Road Weather Information Systems at the Ministry of Transportation, Ontario

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ABSTRACT

The Ontario Ministry of Transportation (MTO) has implemented a comprehensive network of Road Weather Information System (RWIS) stations to provide highway maintenance staff with the most up to date information to proactively make the most appropriate winter maintenance decisions.

The system provides real-time atmospheric and pavement condition data, through NTCIP compliant data transmission telematics, to central servers for interpretation, manipulation and use in forecasting atmospheric and pavement conditions. Data and forecasts are then displayed on a secured web site, in tabular and graphic formats, for easy review and interpretation. Hazardous highway condition warnings are provided to flag the need for prompt attention. Data is automatically archived for future use.

Since the system is web-based, it can be linked to other web-based resources like Automated Vehicle Location systems, and the road condition reporting systems currently in place. The capabilities of the system display can be easily packaged to assist maintenance managers in maximizing the effectiveness of winter maintenance operations.

The RWIS system is part of a suite of tools that the maintenance manager uses to make the right decisions at the right time on winter road maintenance operations. RWIS is essential in implementing emerging operational innovations such as Direct Liquid Application (liquid anti-icing) and Fixed Automated Spray Technology. For agencies that have contracted maintenance services, it can provide quality assurance data to indicate whether the roads have been serviced.

Ontario has been involved in RWIS development since the mid 1990s, and has worked closely with other provinces and Environment Canada to develop standards and implement appropriate forecasting tools appropriate for use in Canada. The MTO network consists of 113 stations comprised of 5 equipment suppliers, all providing data in a legible format for effective provision of forecasting services.

The Ontario RWIS model facilitates the sharing of data among road authorities that have stations, to expand the information available for making operational decisions. In addition, MTO has structured a plan to share its station data with municipalities that do not have stations so that all road agencies may be able to improve their winter maintenance operations for the benefit of Ontario drivers.

BACKGROUND

Approximately 50% of the total highway maintenance budget allotted to the Ministry of Transportation, Ontario (MTO) is spent on winter maintenance operations, specifically snow and ice control. MTO has, and continues to, evaluate and implement new technologies that enhance winter maintenance operations so as to optimize limited financial resources available. Some of these technologies include improvements to equipment, innovative materials management, modifications to procedures and implementation of enhanced decision-making tools.

Winter maintenance practices in Ontario largely involve the operations of road patrolling, plowing for snow removal, and the spreading of sand or salt. Winter road conditions are monitored by patrolling, which includes a visual check of sky conditions, visibility, snow accumulation, and a roadway surface test for slippery conditions by patrol vehicle response or by walking on the pavement. In addition, patrollers monitor radio and television weather forecasts, radar images, and conditions in neighbouring areas. Calls for action (plowing, salting, sanding) are communicated by the patroller to contractors. Patrollers also travel the highways prior to and during the storm to monitor weather conditions, the effectiveness of the operations and the progression of road conditions toward bare pavement.

The most commonly used de-icer is road salt (sodium chloride). Salt is spread on the pavement early in the storm to reduce or eliminate the bond between snow/ice and the roadway surface, as well as during the storm as required. In addition, road salt is used to melt ice where the bond between snow/ice and pavement has already formed. Sand is spread to increase traction on slippery roads at low temperatures when salt is not effective.

Beginning in 1996, the ministry's approach to the delivery of highway maintenance operations changed significantly, becoming a manager of service provider contracts rather than providing these services directly.

RATIONALE FOR ADOPTING RWIS TECHNOLOGY

Information generated by Road Weather Information Systems (RWIS) is one of the inputs used by maintenance managers to aid and improve winter maintenance operations decisions. RWIS is a system of pavement and atmospheric sensors integrated with prediction and monitoring functions that employs real-time sensor data, historical weather patterns, and computer models to forecast specific adverse pavement conditions. The real-time data can reduce the need/dependency for road patrolling in specific locations by providing timely and accurate information to those responsible for directing winter maintenance operations. Weather patterns can be tracked as they move into an area, and associated modeling can predict when moisture is likely to freeze on the pavement, facilitating timely and effective deployment of staff and equipment. In addition, RWIS data can also assist with monitoring contractor's activities by identifying the presence of residual salt brine from the pavement sensors during

winter storms. As such, MTO has recognized the benefits of, and need to develop a rationalized and well-designed province-wide RWIS network.

EVOLUTION OR RWIS IN ONTARIO

MTO installed its first RWIS station in 1991 as a research and development project. At that early point, accessing data was onerous and reliability was marginal. Environment Canada assisted MTO by providing communication linkages and forecasting services to gather and present the information for MTO use. The original access to the data was through a dial up computer connection to an independent server within Environment Canada.

Over the years, the number of sites installed had increased slightly, primarily in the southern part of the province, where the ministry's research and development efforts in winter maintenance technology were taking place. While other jurisdictions within Ontario began investigating in RWIS technology, MTO partnered with some municipalities to share information so both road authorities would benefit from all of the data and forecasts available. Early in 2000, the need for a more coordinated national approach to RWIS was recognized and Environment Canada developed a strategy to establish a national RWIS network.

MTO recognized the benefits of having RWIS data for the proactive deployment of winter operations, as well as having data archived for future use. As such, MTO commissioned a weather zone study for Ontario to determine geographical areas within the province that experienced similar weather patterns. The resulting weather zone maps would become key in determining the appropriate locations to install future RWIS stations. In addition, MTO worked closely with Environment Canada and other provinces on the development of common RWIS standards, which was subsequently presented to and endorsed by senior transportation engineers from across the country. As the thoughts and ideas for a national RWIS network were maturing, MTO moved quickly to install 85 stations from 2001 to 2004, along the National Highway System as defined by Transport Canada, and ensured the stations were in compliance with the national technical standards.

MTO focused Phase 1 (25 stations) of the RWIS expansion program along key economic corridors (i.e. Hwy 401, 400, 417) as well as installing stations at selected locations in northern Ontario. The intent of Phase 1 was to provide this new information technology to ministry and contractor staff to allow them to see the value of RWIS information as an effective tool in proactively deploying winter maintenance operations. Phase 2 (30 stations), while focussed primarily in the south, added more stations across northern Ontario. Phase 3 (30 stations) focussed primarily on installation of stations in northern Ontario with some stations installed in the south where gaps previously existed.

MTO currently owns and operates 113 RWIS stations throughout the province.

SITE SELECTION

In order to ensure that the stations would be located in the optimal locations, the ministry developed a systematic assessment for site selection. Initially, the weather zone maps, along with the highway classification of the provincial highways within the weather zone, were reviewed to determine the need for a station. Consultations with field staff was key in identifying unique characteristics of the local area and providing an assessment of potential locations to ensure that the station would be appropriately located to yield results representative of the surrounding area. The proximity of utilities (telephone and electricity) was also considered to ensure the data could be effectively collected. Once a potential location was selected, field staff determined if there was a plan for pavement rehabilitation in the near future, and if required, would adjust the station location. The potential location of each station was then considered within the broader station location plan to ensure the appropriate distribution of stations to benefit the maximum number of maintenance managers. Final locations were established during construction. While the Phase 1 plan was established early on in the program development, Phases 2 and 3 were developed together to ensure station installation was well coordinated.

RWIS STATION ACQUISITION AND INSTALLATION

When MTO embarked on the expansion program, key factors were considered in the development of the construction tender to ensure that all potential vendors could bid on the work, thus create a strong competitive opportunity. Tenders were advertised in the open marketplace, and were structured to allow potential bidders to present a technical proposal that met the minimum requirements of the tender, as well as a submission of item prices. Technical specifications prescribed in the contract were in accordance with the requirements of the national standards to ensure that MTO could take advantage of potential partnership opportunities with the federal government. In addition, the specifications were based on an open architecture principle and the stations had to conform to NTCIP communications protocols. Recognizing the geographical diversity of the province, separate tender prices were required for northern and southern Ontario stations, as well as for additional equipment to be included in the station (i.e. additional pavement sensors, video cameras, visibility sensors, etc). Separate bid items were also required for traffic control and training of staff and contractors. In order to ensure the maximum financial flexibility for the ministry, provisions were included that permitted the ministry to adjust the tender quantities based on available funding. Once contracts were awarded, and installation underway, Environment Canada worked with the successful bidders to develop station-to-server communications mechanisms to ensure that data could be collected and effectively utilized by Environment Canada. Currently the network consists of stations supplied by five different vendors, namely Surface Systems Inc. (SSI), Lufft, Boschung, Vaisala, and Campbell Scientific.

As well as tendering for the installation of the stations, the ministry also hired consultants to administer the contracts. In this way, the ministry developed an RWIS technical knowledge base within the consultant industry.

The cost to install a typical station ranged between $45,000 to $50,000 (CAD). Each additional pavement sensor adds about $5000 to the typical station cost, and a video camera adds about $6000. Utility installation costs for telephone and electricity, are typically in the range of $7,000 to $10,000, depending on the location and the ability to connect into existing services. The total cost to install 85 stations over a three-year period, including utility installations, traffic control, preparation of as built drawings, training sessions, and contract administration, was approximately $6 million, or about $70,000 per station.

OPERATIONS AND MAINTENANCE

In order to obtain the maximum benefit for RWIS technology, several aspects of the system needs to be monitored to ensure correct data is being generated and that the stations are operating to maximum efficiency. Environment Canada, as part of their service agreement with the ministry, provides quality checks on the data to ensure that the stations are reporting data correctly. In addition, warnings are sent to the ministry if particular components of the system are not functioning as intended.

The ministry also ensures that the stations are serviced annually and that additional servicing during the winter is provided should the need arise. MTO traditionally engaged a service contractor to provide routine annual station maintenance, before the winter season, as well as emergency servicing through the winter months, to address deficiencies identified by Environment Canada, MTO staff or its maintenance contractors. In the past, MTO coordinated the acquisition and deployment of these maintenance and repair services centrally from Head Office. However, concerns were raised by field staff and contractors about the delay in addressing station malfunctions. As such, MTO has shifted the responsibility for acquisition and coordination of station servicing to the field level to decrease the response times and increase the effectiveness of station maintenance.

The total cost to operate the 113 stations, including utility costs, polling, forecasting, web service, and station maintenance amounts to approximately $1.3 million annually, or about $11,500 per station.

ACCESSING INFORMATION

Unlike the original sites, which required telephone connection to the Environment Canada's server to access the data, information generated by the MTO's RWIS network is accessed through a password-protected web site. During the winter season, real-time data is polled every 20 minutes (7 days per week, 24-hours per day) and uploaded to the web site within 2 minutes. In addition, 3 atmospheric forecasts and 2 pavement condition forecasts are generated daily. Observation data and forecasts for the current and previous year are saved in an archived area of the website should the maintenance manager wish to access this information.

MTO is not the only jurisdiction in Ontario that owns RWIS stations. There are 10 other road authorities, representing 20 additional RWIS stations and many other jurisdictions are showing interest in this technology. As a result, data sharing agreements have been established in Ontario where RWIS owners enter into agreements with other owners to share access to information. Access to data from these sites provides information that would not normally be available to MTO's maintenance managers by providing road and atmospheric information that supplements information generated by MTO owned stations. It also allows other station owners access to MTO data, which can be very valuable.

Recognizing the broader safety benefits of data sharing with municipalities, MTO embarked on a partnership model with the Ontario Good Roads Association (OGRA) to enable all municipalities access to MTO RWIS data. The tri-party agreement among MTO, OGRA and Environment Canada stipulates the terms and conditions by which data will be shared by MTO, how access to the RWIS station information would be provided by Environment Canada, and how the OGRA will liaise with municipalities in collecting service fees and verifying that training is obtained prior to obtaining access. Municipalities wishing to access MTO data, register with OGRA and remit an access service fee to cover the cost of initializing a website identification profile and password, as well as the provision of a computer-based training package (Ontario modified version of the AASHTO computer-based training). Once the training is completed, the candidate is provided access to the web site by Environment Canada.

USING THE INFORMATION

Usefulness and reliability of data can determine if acceptance of RWIS technology is a success or failure. To support this premise, a full suite of decision-making tools is available on the RWIS web site. Observations are displayed in tabular format for each location so the maintenance manager can see, in real-time, current atmospheric and road condition data (see Figure 1). In addition, atmospheric and pavement condition forecasts are generated and displayed in a graphical format, covering a 24-hour period; 12 previous hours plus 12 hour forecast (see Figures 2 and 3).

As RWIS station data is not a stand-alone decision making tool, it does not implicitly indicate whether a spreader or plow should be dispatched. The intent is for each individual maintenance manager to use RWIS information in conjunction with field and operational experiences to decide if, when, and what types of maintenance activities should be deployed. In addition to traditional salting practices, RWIS data is critical for the effective deployment of liquid anti-icing strategies. Current conditions and forecasts of both weather and pavement conditions are essential in deciding the appropriateness and the timing of liquid anti-icing operations.

Automated anti-icing systems, such as Fixed Automated Spray Technology (FAST) currently installed at 5 structures in Ontario, have on-site RWIS stations to ensure that the prevailing conditions warrant the initiation of bridge anti-icing. The RWIS data from

these locations is used to automatically predict icing potential and trigger the spraying of the anti-icing liquid.

RWIS can also serve as a monitoring aid, particularly in situations where winter operations have been contracted to the private sector. Data can be used for quality assurance purposes, indicating if routes have been serviced and can assist in reconciling other maintenance operations documentation.

As RWIS is part of a suite of tools available to the maintenance manager for the effective management of winter maintenance activities, advances in web-enabled software has permitted the integration of RWIS data to be accessed through other contracted services such as Automated Vehicle Location (AVL) system monitoring displays. As such, the manager can obtain AVL information and RWIS station data on one web site in real time to enable the comparison of field conditions to actual equipment operations.

BENEFITS OF AN RWIS NETWORK

An RWIS network has been shown to provide both direct and indirect benefits. Direct benefits include costs savings due to efficient use of labour, materials and equipment for winter maintenance operations. Many jurisdictions that manage an RWIS network report improved level of services when compared to operations without RWIS. Experience has also illustrated that RWIS can reduce the number of costly decision errors.

Indirect savings include fewer accidents, lower insurance premiums, better traffic flow and less harm to the environment due to reduced amounts of salt being used. Another indirect benefit of RWIS is the savings generated by related technologies that rely on RWIS as an information source (i.e. anti-icing strategies) or as a complementary tool for other technologies such as Automated Vehicle Location systems.

While MTO has not conducted research on the cost-benefit of RWIS, several studies in other jurisdictions have estimated the benefit cost ratios to be as high as 20:1. The following summarizes the findings of some RWIS benefit-cost assessments:

- A benefit-cost assessment of RWIS and weather forecasts performed by S.E. Boselly for the Strategic Highway Research Program (1992) involved field tests in seven states: Colorado, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, and Washington (1).
    - The greatest benefit-cost (B/C) ratios are produced by using weather and pavement condition forecasts; B/C > 20 result from the low cost of forecast services when compared with the cost of snow and ice control activities.
    - The combination of forecasts, sensors, and thermal mapping synergistically provides improved level of service for snow and ice control, and a significant reduction in decision errors.

- Sweden has been using RWIS since the 1970's. During that time, several studies have examined the performance of such a system in terms of economic value. The Swedish National Road Administration reports the following cost analysis (2):

RWIS Benefit/Cost Factors	
Road authority	2.5 to 1
State economy	20 to 1

- In Finland, benefits and costs were estimated to include savings in driving costs, which involve savings in accident costs, time costs and vehicle costs. Costs of the Road Weather System, including investments (system, software, hardware) and yearly costs (maintenance of the system, forecasts, radar pictures) were compared with benefits calculated (mostly due to reductions in accidents) resulting in a benefit/cost ratio of 5:1. (3)

- Minnesota's Department of Transportation (Mn/DOT) has phased their state-wide RWIS installation over three years. A benefit/cost study has been conducted which examines both the effects of RWIS on Mn/DOT's maintenance activities and public benefits. Results of the study indicate that the benefit-cost ratios after installation to MnDot was 2.1:1 and for the public (accident reductions, environmental, and travel delays) was 11:1. (4, 5, 6).

TRAINING

Training is a critical component that ensures those having access to the data are able to understand and correctly interpret the information. Annual winter maintenance training provided by MTO contains a module on RWIS. This particular course is targeted to patrollers, dispatchers and patrol supervisors, and shared with ministry maintenance contractors for their use. With the increase in RWIS technology implementation in Canada and the Untied States, new RWIS training programs and tools have become available. Most recently, the American Association of State Highway and Transportation Officials (AASHTO) produced a computer-based training (CBT) program to allow maintenance staff to work through the training at their own pace, learning the details of the technology and how to apply the information in winter maintenance decision making. OGRA, in cooperation with AASHTO, has produced an Ontario version of the CBT, which is being used as a pre-qualification tool for municipal staff that wish to access MTO RWIS data. In addition, MTO RWIS installation contracts require the contractor to provide training of their system to MTO staff and maintenance contractors that will have access to the station data.

OTHER APPLICATIONS

There is the potential to integrate the current RWIS system with other web-based information systems like the ministry's Road Condition Weather Information System (RCWIS), and electronic diary technology. While some integration of RWIS and AVL

has already taken place, full integration with other systems will likely occur when RWIS and electronic diary technology are successfully provided by the private sector.

In addition, MTO is exploring the potential use of RWIS station data for determining the most appropriate time to implement and remove reduce load restrictions on designated highways during the spring thaw period. Accurate subsurface data along with sophisticated weather and pavement prediction models may prove to be a key tool in assisting maintenance managers in successfully transitioning from winter to spring. Adding RWIS data to the decision making process, has the potential to reduce damage to roads normally subject to load restrictions along with reduced impacts on industries that utilize truck transportation during this period.

Many other parties have expressed an interest in gaining access to RWIS information for uses other than winter maintenance operations. Pavement marking supervisors are interested in atmospheric conditions for specific locations, particularly in the early spring and late fall when minimum air and pavement temperatures can affect this operation. A number of private organizations have also expressed interest in the data for diverse reasons, ranging from evaluation of locations for wind-power apparatus, to monitoring wind direction for forest firefighting and the operation of landfills. While there is broad interest in this data, the true value of such information will become more evident as the provincial and national systems are implemented.

FUTURE EXPANSION

MTO has future expansion plans to add 40-50 stations to the existing network. These locations will improve coverage on the provincial highway network throughout the province. Up to this point, stations are located primarily on the National Highway System including portions of the TransCanada highway. With that network essentially completed, it is now possible to focus on other highways that are on the windward side of the highway network already serviced with RWIS stations. System expansion will be largely dependant on funding available to operate not only the existing systems, but also the new stations that may be installed in the future.

SUMMARY

Since installing the first station in 1991, MTO's Road Weather Information System network has grown to a total of 113 stations with plans to add up to 50 more stations in the near future. This technology has become an essential and accepted winter maintenance tool, by providing real time information to maintenance managers for the effective and efficient deployment of winter maintenance operations. The RWIS technology has also become an essential component for other new and emerging technologies including liquid anti-icing and Fixed Anti-icing Spray Technology. While many road jurisdictions are just beginning the journey in RWIS technology, Ontario has embraced this key information tool, built a strong network, and will continue to share experiences with others at the municipal, provincial and national level in an effort to enhance road safety in Ontario and across Canada.

REFERENCES

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FIGURE 1. EXAMPLE OF OBSERVATION TABLE

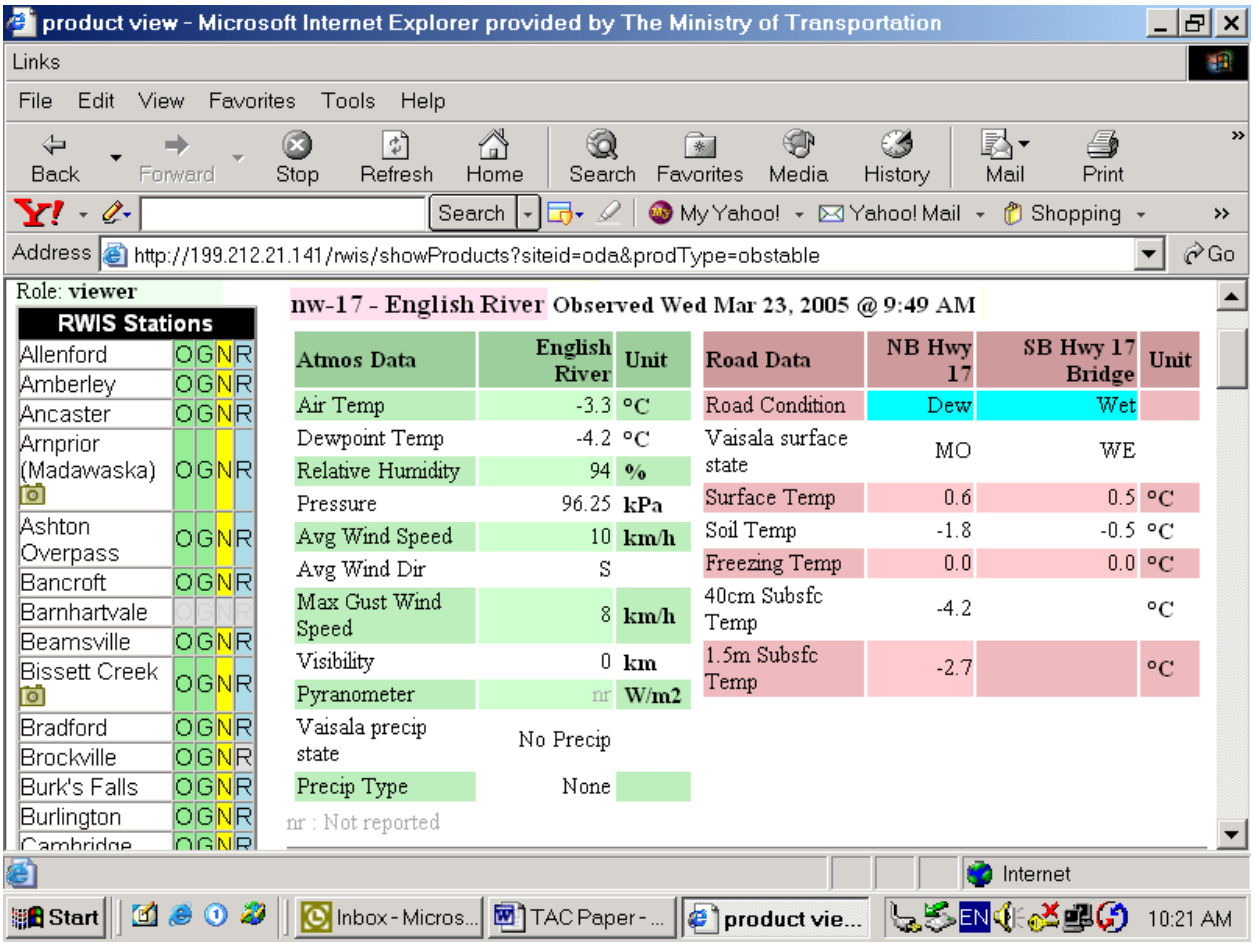

FIGURE 2. SAMPLE OF ATMOSPHERIC FORECAST

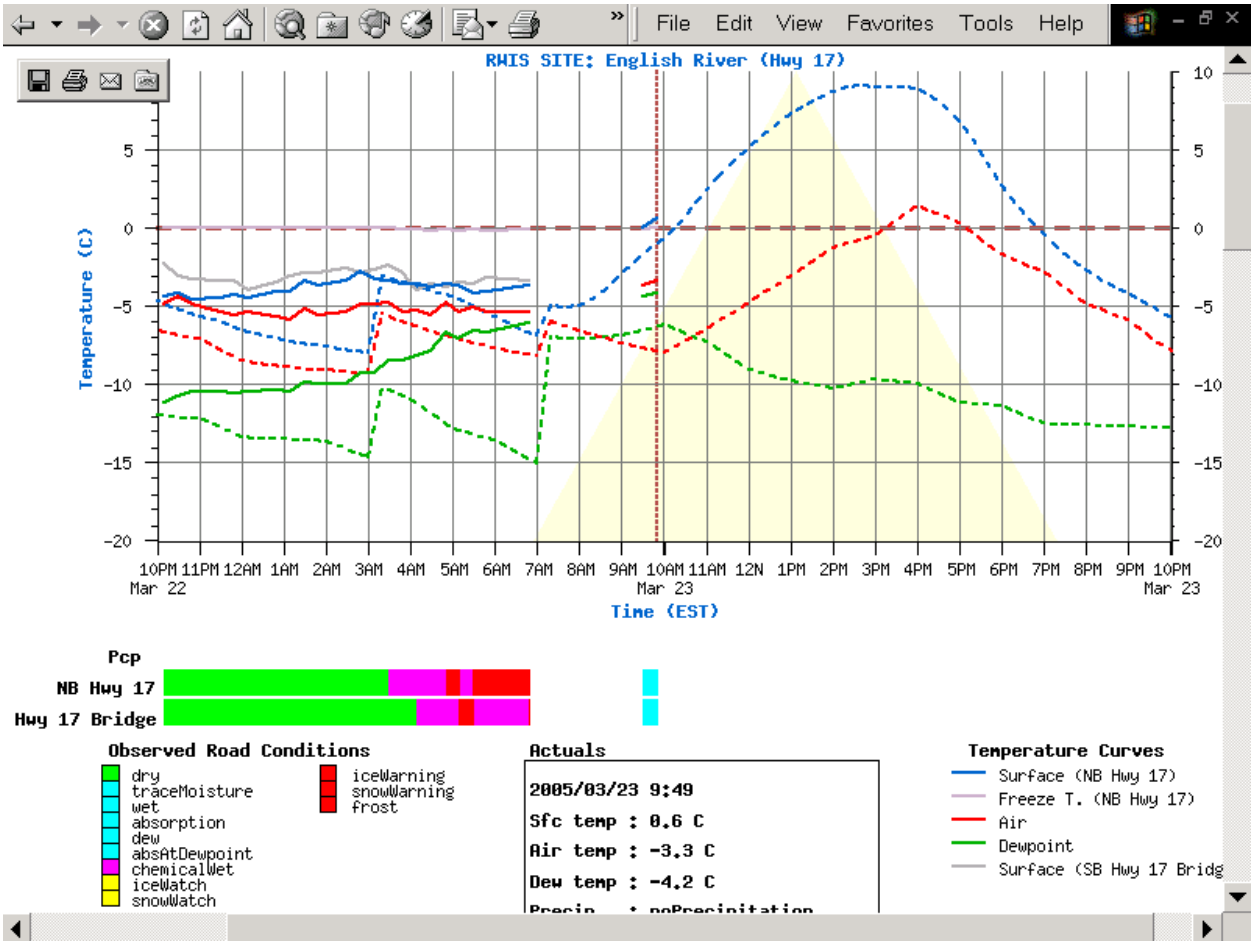

FIGURE 3. SAMPLE OF PAVEMENT FORECAST