

**TWO PLOWS – ONE OPERATOR  
THE USE OF TOW PLOWS ON AN ARTERIAL HIGHWAY  
IN NORTHERN NB**

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## **Abstract**

### **Two Plows – One Operator The Use of Tow Plows on an Arterial Highway in Northern NB**

This paper describes Brun-Way Highways Operations Inc. (Brun-Way) journey of incorporating a new type of snow removal equipment, the Tow Plow, in the echelon plow train, discusses the resulting impacts on the public, environment and facility assets and evaluates this method of snow and ice control based on performance and training requirements.

Brun-Way undertook a pilot project in the winter of 2006–07 to evaluate the use of Tow Plows for snow and ice removal on Route 2, a portion of the four-lane divided highway between the Quebec Border and west of Fredericton, NB. Brun-Way is the Operator for the Trans Canada Highway Project, a P3 project in New Brunswick. One Tow Plow was provided by the Viking-Cives Group of Mount Forest, Ontario to Brun-Way for this evaluation. Following reasonable results with the unit, Brun-Way ordered three more Tow Plows for the winter of 2007–08 and a further six units for the 2008–09 winter season. The use of the Tow Plows has enabled Brun-Way to improve its level of service in a safe, cost effective manner and serves as a strategy to deal with the shrinking pool of trained and experienced operators.

Although Tow Plows have previously been in use with the Missouri Department of Transportation, Highway 407 ETR and Minnesota, the Brun-Way Tow Plows required several modifications in order to be considered compliant with NBDOT vehicle licensing and safety requirements. As well, other modifications were made to suit the Brun-Way snow and ice control processes. Brun-Way actively practices anti-icing, pre-wetting and other salt-reduction strategies, so the Tow Plows were retrofitted to be useful in these circumstances.

Brun-Way implemented training programs for operators in order to ensure that the Tow Plows were used in a safe and efficient manner. As a result of our experience with the Tow Plows over three winter seasons, the training has been modified to suit the needs of our operators and the travelling public.

The use of Tow Plows for certain plow routes on the highway has resulted in economic changes related to fuel and payroll while maintaining or improving upon the required level of service. However, not all plow routes or storm types are amenable to the use of Tow Plows. As a result, Brun-Way has developed methods to deal with heavy and wet snowfalls, hills, narrow medians, and other such challenges associated with the highway infrastructure.

# 1 The Project

The Trans Canada Highway Project is the second Public Private Partnership (PPP) highway operations, maintenance and rehabilitation (OMR) contract to be awarded in New Brunswick. The project consists of the OMR of 275 kilometres of Routes 2 and 95 in western New Brunswick.

The OMR portion of the PPP project was awarded to Brun-Way Highways Operations Inc. (Brun-Way) in 2005, and operations began in June of 2005. In the first winter, Brun-Way was responsible for snow and ice control over 130 km of four-lane highway (other portions of the project were still under construction by Brun-Way's sister company, Brun-Way Construction Inc., and the New Brunswick Department of Transportation).

In 2006 a further 32 km of four-lane highway was turned over to Brun-Way and in November of 2007, the Design-Build portion of the contract was completed, at which time a further 113 km of four-lane highway was turned over to Brun-Way for snow and ice control.

In addition to winter operations, Brun-Way is responsible for the operations, maintenance and rehabilitation of all the highway-related assets within the right-of-way until the end of the concession period on June 30<sup>th</sup>, 2033. At that time, all assets will be required to be in good condition as defined by Hand-back Standards.

For the Design-Build portion of the contract, the Developer was required to finance the construction of the highway, and was paid at the point of final completion of each defined segment of highway. During the OMR phase of the contract, the Operator is paid a defined amount annually which is adjusted each year for inflation by the New Brunswick Consumer Price Index.

Brun-Way is required to meet performance-based standards for all aspects of the operation, maintenance and rehabilitation of the project. The Owner, the New Brunswick Highway Corporation (NBHC) monitors the performance of the Operator through regular, periodic and random site and office audits to ensure that the OMR standards are being met.

The project agreements also required Brun-Way Group to obtain and maintain ISO 9001 Quality Management Certification and ISO 14001 Environmental Management certification. Brun-Way Group has achieved both of these certifications ahead of schedule. By requiring Brun-Way to obtain the certifications, the Province was assured that third-party monitoring of Brun-Way quality management processes would occur in addition to the Province's own audit processes. Brun-Way was also required to have a New Brunswick Certified Safety Management System in place.

Brun-Way Highways Operations has implemented an integrated management system that contains all of the necessary documentation to satisfy the province's quality,

environmental and safety requirements. As a result, only one manager is required to manage all three systems. This has proven to be a highly efficient system as it provides the Province with a single point of contact and eliminates duplication between systems.

Asset management is another key component of the Project. Brun-Way is required to have asset-management plans and key performance indicators for structures, drainage systems and pavements.

## **2 The Challenge**

The Winter Standards for snow and ice control that form part of the Agreement with the NBHC are performance-based standards. The level of service required is the highest standard in the Province, and requires a great deal of effort from Brun-Way to achieve. Brun-Way prepares a Winter Operations Management Plan (Winter Plan) every year that indicates to the Owner just how Brun-Way plans to meet and exceed the Standards.

The annual Winter Plan contains details on specific items such as:

1. The 24 hour per day, 7 day per week Operations Control Centre with trained staff that will direct, co-ordinate, report and communicate the winter maintenance program;
2. The equipment and personnel resources that will be available to combat all storms including major storm events as forecast by Environment Canada;
3. The use of weather forecasting services and the deployment of five Road Weather Information System (RWIS) reporting stations to forecast and track storm events;
4. A Salt Management Plan to ensure proper and environmentally-responsible usage of de-icing chemicals;
5. Plow routes and equipment allocations in order to meet cycle times in average storm and severe storm events; and
6. Contingency plans for equipment failure and severe storm events;
7. End-of-storm clean-up operations.

During the winter of 2005–06, Brun-Way was fortunate to be mandated to operate less than half of the Facility, and was therefore able to phase in gradually towards full implementation by November 2007. (See Figure 1) For that first winter, Brun-Way operated from its first of three permanent district facilities, in St. Leonard in northwest NB. A temporary facility was also in use in Woodstock, NB, and an isolated short section of 7 km of four-lane highway near Perth Andover was under the control of a subcontractor. However, over the course of the first winter, it became apparent in the first winter that changes would have to be made in order to meet the requirements of the Winter Standards. The 2005–06 challenges were:

1. Severe storm events occurred that were more severe than historical records had indicated and taxed Brun-Way resources;
2. Experienced local highway plow and spreader operators were difficult to find as historically the New Brunswick Department of Transportation had been the sole supplier of these services with their own employees.

3. Available staff was not trained in snow and ice control methods that Brun-Way had adopted, such as echelon plowing, anti-icing and prewetting;
4. New and untried equipment did not perform as predicted or required;
5. Employment opportunities in Western Canada resulted in shortages of qualified or trainable operators;
6. Global warming was resulting in winters with more extreme storm events than history predicted; and
7. Fuel prices were escalating rapidly.

As a direct result of the experiences with the first winter of operations in snow and ice control, Brun-Way embarked on research into new technologies to assist in meeting the stringent project requirements, and to meet these challenges. One of the major innovations explored by Brun-Way was the Tow Plow.

### **3 Tow Plows – Part of the Solution**

#### **3.1 History**

The Tow Plow (see Figure 2) is a snow plow designed to be towed behind a standard snow plow truck. In combination with the standard front-mounted plow, this can increase the snow clearing path to as much as 7.85 m. Although the primary use is multi-lane, high speed echelon plowing in which the Tow Plow effectively replaces one standard plow unit, they are also used in some municipalities (Figure 3).

In 2007, Missouri Governor Matt Blunt recognized the Missouri Department of Transportation with the prestigious Governor's Award for Quality and Productivity for developing a snowplow that is able to clear two lanes of pavement with only one truck. The idea of a large steerable side wing which would double the clearing path of a snowplow truck was first presented to Viking-Cives in the fall of 2004 by Bob Lannert, then an engineer with the State of Missouri. The Missouri DOT built three prototypes and then handed over the licensing and manufacturing rights to Viking Cives. Since that time the research and development staff at Viking-Cives, in Mount Forest, Ontario, Canada has developed that idea into a unique piece of snow removal equipment.

As of spring 2009, there are about fifty Tow Plows in service, with approximately twenty in Missouri, ten with Brun-Way and the remainder with Minnesota DOT, the Province of Alberta (under evaluation), Maine DOT, a private contractor on Highway 407 ETR, the Fredericton Moncton Highway Project with Maritime Road Development Corporation in New Brunswick, and a private contractor in Montreal.

During development of the Tow Plow, challenges with which to contend included keeping the width of the machine under a legal maximum; allowing for a number of options such as sander, ballast tank, anti-ice equipment, etc. and retaining enough weight on the trailer to make the machine work. Finite element analysis testing was conducted to ensure the integrity of the frame as well as testing in winter conditions for performance limits. The goal was to develop an easy to operate snowplow as well as a "street legal" trailer.

According to Viking-Cives product information, the frame is constructed of 15" (50 lb/ft) channel iron with 3/4" gussets and cross bracing. The articulation of the tongue is controlled by a 4" x 12" cylinder. There are two 16,000 lb steering axles capable of turning 30 degrees to the right. The steering is controlled by a 4" x 12" hydraulic cylinder. There are 4-wheel air brakes with ABS. The tire size is 385/R22.5. The steering and frame articulation operate simultaneously from one in-cab control. There are two plow mouldboards pinned together raised and lowered as a unit by two 3" x 16" cylinders. The front mouldboard is 12' long by 30" high. The rear mouldboard is 14' long x 30" high. Both mouldboards operate from a single acting valve section with in-cab control. The unit requires ballast on the wheels and this is provided by a 4,000 litre poly tank (other tanks, spreader units, etc. are optional). In transport mode, the unit meets all requirements of a trailer lighting package. Different plow lighting packages are available in order to meet the requirements of individual jurisdictions.

Tow Vehicle Requirements:

- 30,000 lb pintle hook
- Two tow eyes
- Trailer air package
- Seven-wire trailer plug
- Six-wire trailer plug for plow lights

### ***3.2 Implementation***

In the spring of 2006, Brun-Way staff attended the annual American Public Works Association (APWA) North American Snow Conference in Peoria, Illinois. During the visit, they were introduced to the Tow Plow as demonstrated by the Viking-Cives Group. Staff researched the equipment further, and spoke with the other agencies using the equipment. At that time, only the Missouri DOT had the equipment in regular service, and one unit was on loan to Highway 407 ETR for demonstration purposes. The manufacturer expressed a willingness to provide a unit to Brun-Way for evaluation purposes.

### ***3.3 Trial Period – Winter of 2006-07***

After learning about the Tow Plow at the 2006 APWA North American Snow Conference, Brun-Way expressed an interest in using one Tow Plow in a trial situation. One unit was provided by the Viking-Cives Group of Mount Forest, Ontario to Brun-Way for this evaluation. The manufacturer informed Brun-Way that one unit was also being tested on Highway 407 ETR and units were in service with the Missouri DOT. Arrangements were made to have the trailer and a Brun-Way truck delivered to Moncton, NB for modifications to the truck to allow the trailer to be towed. Brun-Way contacted the truck manufacturer (Sterling) to ensure that the truck frame and pintle hook were adequate for the mass of the trailer. The specifications of the pintle hook were found to be more than adequate and the truck was subsequently modified to tow the trailer.

The demonstration Tow Plow was a TP 26 designation, with a 26 foot ((8.7 m) mouldboard with dual polyethylene ballast tanks with 8000 litre brine capacity and Compu-spread anti-ice pump with spray bar to cover 1.5 lanes.

The unit was first put into service in the southernmost district, from Woodstock to Longs Creek and then deployed in the northernmost district, from Grand Falls to the Quebec border. Both Area Managers expressed satisfaction with the unit and made several recommendations as a result.

The trial period was in the latter part of the winter, but Brun-Way gained sufficient experience with the Tow Plow to proceed to purchase the original demonstration unit and three additional units for the following winter season.

### **3.4 Modifications Required**

Prior to putting the Tow Plow into service, Brun-Way requested approval from the Owner for use in our fleet. Approval was required on two aspects:

- Was the Tow Plow considered legal for use on New Brunswick highways; and
- Would the Owner consider a Change Request to the Winter Plan to allow the use of the Tow Plow?

After considering the equipment, the legality of the Tow Plow for use on provincial highways was affirmed by the New Brunswick Department of Public Safety in July, 2007. This approval covered the use of the Tow Plow when operated as a trailer (when travelling or when being operated for brine application) as the Tow Plow was considered to be in conformance with New Brunswick's Vehicle Weights and Dimensions regulations.

The Province of New Brunswick has a legislative exemption policy for snow plow equipment while actively engaged in snow removal operations within the Motor Vehicle Act for Vehicle Weights and Dimensions. Based on this exemption the Tow Plow was acceptable to the Province for use on a trial basis as well.

The Operations, Maintenance and Rehabilitation Winter Standards for the project are performance standards (e.g. "Plow all snow from the surfaces of shoulders and travelled lanes within twenty-four hours following the end of a winter storm.). The Winter Plan provides for the methodology to meet these standards and includes the fleet deployment and the size and makeup of the fleet all of which require the annual approval of the Owner. Therefore the Winter Plan required revision to include the use of the Tow Plows. The process for revision of the Winter Plan is a Change Request, which details the changes proposed by the Operator. The Change request was approved by the Owner.

During the trial phase of the implementation project, the use of the Tow Plow was reviewed by the New Brunswick Department of Transportation and the Department of Public Safety. The unit was declared legal for use on NB highways by the Department

of Transportation, provided it was properly licensed. As a result of these reviews, several modifications were made to the Tow Plows (Figure 5):

- a. During deployment, the tires of the trailer were not adequately covered by the fenders, as the wheels skewed and the fenders stayed in place. Cycle fenders were added and modified to move with the wheels.
- b. Lighting, in addition to the normal lighting required when the unit was in “trailer mode”, was added including two additional high-mounted strobe lights.
- c. The rear bumper was chamfered at 30 degrees on both sides to address collision concerns while the unit was deployed.
- d. Hard plastic deflectors were installed on the top edge of the plow blades to reduce snow “kick-up”.
- e. When deployed, a light bracket on the side of the trailer became a point of potential impact for vehicles encroaching on the trailer. This mount was remanufactured to become “break-away” if hit.
- f. The back end of some of the plow mouldboards were cut off at an angle to allow the blade to come closer to the guiderail when plowing.

### **3.5 Dynamic Performance of the Tow Plow**

There were a number of questions concerning the dynamic performance of the trailer, specifically whether it was prone to roll-over when deployed. However, it was pointed out that the truck and trailer combination was within the dimensional limits for a truck-pony trailer combination as given in New Brunswick Regulation 2001-67. When the Tow Plow was compared to a tandem axle gravel end dump pony trailer (most common pony trailer) it was noted that:

- a. The tare weight of the two trailers is comparable, but the tare centre of gravity is about 0.74 m above the ground, while that of a gravel pony trailer is about 1.52 m.
- b. The gravel pony has a payload of approximately 12 t at a centre of gravity about 1.73 m, while a Tow Plow with two brine tanks (Brun-Way configuration) would have a payload of approximately 9 t at a centre of gravity about 1.52 m.
- c. The Tow Plow has single tires which give a greater effective track width than the dual wheels on a pony trailer.
- d. The Tow Plow has no suspension, while the gravel pony has a flexible suspension.

All these factors favoured the Tow Plow. With a roll threshold of greater than 0.5 g, the Tow Plow is designed to slide out of a high speed turn on a dry road before it would roll over. Similarly, the Tow Plow would out perform a gravel pony in a high speed evasive manoeuvre, however, the Tow Plow typically plows at a speed of 60 kph or less.

When deployed, all four wheels of the Tow Plow turn to the right, the trailer skews accordingly and the plow blade is lowered to the pavement surface. As a result, the trailer centre of gravity is lowered, the effective track of the trailer increases, the plow blade acts as an outrigger which prevents roll-over to the right; and the trailer centre of gravity moves to the right which increases the roll threshold to the left.



When equipped with brine tanks, the load serves to ballast the trailer when the Tow Plow operates as a snow plow. When the tank is full, the centre of gravity is higher than when empty. As the tank empties, the centre of gravity is lowered and the roll stability increases. As the tank is circular, sloshing of the brine is of little consequence.

There was also a question regarding the force on the pintle hook of the truck when the Tow Plow was deployed and plowing. Normally, when a stand alone truck is plowing to the right, there is a reaction on the front axle forcing the truck to steer to the left, and a corresponding reaction on the rear axle, forcing the rear of the truck to the right. The driver compensates by steering right.

With the same truck towing the Tow Plow, the same reactions from the front plow occur, but the force of the snow against the trailer plow results in a reaction on the pintle hook and rear axle forcing the rear of the truck to the left in opposition to the forces applied by the front plow. Similarly, there is a reaction on the front axle of the truck forcing the truck to the right again in opposition to the forces applied by the front plow. The driver will still be required to compensate but under most circumstances will not have to compensate as much as when plowing without the Tow Plow. (Figure 6)

### **3.6 Subsequent Winters**

Following reasonable results with the units over the winter of 2007-08, Brun-Way ordered an additional six units for 2008–09 winter season, for a total of ten units. It should be noted that these units were an augmentation to the Brun-Way fleet. The number of standard trucks was not decreased as a result of the addition of the Tow Plows.

In the past winter (2008–09), Brun-Way had instituted new plow routes designed to shorten cycle times and optimize equipment use. In addition, a strategy for intense storms was introduced, whereby many of the routes were shortened, and additional enhanced routes added to ensure the Winter Operational Standards were met.

In normal conditions, the Tow Plows are included in the seven normal plow routes. During intense storms (Figure 7), ten plow routes are utilized, with a Tow Plow in each of the ten enhanced routes. The Winter Plan accounts for two operators per plow truck, (12-hour shifts, allowing for continuous operations) including the Road Patrollers who are trained as operators. The total complement requires forty-nine operators to be trained.

As Brun-Way utilizes echelon plowing (plowing of both lanes and shoulders in one pass), the Tow Plow is normally used in the right lane and shoulder as the second (following) unit (Figure 8). In the enhanced mode, the Tow Plow is used to clear both the left shoulder as well as the left and right lanes as the lead unit, with shoulders being cleared by second units.

In addition to the modifications that were required by the Province of New Brunswick, Brun-Way continually evaluated the units in-service and made several modifications in order to improve the abilities and reliability of the Tow Plows. The suggestions for the modifications came generally from the operators and were based on their first-hand experience with the units. With increased experience in varying conditions, the operators found several opportunities to improve the units such as:

- a. Lower the brine nozzles closer to the road surface to reduce misting of the brine;
- b. Add two adjustable fire hose-style nozzles on the left side to improve brine application;
- c. Higher capacity brine pump for an application rate of 100 litres per lane-km.
- d. Connect the two brine tanks with a shut-off valve between them;
- e. Utilize the trailers for hauling water and add a pump and fire hose for use in bridge washing operations in the spring; and
- f. Add an arm to the rear of the Tow Plow that deploys similar to a school bus arm, to prevent vehicles coming into the area between the truck and the trailer when the trailer is deployed.

### **3.7 Training**

Brun-Way conducts training for staff and subcontractors for all facets of the OMR work on the Facility, including snow and ice control. With respect to plow trucks, only drivers towing the Tow Plows are required to have Class 1 Operators licences, but all are required to pass a driving test conducted by a subconsultant to Brun-Way. The Winter Operations Training Program consists of:

- Brun-Way Quality/Safety/Environmental (QSE) Awareness that discusses quality, safety and environmental issues as they relate to winter maintenance activities; Also covered are an overview of RWIS and the science of materials used for anti-icing and de-icing;
- Equipment training on the control mechanisms installed in or attached to the plow, loaders and other winter maintenance equipment;
- Safety training related to personal safety and job specific training in accordance with the Brun-Way Safety Management Systems and the Occupational Health and Safety Act and Regulations;
- Brine production system training which includes training staff in the manufacturing and monitoring process for brine;
- Automated Vehicle Location/GPS training and record keeping;
- RWIS training on data interpretation and forecasting for decision makers;
- Snow and Ice Control training which includes a detailed analysis of anti-icing, de-icing techniques and abrasives applications;
- Traffic Control; and
- Safe driving practices.

Operators receive training for all makes and models of plow trucks owned by Brun-Way; however, "Tow Plow" specific training is provided "on the job". Experienced Tow Plow operators train and shadow the new operators until such time as they are assured they

are competent. All Tow Plow operators are required to have a valid Class 1 air-brake licence to operate the Tow Plow.

### **3.8 Public Communications**

Highway agencies involved in snow and ice control face a common issue when plowing. Road users often do not respect the snow plows and try to maintain their normal speed on snow covered highways. Unfortunately Brun-Way Highways Operations Inc. experiences this as well. Historically, each winter brings at least a dozen collisions between plow equipment and other passing vehicles. These collisions typically occur when motorists attempt to pass around or between plows during echelon plowing operations and some are severe enough to disrupt the snow and ice control. Brun-Way does its best to periodically allow drivers to pass the plow echelon, except in conditions deemed dangerous by the operators. It should be noted that Brun-Way plows from left to right with the lead plow passing a windrow of snow to the following plow. Often the windrow is large enough to potentially cause vehicles to lose control. In these instances, Brun-Way staff try to keep the echelon closed and to prevent potential problems by keeping the traffic behind.

Impatient drivers have been known to pass on the right or the left, or to force the following plow onto the shoulder by crowding in order to pass the plow echelon. The introduction of the Tow Plow has brought additional concerns. Road users are not familiar with the equipment and are unaware that the trailer often shifts from tracking mode to trailer mode and anywhere in between when approaching highway appurtenances such as guide rail or abandoned cars. Impatient drivers have been seen encroaching on the plow truck beside the deployed Tow Plow, and the plow truck has been forced to stop rather than hit the guide rail. Brun-Way has attempted to counteract these actions by appealing to the public through the local media.

The Brun-Way Communications Coordinator regularly appears on a local radio station during storms to provide the current road conditions as well as caution drivers to leave early and go slow. The need to stay behind the plows is emphasized and patience is requested from the public.

Each fall, local newspapers are provided with media kits discussing Brun-Way snow and ice control methods and again, a plea for caution and patience during winter conditions. Local reporters are provided with rides behind the snow plow and Tow Plow trucks in order to get an understanding of the winter operations. Brun-Way staff meets yearly with trucking companies and the Atlantic Provinces Trucking Association to ensure that this message gets out to the truck drivers. Brun-Way staff (Road Patrollers/Lead Hands) have met with local school driver education classes to get out the message as well.

The message goes out, and as most of the highway users are local, or long distance truck drivers headquartered in the Province, the message is getting heard. Each year there are improvements in the statistics relating to plow collisions and there are also fewer complaints about the practice of echelon plowing.

## 4 Benefits Realized

While one would expect that there would be substantial savings in fuel usage, the fact is that in order to utilize the Tow Plows in the hilly terrain of Western New Brunswick, firstly engine modifications and secondly, more powerful trucks were required. The end result was only minor fuel savings over the use of two less powerful standard plow trucks.

There are definite savings when the costs of vehicle maintenance are considered. When one considers that the Tow Plow has no engine, transmission or differential, and six (6) fewer tires than a standard plow truck, it is forecast that savings will begin to accrue. Presently, there is insufficient evidence to determine any actual savings, but there are other factors that enter into this determination. One factor is the severity of the past two winters. Western New Brunswick has endured winters with nearly twice the historical average precipitation in both years, and this has been a factor in the required maintenance to the plow trucks. The maintenance required for both standard trucks and those pulling the Tow Plows has increased significantly as the result of abnormal usage.

Cutting edges on standard front and side-mounted plows generally require changing at least twice per season. The cutting edges on the Tow Plows usually last for the entire winter season.

## 5 Opportunities for Improvement

Brun-Way has identified several opportunities for improvement in the use of the Tow Plows:

- a. Incentives are required to ensure that more Operators are interested in using the Tow Plow. The operation of the Tow Plow needs to be “user friendly”.
- b. Actual cost savings need to be identified. This may require the establishment of baseline fuel and maintenance costs using two standard plows versus the truck and Tow Plow.
- c. The visibility of the Tow Plow for the operator requires improvement so that the operator can see the Tow Plow in all conditions.
- d. Improvements to the hydraulic cylinders are planned for the 2009 – 2010 winter to ensure quicker response to the deployment of the plow in order to avoid hitting guiderail end treatments.
- e. Investigate methods to ensure that following vehicles stay behind the Tow Plow and do not enter into the zone behind the truck and beside the plow when it is deployed.
- f. On plow routes containing vertical alignments with more than 4 percent grade and in storm conditions with heavy, wet snow, more horsepower and torque is required in order to maintain an acceptable speed.

## 6 Conclusions

With the implementation of the Tow Plow, Brun-Way was able to augment the winter operations fleet with ten additional plows without adding ten additional operators. In doing so, Brun-way was also able to improve on the level of service each year of the implementation program. This happened despite the increasing storm frequency and intensity resulting from global warming (Figure 9).

Fuel savings were not as high as anticipated, as the calculations were based on less powerful trucks and lower snow accumulations. However, a minor improvement in fuel economy (dependant on the particular snow route) was realized. As the Tow Plow has no engine, transmission, differential and fewer tires, additional savings as compared to normal plow trucks were also realized. Despite the added stress of towing the trailer and the stress of two record-breaking snow seasons, Brun-Way has noticed only limited additional maintenance concerns with the trucks towing the trailers.

Overall, the addition of the Tow Plow to the winter snow and ice control complement has provided Brun-Way with the ability to maintain and improve the level of service on the Trans Canada Highway Project. The Tow Plow has enabled Brun-Way to survive two extreme winter seasons as well. The public communications efforts have resulted in general acceptance of the Tow Plow on the highways by the road users. Brun-Way operators have embraced the Tow Plow and to operate one has become a point of pride with staff.

## Figures

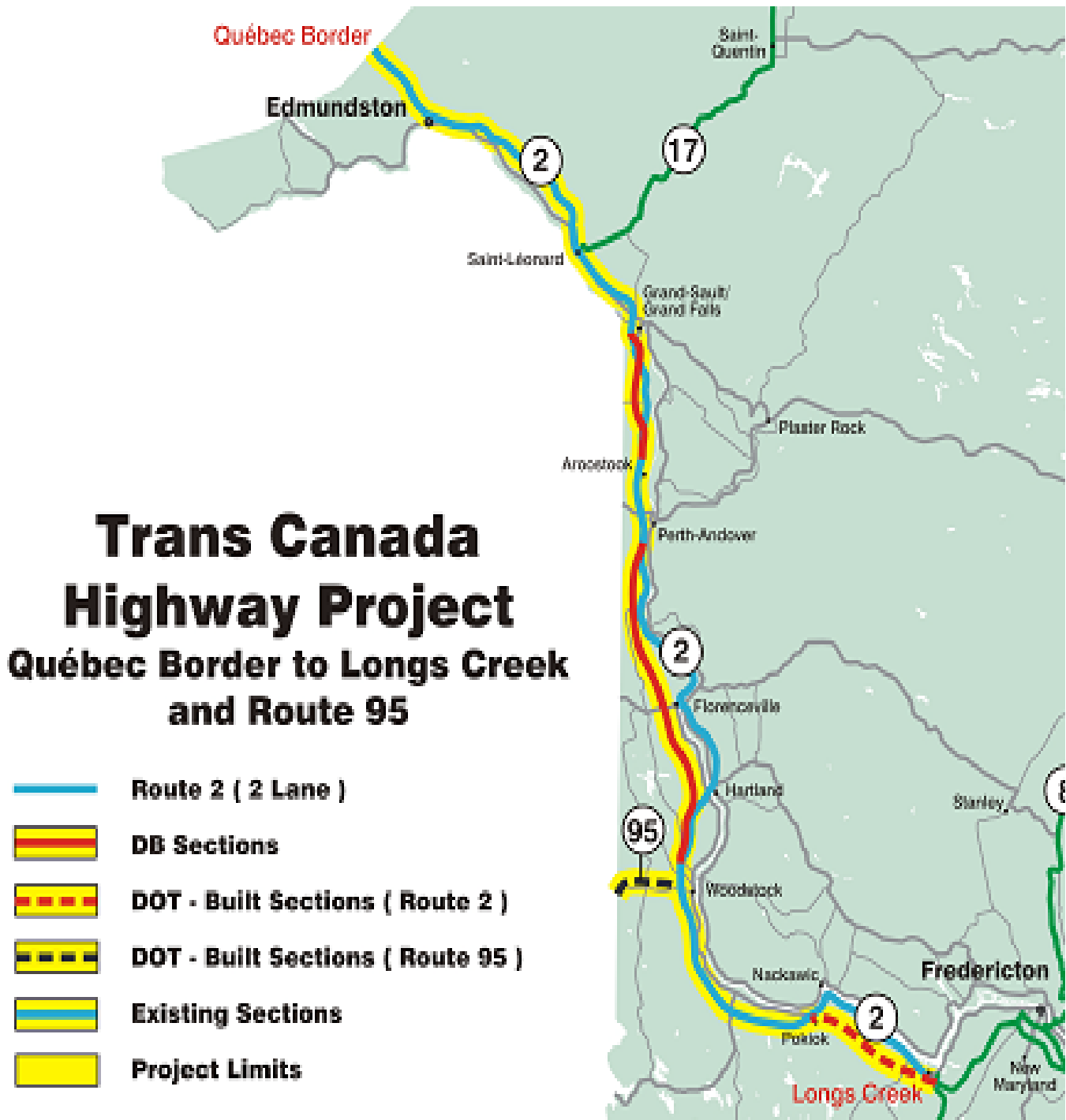


Figure 1 – Map of Trans Canada Highway Project



Figure 2 – Tow Plow



Figure 3 – Tow Plow in an Urban Setting



Figure 4 – Anti-Icing with Tow Plow



Figure 5 – Modifications including cycle fenders, chamfered bumper



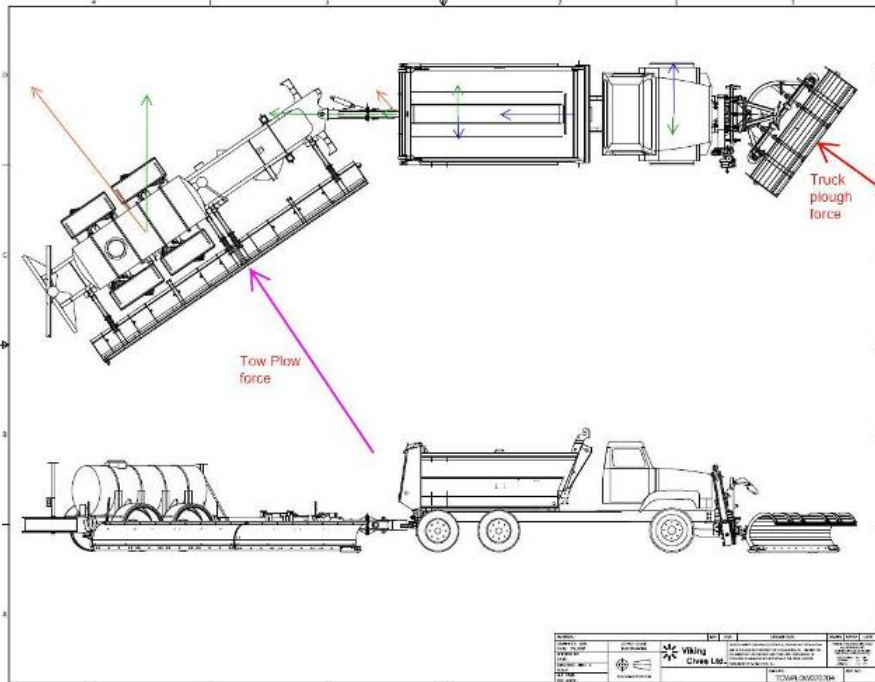


Figure 6 – Forces on Truck and Tow Plow

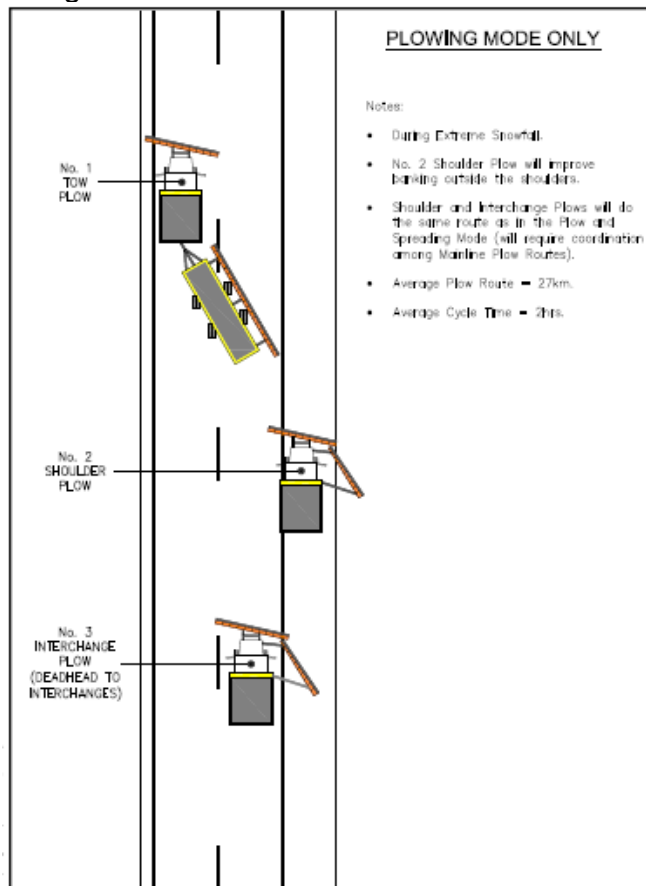


Figure 7 – Plow mode for severe storms



Figure 8 – Normal Echelon Plow Mode



Figure 9 – At work in heavy snow