CORPORATION OF THE COUNTY OF ESSEX

State of the Art Winter Maintenance Operations

TAC – Environmental Achievement Award, 2012

Essex County Highways

3/1/2012

1.0 INTRODUCTION

The County of Essex Transportation Services Department, Essex County Highways (ECH) has committed to ***state of the art best management practices*** as it maintains the County Road infrastructure through summer and winter maintenance operations from patrol yards that are located county-wide.

Winter road maintenance activities include snow removal and application of winter abrasives and de-icing chemicals. Road salt usage in Canada is one of the highest in the world, with approximately 5 million tonnes being utilized annually to maintain safe winter roadway conditions. With its relatively low cost, high effectiveness, and ease of handling, road salt is the product of choice for keeping roads clear of the snow and ice that is inevitably received from winter storms each year.

Environment Canada has expressed some concerns with regard to the excessive use of road salt, linking it to adverse impacts on the environment. In 2001, following a 5-year comprehensive assessment, Environment Canada released a report detailing the impacts and outlined consideration of making road salt a "toxic substance," under the Canadian Environmental Protection Act (CEPA). It must be noted, however, that under this Act salt would only be considered as "toxic to the environment" and not "toxic to human health," as road salt is not found to be detrimental to human health in any way. Environment Canada does not propose to ban salt use or propose any measures that would compromise or reduce road safety. Instead they are encouraging implementation of safer methods of use in order to protect Canada's environment.

In 2004, Environment Canada released a Code of Practice for the Environmental Management of Road Salts in order to give Road Authorities the opportunity to improve their salt usage methods. The Code of Practice's purpose was to guide the development of Salt Management Plans to reduce the environmental impacts that the use of road salt may have. The Code applies specifically to organizations using more than 500 tonnes of salt annually or which have vulnerable areas that could be potentially impacted. Transportation Association of Canada (TAC) has in turn published numerous publications to assist Road Authorities with winter maintenance practices. The *Synthesis of Best Practices for Road Salt Management* is a series of nine documents related to the management of road salts. As suggested in the Code of Practice, the *Synthesis* deals with the following:

- **Salt Management Plans;**
- Training;
- Road and Bridge Design;
- Drainage and Stormwater Management
- **Pavements and Salt Management;**
- Vegetation Management;
- **Design and Operation of Road Maintenance Yards;**
- Snow and Storage Disposal; and
- **Winter Maintenance Equipment and Technologies.**

Synthesis titles that are highlighted with blue font in the list above are carried forward in this document as each publication was instrumental in the County's decision making process to improve winter maintenance operations.

2.0 SALT MANAGEMENT PLANS

"Salt Management Plans" is the first series in the *TAC Synthesis of Best Practices for Road Salt Management*. The document provides guiding principles that are essential to the development of a successful salt management plan (SMP). Overall, a successful SMP operates in a cycle that includes continuous improvement as illustrated below in Figure 1.

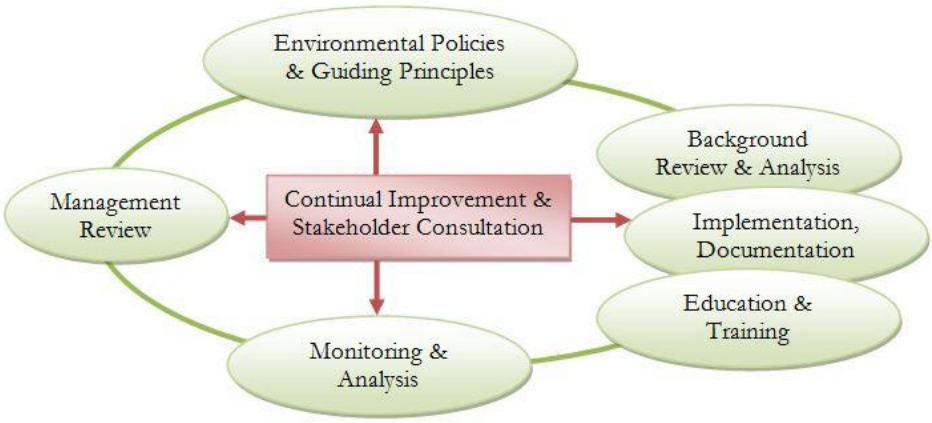


Figure 1: Salt Management Improvements Cycle

The County of Essex used this concept to evolve from the previously adopted 2005 SMP. The recently adopted 2011 SMP provides a road salt usage policy as approved by County Council, best management practices for winter maintenance operations, and a framework for monitoring progress toward effective management of de-icing chemicals. The plan incorporates the TAC principles into four (4) chapters: Policy Context, Winter Maintenance Standards, Operational Practices and Strategies, and Measurement and Monitoring.

A key element of the SMP is the Monitoring and Updating Annual Report, which includes setting objectives, targets, and provides certain performance measures. Targets are associated with specific objectives and describe when an outcome is to occur and how much. Targets can reflect both short-term and/or long-term timelines to effectively implement the SMP by breaking down major implementation requirements into more manageable sub-units. Each year, as work is completed, the targets and objectives will be reviewed and updated for the following fiscal period. Performance targets describe what will be measures to track achievement of the objectives and targets. Each measure is ranked in the form of "percent (%) complete". This report forms part of the 2011 SMP in the form of an Appendix. Refer to Appendix A for a sample of the report.

Results from the TAC Winter Severity Index (*wsi*) model are also included in the updated SMP. The model was used for winters from 2005 to 2011. An analysis of the effectiveness of the *wsi* indicates that while it may provide some insight into reconciliation between predicted and actual road salt usage, the model still shows some weaknesses for use in the Essex County region as a result of the region's unpredictably mild winters. As a result of snowfall events and relatively high daytime temperatures, there are greater chances of freeze-thaw cycles; a phenomenon that is not captured by the *wsi* and requires chemical de-icer application or creative engineering (i.e. Essex County Highway's Geothermal Bridge).

As part of any salt management strategy, *salt vulnerable areas* were identified and the potential for salt impacted drainage to affect these vulnerable areas must be assessed. GIS maps of the following features (PSW, ANSI, ESAs) were overlaid on the Salt/Plow Route map to determine intersecting roads to produce salt vulnerability risk map (see Appendix B).

3.0 Pavement and Salt Management

3.1 Salt and Plow Route Optimization

The County of Essex operates from its four (4) active patrol depots for its winter maintenance to cover 18 salt/plow truck routes with 21 pieces of equipment dispatched in a 'normal' winter event. Each active patrol yard is currently responsible for 3 to 5 routes with each one being 25 to 60 centre-line kilometers in length as illustrated in Appendix C. It should be noted that existing yards and routes have been designed and located based on historical rationale reflecting a smaller network both in road length and lane kilometers.

Essex County Highways (ECH) strives to continuously improve level of service and decrease operating costs by creating routes that balance cycle times and pavement condition demands. The introduction of AVL / GPS, improved plow and spreader fleets, the use of liquids, improved storm response and variable application rates has in some cases increased the service area of each truck. Also, the approach to winter maintenance in Canada has changed significantly since Environment Canada raised concerns about the environmental effects of excessive salt use. ECH looked at the opportunity to better balance their plowing & salting routes. The intention is to provide an optimal schedule for deployment of winter maintenance vehicles subject to a number of constraints which model LOS requirements, fleet size restrictions, patrol yard locations and route choices.

ECH identified disparity amongst the existing routes in terms of route length, lane kilometers services and time to complete. As a primary objective, route lengths should be balanced in terms of time to complete. This task is made all more difficult by the ever-changing weather conditions, traffic volumes, congestion, additional lane kilometers and environmental concerns. The existing routes were evaluated based on achieving balanced route times and minimizing the number of routes while meeting minimum maintenance requirements. A route optimization model was developed by County staff to provide continuous monitoring of the routes to determine the most cost effective manner to deploy vehicles and to confirm the location of the patrol yards. Alternative routes were selected for a particular region of the County based on future roadway acquisitions and relocated patrol yards. To analyze the effect each redistributed route, the existing routes were divided into numbered segments with corresponding lane-km lengths. The model allows the user to add or remove a particular segment, and in turn, readjusts the total length of each route. The model also provides outputs for each route and alternative, including details regarding the percentage of the route in terms of MMS road classifications. Future analysis will evaluate the efficiency of each route based on salt application rates, salt capacity of each vehicle, and refueling cycles.

3.2 Fuel Management System

The County has also recently installed a Fuel Management System (FMS) that enables fully electronic fuel tracking with the ability to reconcile fuel delivery with usage. The system monitors and records fuel dispensing activities that can be tracked to a vehicle unit number and operator. In addition to fuel tracking, the system limits vehicle refills, starting/finishing fuel times, and prevents the incorrect fuel from being dispensed to the vehicle. All of the data is polled electronically via a secure server and can be managed from a computer with the appropriately installed software. Currently, the FMS is fully operational at the County's main Patrol Yard and is in the process of being expanded to all active patrol yards. The system has demonstrated capabilities of expanding into other departments of the County such as Emergency Medical Services.

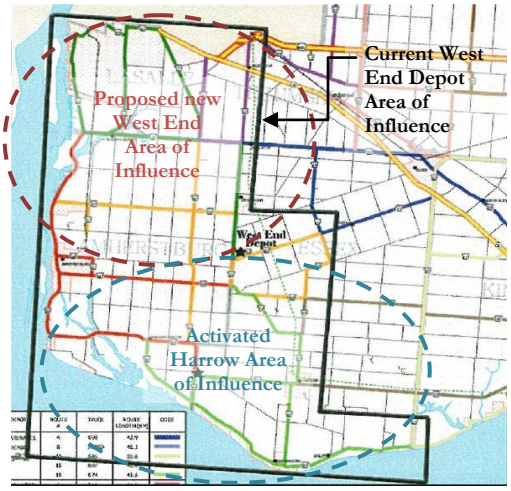
3.3 Biodiesel Pilot Project

Biodiesel is a biodegradable, non-toxic fuel made from natural, renewable sources such as soybean and vegetable oils, or animal fats. It is essentially free of sulphur and aromatics and provides an opportunity for a reduction in unburned hydrocarbons, carbon monoxide, sulphates, and particulate matter. A pilot project was initiated by Essex County Highways to explore the advantages and/or disadvantages of using biodiesel in its municipal fleet. Goals of the pilot project are to investigate the opportunities and constraints with regard to implementing the use of biodiesel in the County diesel fleet, including possible sources, blend rates, delivery and price options, to transfer knowledge gained and explore further opportunities for the Corporation as well as the local municipalities. The Pilot program currently tests B5 biodiesel in a small dump truck and compares its performance operationally and from a consumption perspective to a similar unit operated on standard commercial diesel fuel. Monitoring of results is on-going and improvements to the pilot project are being explored.

4.0 Design and Operation of Road Maintenance Facilities

A total of six (6) patrol yards, four (4) active are integral to winter operations as they house all necessary equipment, fuel, and de-icing agents to complete winter maintenance activities. The County is continuously improving existing maintenance facilities in accordance with the *TAC – Design and Operation of Road Maintenance Facilities*. This series of the *Synthesis* provides guidelines for the construction of new maintenance facilities. The County is improving existing maintenance facilities with close attention to the "Salt Handling Cycle" identified in the *Synthesis*, which includes salt delivery, stockpiling, loading, spreading, offloading, and vehicle washing. Some key aspects to maintain efficient and environmentally conscience "Salt Handling Cycle" include the ability to load and offload salt inside a covered structure, store salt on a low permeable surface, and collect vehicle washwater and site drainage. In an effort to meet these guidelines, new salt dome structures were constructed at each active patrol yard. Each structure is large enough to accommodate fully indoor salt deliveries, and enable county vehicles and equipment to maneuver inside as well. The structure floors are paved to prevent salt seepage, and the walls are poured concrete with a permanent clear-coat that helps defend against concrete deterioration caused by salt. Refer to Appendix D for photographs of the new structures at the Kingsville Maintenance Yard.

In addition to upgrading existing facilities, the County is also utilizing the *Synthesis* as a guide to locate suitable land for the construction of a new state of the art patrol yard. A new patrol yard became a priority in 2008 after the completion of the Yard Rationalization Study. Several alternatives were considered that had potential to meet Essex County's existing and future needs as they related to season maintenance operations. The final recommendation, as adopted by County Council, was to search for suitable land for a new patrol yard in the northeast part of the county with the potential to activate the existing Harrow Depot. The search is still ongoing; however, once complete, Essex County Highways will have the ability to effectively manage salt and reduce costs associated with excess travel time and fuel costs, along with fewer salt deliveries to each site.



5.0 Winter Maintenance Equipment and Technologies

"Winter Maintenance Equipment and Technologies" describes a variety of technologies that improve winter maintenance activities. Various combinations of technologies and strategies are used in response to a winter storm event. For example, pre-wetting is a process that involves spraying de-icing salt with a solution of liquid chemical (brine) before spreading the salt on the roadway. This process allows for better adhesion between the road salt and the road surface. It also ensures enough moisture is present to facilitate the snow melting process. As a result, pre-wetted road has the potential to function faster and at lower temperatures than dry road salt. Pre-wetting capabilities has the potential to reduce the amount of rock salt applied to a road surface to due increased adhesion and efficiency in the snow melting process. Other advantageous equipment includes vehicle mounted infrared temperature sensors and direct liquid application. Infrared sensors monitor the pavement temperature as operators drive over a paved surface. This enables the operator to deploy de-icing chemicals at the most efficient time rather than contributing to salt loss during low temperatures where salt is no longer effective. Direct liquid application can be deployed to a road surface prior to a winter storm event occurring, which enables improved response time to other problematic areas within the County.

Essex County Highways maintained records of improvements to winter maintenance vehicles capabilities between the years 2005 and 2011. Table 1 shows the percentage of our winter maintenance fleet equipped with a specific technology.

Table 1: Winter Maintenance Fleet Equipment Improvements

Technology	2005	2011	2012 Goal
Electronic Controlled Spreaders	100%	100%	100%
Vehicle Mounted Infrared Temperature Sensors	25%	100%	100%
Pre-Wetting Capabilities	6%	35%	50%
Direct Liquid Application	0%	5%	11%

Other technological improvements include a bridge structure within a Provincially Significant Wetland. The structure provided an opportunity to be a testing facility for utilizing geothermal energy and was nominated for the TAC 2009 Environmental Achievement Award. The geothermal design reduces the need for road salts to be used on the concrete approaches and bridge deck. Refer to Appendix E for photographs of the geothermal bridge.

All of these improvements in equipment and technology enable Essex County Highways to practice the 4-Rs of salt management:

- **Right** material;
- **Right** amount;
- **Right** place; at the
- **Right** time.

6.0 Cost Implications

Essex County Highways has implemented several initiatives to reduce its contribution to the degradation of the environment. Aside from the obvious link between a reduction in road salt use and fossil fuel consumption, the net environmental impacts, including ecological gains, improved quality of life, and aesthetic/scenic vistas, are challenging to quantify with a monetary value. As such, a traditional cost-benefit analysis is not appropriate to evaluate the effectiveness of these programs. Notwithstanding, each program will be monitored for its effectiveness and evaluated to quantify direct cost savings associated with salt, fuel, and operational time and expenses. It is expected that the programs provide savings in all areas upon full implementation.

Methods to evaluate those unquantifiable environmental impacts exist, including hedonic pricing and contingent valuation; however, at this time it is the County's impression that these methods would not provide any additional motivation than what already exists. The Essex County region has demonstrated great support for such environmental initiatives, as is evident through County Council adoption or endorsement of the programs highlighted in this report.

7.0 Lesson Learned

ESTABLISH GOOD INTERNAL COMMUNICATION. The County owes much of its success to the strong support Council has given to sustainable planning and energy initiatives.

STRONG INTER-DEPARTMENTAL LEADERSHIP. Success in each initiative requires an interdisciplinary approach. Strong leadership in the fields of transportation planning, engineering, and maintenance operations has led the County to its current state.

COST-BENEFIT ANALYSIS. A lesson drawn from this work is that it is a challenge to develop a standardized approach to cost-benefit analysis for items as widely disparate as winter maintenance practices, equipment and operations.

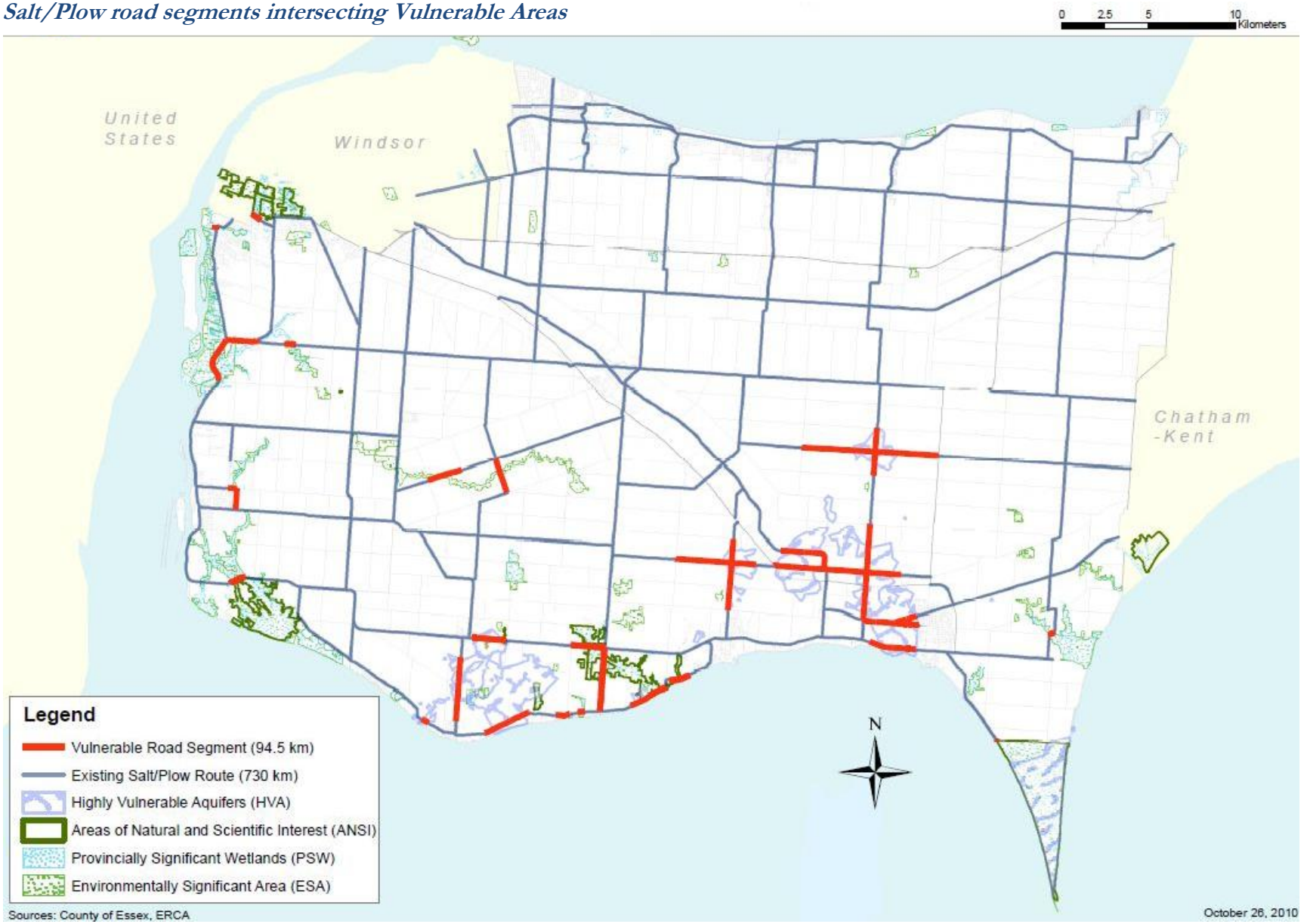
TECHNOLOGY GAP. As with many workforces, a technology gap can hinder or slow the implementation phase of newer, more technologically advanced programs. Communication with all employees, including several training sessions is essential to moving forward.

CAPITALIZE ON FAMILIARITY. Different users have different levels of familiarity and/or experience with new technologies as they evolve. Draw on the experience of other municipalities facing similar challenges.

Excerpt from 2011 SMP Monitoring and Updating Annual Report

4.2 EQUIPMENT UPGRADING, CALIBRATION & WASHING					
4.2.1 Pre-Wetting and Anti-Icing Equipment					
Purpose/Description	Pre-wetting is the process of spraying de-icing salt with a solution of liquid chemical (brine) before spreading the salt on the roadway. This process allows for better adhesion between the road salt and the road surface. It also ensures enough moisture is present to facilitate the snow melting process. As a result, pre-wetted road salt has the potential function faster and at lower temperatures than dry road salt.	**Best Management Practice**	• Anti-icing is carried out when and where warranted. • Staff is knowledgeable in the use and handling of solid and liquid anti-icing chemicals. • Staff is knowledgeable in the use and handling of liquid fuels		
Environmental Consideration	Equipment upgrades such as "pre-wetting" has the potential to reduce the amount of rock salt applied to a road surface due to increased adhesion and efficiency in the snow melting process.				
			SMP Target	**FY 2012 Target**	**FY 2011 Status**
Performance Measure	• Percentage of fleet vehicles with pre-wetting capabilities		85%	50%	35%
4.2.2 Electronic Spreader Controls					
Electronic Spreader Controls	Electronic spreader controls can be accurately calibrated, regulated to ground speed, and generate pertinent salt-use data.	**Best Management Practice**	• Material application data from each event, at the truck or route level, is logged. Data can be reviewed and archived.		
Environmental Consideration	Electronic controllers ensure that the chosen and prescribed amount of salt is being placed on the roadway consistently, regardless of speed and provides data that permits salt use to be tracked.				
			SMP Target	**FY 2012 Target**	**FY 2011 Status**
Performance Measure	• Percentage of fleet vehicles with electronic spreader control		100%	100%	100%

Salt/Plow road segments intersecting Vulnerable Areas



Salting & Snow Plow Routes

DEPOT	ROUTE #	TRUCK	ROUTE LENGTH (KM)	COLOR
MAINTENANCE DEPOT	4	611	38.8	
	8	HIRED	44.4	
	10	685	44.3	
	15	609	54.3	
	16	602	33.8	
TILBURY NORTH DEPOT	6	622	50.6	
	7	709	43.5	
	9	HIRED	45.5	
WEST PIKE CREEK DEPOT	1	708	30.5	
	5	636	48.0	
	12	697	35.4	
	13	692	22.9	
	17	HIRED	23.3	
WEST END DEPOT	2	704	41.4	
	3	691	29.7	
	11	HIRED	46.3	
	14	608	41.6	
	18	HIRED	36.3	

New Salt Dome Structures at Kingsville Maintenance Yard

Geothermal Bridge Over North Branch Cedar Creek, County Road 23