optimization. Overtime labour costs can also be reduced using salt management techniques such as RWIS. Information and environmental data from RWIS sites can be used to generate a 24-hour forecast of pavement temperature and conditions. These forecasts can help determine when temperatures will likely drop below freezing. This advanced warning can provide sufficient time to plan operations and reduce unnecessary costs while ensuring the safety of the roads. (Pinet, McDonald, Pirani 7)

1.2 Phase 1 RWIS Planning

AECOM (formerly Mark F. Pinet & Associates Limited) acted as the RWIS subject matter expert for Alberta's 2003 ATIS and ATMS Blueprint project. Although the ATIS and ATMS portion of the project addressed the Highway 2 corridor between Edmonton and Calgary, the RWIS portion of the project addressed the entire NHS. The RWIS portion of the study included needs assessment, technology assessment, site selection, deployment plan preparation, specification development and cost estimate for the proposed RWIS improvements on the NHS. A service provider was subsequently retained by AT under a multi year contract to deploy and operate the network on their behalf.

The Phase 1 study focused on the NHS and, consequently, a number of primary provincial highways were not analyzed from a RWIS or Fixed Automated Anti-Icing Spray Technology (FAAST) warrant/priority perspective. **Figure 1** illustrates the differences between the Phase 1 study area and the primary provincial highway network.

An RWIS site is a point specific, automated Environmental Sensing Station (ESS) which is specifically designed to detect atmospheric and pavement conditions. The system collects detailed real-time data on weather conditions at and near the road surface to assist road maintenance crews. FAAST is an advanced form of RWIS and a demonstrated technology proven to provide the ultimate response in anti-icing approaches. The system is able to automatically detect pending icy conditions and automatically apply the appropriate volume of liquid de-icing chemicals before the ice forms.

The number of candidate RWIS locations in Phase 1 was limited to 70 sites as suggested within the federal funding proposal.

Maintenance hot spots were identified on the NHS; however, no mitigation beyond the installation of a site specific RWIS was investigated as part of the study. AT recognized that some sites were at higher risk for winter conditions, particularly at bridge locations. The FAAST priority task within the Phase 1 study included only a review of the bridges on Highway 2 between Edmonton and Calgary and a relative ranking. Since that time, numerous proposals for FAAST systems have been received outside of the Highway 2 Edmonton to Calgary corridor. AT has been challenged in these instances to determine the relative priorities between FAAST and other winter countermeasures. AECOM, on behalf of AT, has assessed the sites by completing a winter focused safety review or safety audit whereby the warrants and risks were assessed relative to other known high risk locations. However without a complete list of the provincial sites, a complete comparison to establish relative priorities was difficult.

1.3 Phase 2 RWIS Planning

The objective for the Phase 2 study was to perform the necessary evaluations and assessments to facilitate the selection of appropriate RWIS sites which would provide the relevant road weather condition information necessary to best support winter maintenance activities. Implementation of the resulting deployment plan

will seek to provide comprehensive and consistent coverage of winter road condition information for the entire primary provincial highway network in Alberta.

The specific objectives of the Phase 2 study were to:

- Determine the provincial highway segments requiring improved road weather information to support the needs for safety and operational improvements
- Assess the range of available road weather information technologies to determine how these technologies could meet the needs
- Propose approximately 20 RWIS sites on the provincial highway system to improve forecasting capabilities in conjunction with Alberta's weather forecasters

2. Macro Level RWIS Assessment

2.1 Macro RWIS Site Selection

A regional review was undertaken to identify RWIS Deficient Regions (RDR). RDR's were selected using GIS tools. The selection considered the location of existing and planned RWIS, topography, hydrology, meteorological zones, winter collision severity and frequency, traffic volumes, and input from the current meteorological forecasters.

The meteorological zones used were prepared and presented as part of the Phase 1 RWIS Deployment Plan. Winter collision and traffic volume information was provided by Alberta Transportation. The weather forecasters suggested ten areas that they felt contained gaps in the current forecast.

2.2 Regional Meetings

Two regional meetings were held in Edmonton and Calgary. Representatives from all the stakeholders were present. The purpose of the regional meetings was to:

- Verify and validate the location of the RDRs selected
- Receive input from the operational staff
- Determine if any RDRs were missed during the initial review

A prioritized list of RDRs and their boundaries was presented at the regional meetings. The affected Maintenance Contract Inspectors (MCI) were requested to propose potential locations within each RDR. The MCI's were instructed to look for sites which represent typical atmospheric and pavement conditions for the entire RDR. They were also advised that candidate sites should be close to utility services to facilitate reasonable installation and operational costs.

The prioritized list of RDRs was confirmed at the regional meetings and three additional RDRs were identified in southern Alberta.

Following the regional meetings, AT staff completed preliminary site surveys in accordance with the RDR guidelines provided by AECOM. The surveys were then reviewed by the project team.

2.3 Risk Assessment

2.3.1 Overview

In addition to a review of potential RWIS sites, a winter collision risk assessment was undertaken. The objective of the risk assessment exercise was to identify sites or segments within the provincial highway network that may have experienced a proportionately higher number of winter related collisions. These sites may be considered as potential candidate sites for advanced winter maintenance solutions.

The methodology for this risk assessment is similar to past site specific warrant reviews AECOM has completed for AT in the past. For previous warrant reviews, the sites for review were all identified by the AT as requiring investigation. During the review of the identified sites, the criteria assumed to influence winter collision risk at the specific location were considered. However, the previous warrant reviews also included a site specific cost/benefit analysis which was used to determine which winter maintenance countermeasure was most suitable.

In the previous warrant reviews and the current risk assessment, the identification of sites with abnormally high winter collision risks was conducted by filtering all possible locations according to criteria assumed to influence winter collision risk. These criteria included:

- Frequency and severity of major injury collisions within past 5 years
- Frequency and severity of fatal collisions within past 5 years
- Proximity to Water (rivers, lakes or streams)
- Degree of grade or degree of curvature of roads/bridge approaches
- Combinations of the above listed criteria

The intent of this analysis was to identify “at-risk” locations along the provincial highway network which may have experienced a proportionately higher number of winter related collisions. However, given the limited data available, a complete network analysis was not possible.

All past warrant reviews that have been requested by AT have been for bridge locations. Therefore, based on AECOM’s experience, it was decided that the risk assessment concentrate on existing bridges within the provincial highway network.

There are three general stages involved in the risk assessment:

- Data Preparation
- Analysis
- At-Risk Location Ranking and Conclusion

2.3.2 Data Preparation

The risk assessment relied heavily on accurate data that covered the entire study area. Some data was available from the Phase 1 study. However, the previous and current studies covered different areas.

The Phase 1 study assessed the province of Alberta's infrastructure in terms of risk along the NHS. The data obtained as a result of the Phase 1 study included: roads, traffic, structures, towns, collisions, elevations (contours), water and land uses. As part of the macro level assessment, the following data (updated in 2007) were obtained: structures, collision statistics, topography and traffic. All data was obtained from the AT in the form of GIS shapefiles. GIS was used for analysis and mapping in the risk assessment.

There were some limitations associated with the data; some data was missing or incomplete and as a result, some analyses were completed manually using non-digital data sources. For example, the 50m contours did not contain enough detail to provide an accurate depiction of the grades on the road network. As a result, 10m contour topographic maps were obtained and used.

2.3.3 Analysis

The identification of sites with abnormally high winter collision risks was conducted by filtering all possible bridge locations according to criteria assumed to influence winter collision risk. The project team developed threshold criteria to identify the data sets of the sites of study which corresponds to the implementation of advanced winter maintenance countermeasures by AT.

The original structure dataset contained over 21,000 structures which included bridges, culverts, sign structures, and other structures. Filtering scenarios were developed to provide a reasonable subset of data to review. The first filter was to isolate only the bridge structures on the provincial highway network which resulted in over 650 locations.

Subsequent filters based on winter collisions rates, traffic volumes, and proximity to water were applied to further reduce the number of locations to a manageable number for the manual evaluation of horizontal and vertical alignments.

Winter collision rates were provided for reference for the entire list of "at-risk" structures. The collision rates were then compared to the Alberta average collision rate. In an attempt to determine the remaining service life, it was assumed that each structure has an expected service life of 50 years. This assumption was made since the actual expected service life was not available.

Taking all these filters into account, the final number of bridges remaining was 48. These bridges were evaluated manually and ranked accordingly.

2.3.4 At-Risk Location Ranking

A summary of the top 48 “at-risk” bridges in the province of Alberta (along the provincial one and two digit highways) is shown in **Table 1**.

Table 1 – Summary of Ranked "At Risk" Locations in Alberta

| Rank | Relative Risk | Count |
|--------|---------------|-------|
| 1 - 7 | High | 10 |
| 8 - 13 | Moderate | 34 |
| 14 | Low | 4 |

Bridges with the highest winter collision risk were recommended for a detailed warrant review to determine the magnitude of the winter maintenance countermeasure. Bridges with a moderate winter collision risk should be monitored closely. If the collision rate increases then further investigation into potential winter maintenance countermeasures would be recommended. Bridges with a low winter collision risk should be monitored periodically.

3. RWIS Deployment Planning

RDR’s were selected because of an operational gap, a forecasting gap, or a staff request at one of the two regional meetings. The MCI’s were requested to complete two site selection surveys within each RDR. From the received surveys, the project team was then responsible for selecting a preferred site within each RDR.

The project team reviewed all surveys received from AT field staff. A summary of the recommendations can be found in **Table 2**. A map illustrating the candidate RWIS sites can be found in **Figure 2**.

Table 2 - Recommendation Summary

| Recommendation | Count |
|-------------------|-------|
| Full RWIS | 18 |
| Atmospherics Only | 1 |
| Camera | 1 |

4. Project Summary

The project team undertook the task of determining the gaps in the province of Alberta's RWIS coverage and recommend locations for new RWIS stations to be installed to fill these gaps. The team used a variety of tools including GIS, desktop reviews, field surveys and general meetings to accomplish its goals. The result of the study was the recommendation of a series of RWIS sites to be installed in the province to enhance the current RWIS network.

As part of the study, a risk assessment was conducted to determine the locations, along provincial highways, that warrant a more detailed inquiry into the need for advanced winter maintenance strategies. These strategies generally include:

- Basic maintenance
- RWIS
- RWIS and Traveller Information
- FFAST

The analysis was completed using a combination of GIS tools and desktop reviews. The risk assessment resulted in a prioritized list of "at-risk" locations for Alberta Transportation to consider when advanced winter maintenance mitigation is being requested by the Districts and Regions.

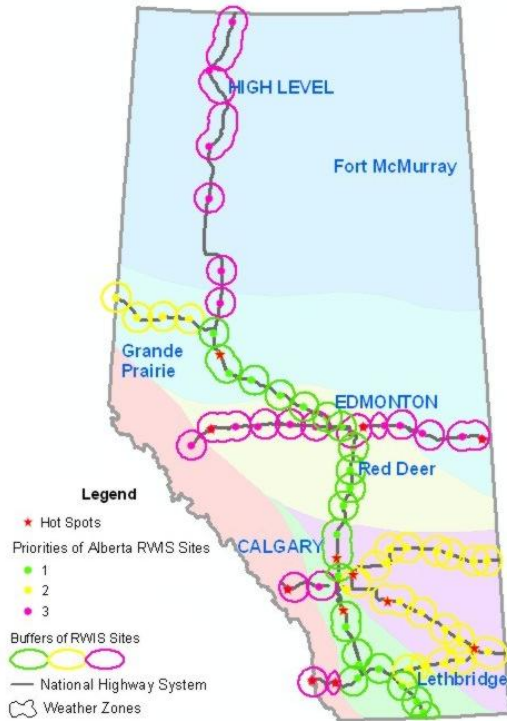
Using RWIS allows AT to employ a technology based approach to winter maintenance which can facilitate the use of more advanced chemicals and application techniques.

Anti-icing is one of these strategies that "that involves preventing or minimizing the formation of a bonded snow and ice layer. De-icing chemicals are applied to the road shortly before a storm hits, so that the precipitation is less likely to bond to the road surface. For this application, timing is very important. The anti-icing chemical must not be applied too long before the storm, and certainly not after the ice has formed." (Pinet, McDonald, Pirani, 10).

The RWIS station network can provide the necessary information through the use of 24 hour pavement condition forecasts to ensure decisions related to anti-icing and other advanced maintenance strategies are made correctly. Without information from the RWIS, these decisions would be near impossible to make.

It is expected that a higher level of service can be achieved at a lower cost with network-wide RWIS coverage since the unknown timing factor is reduced allowing for scheduling improvement and a reduced application of maintenance chemical.

5. Figures



National Highway System and Results of Phase 1 RWIS Assessment



Provincial Highway Network in Alberta: Study area for Phase 2

Figure 1 – National Highway System and Provincial Highway Network

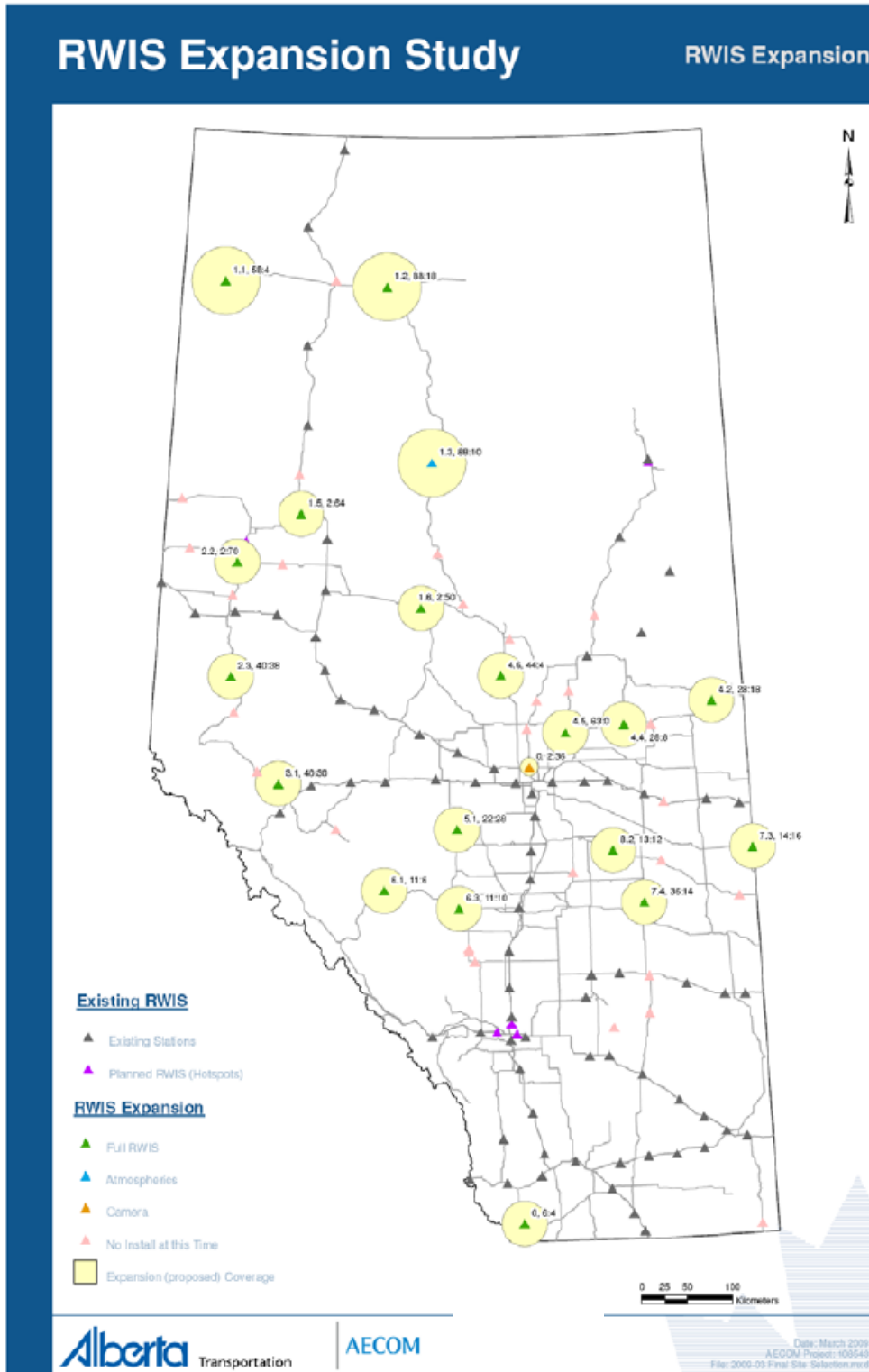


Figure 2 – Candidate Sites

6. Works Cited

Pinet, Mark, Sarah McDonald, and Sadiq Pirani. "Review of the Economics of Winter Focused Safety Investments". 2007 Annual Conference of the Transportation Association of Canada