Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R14E0081

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
FREIGHT TRAIN A41851-11
MILE 202.3, SLAVE LAKE SUBDIVISION
FAUST, ALBERTA
11 JUNE 2014

Canada

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Cat. No. TU3-6/14-0081E-PDF
ISBN 978-0-660-04027-1

This document is available on the website of the Transportation Safety Board of Canada at www.tsb.gc.ca

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Railway Investigation Report R14E0081

Main-track derailment
Canadian National
Freight train A41851-11
Mile 202.3, Slave Lake Subdivision
Faust, Alberta
11 June 2014

Summary

On 11 June 2014, at 1530 Mountain Daylight Time, eastbound Canadian National freight train A41851-11 derailed the last 20 cars at Mile 202.3 of the Slave Lake Subdivision in Faust, Alberta. The last 17 cars were residue tank cars that had last carried diesel fuel (UN 1202). There was no release of product and there were no injuries. Approximately 1200 feet of track was damaged.

Le présent rapport est également disponible en français.

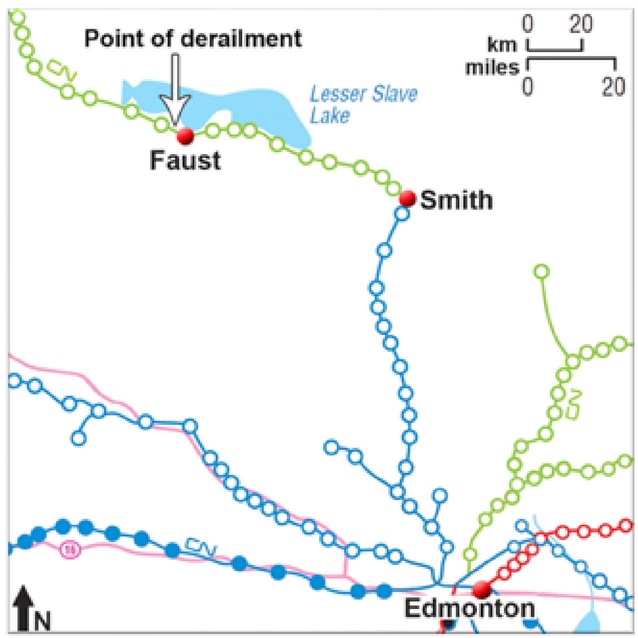
Factual information

The accident

On 11 June 2014, Canadian National (CN) conventional[1] freight train A41851-11 (the train) departed McLennan, Alberta, and was proceeding eastward, destined for Smith, Alberta. The train was made up of 4 locomotives, 1 of which was isolated,[2] and 126 cars (105 loaded cars, 4 empty cars, and 17 residue tank cars). Of the 105 loaded cars, 20 carried petroleum crude oil (UN 1267). The remaining loaded cars carried lumber, wheat, and rapeseed. The train weighed approximately 14 581 tons and was about 7945 feet long. The crew consisted of a locomotive engineer and a conductor. The crew members were qualified for their respective positions, familiar with the territory, and met fitness and rest standards.

The train was powered by two EMD SD40-2, six-axle, 3000 horsepower locomotives in the lead, neither of which was equipped with dynamic braking (DB),[3] and one EMD SD60, six-axle, 3800 horsepower locomotive equipped with extended range DB, capable of generating nearly 60 000 pounds of braking effort. The 3 lead locomotives were immediately followed by an isolated EMD SD40-2, six-axle, 3000 horsepower locomotive with extended range DB. As the lead locomotive was not equipped with DB, the train did not have access to DB for train control.

Figure 1. Map of the derailment location (Source: Railway Association of Canada, *Canadian Railway Atlas*, with TSB annotations)



1 “Conventional” refers to trains in which all locomotives are located at the head end of the train.

2 When a locomotive is isolated, the engine remains in idle and the locomotive does not develop tractive or dynamic braking effort.

3 “Dynamic braking” is a locomotive electrical braking system that converts the locomotive traction motors into generators to provide resistance against the rotation of the locomotive axles. Energy is produced in the form of electricity, which is dissipated as heat through the dynamic brake grids. This system can be used alone or in conjunction with the train air brake system.

At approximately 1530[4] while the train was travelling at 17 mph, at maximum throttle and approaching the town of Faust, Alberta (Figure 1), a train-initiated emergency brake application occurred. Subsequent inspection of the train determined that the last 20 cars (107 to 126) had derailed.

Weather

At the time of the occurrence, the weather was clear and the temperature was 17°C.

Site examination

At the west end of the derailment site, the track had buckled and shifted laterally to the north by up to 12 inches. The track buckle began approximately 200 feet east of the switch located at Mile 202.53 and extended eastward in an "S" shape (Photo 1 and Photo 2). Near the middle of the track buckle, there was a diagonal wheel flange mark on the head of the north rail, extending eastward from the gauge side. On the field side of the north rail, there were impact marks on the spikes, tie plates, and ties. There were corresponding impact marks on the ties on the gauge side of the south rail. The point of derailment was determined to be Mile 202.3.

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[4] All times are Mountain Daylight Time.

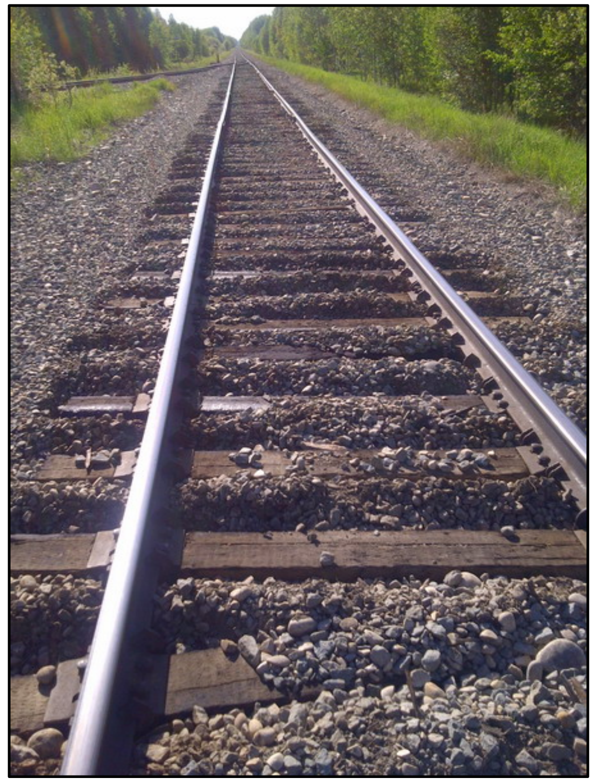
Photo 1. Eastward view showing the track buckle (north is to the left)

Photo 2. Westward view showing track shifted in the ballast, leaving gaps of up to 12 inches between the end of the tie and the ballast shoulder

Track damage consisting of broken tie ends and damaged fasteners extended for approximately 1200 feet. Leading up to the track buckle, rail anchors had moved away from the ties, and the ties were plowing and skewed in several locations (Photo 3).

All 20 cars derailed to the north side of the track. Cars 107 to 120 derailed upright, cars 121 and 122 were leaning, and the last 4 cars (123 to 126) were on their sides (Photo 4). Car 107 was a load of wood products. Cars 108 and 109 were empty hopper cars, and the remaining 17 derailed cars were residue tank cars (DOT 111A100W1) that had last carried diesel fuel (UN 1202).

Photo 3. Ties plowing and skewed west of the derailment site



Double-shelf couplers

The 17 derailed residue tank cars were each equipped with double-shelf couplers, as required by tank car specification (CGSB 43.147/TP14877). Double-shelf couplers are designed to restrict upward and downward movement, which minimizes the possibility of couplers disengaging when subjected to forces that can occur during train derailments. With the couplers engaged, it is less likely that a coupler will puncture another tank car. In this occurrence, the double-shelf couplers on the derailed tank cars generally functioned as designed, as all cars but one remained coupled together, and no tank heads were punctured.

Photo 4. Tank cars derailed on their sides

Although double-shelf couplers can be effective in preventing tank head punctures, they can also increase the number of cars that derail, particularly when empty (or residue) tank cars are involved. When the couplers remain interlocked during a derailment, high torsional forces can be transferred to a following tank car. An overturning car can thereby initiate the rollover of adjacent cars, increasing the severity of the derailment. While this sympathetic rollover phenomenon can occur for both loaded and empty tank cars, loaded tank cars are less likely to be affected. The weight of the loaded tank car will tend to counteract the torsional force transmitted through the double-shelf coupler. However, when the forces exceed the design specifications of the coupler, the coupler can disengage, or the coupler shank can fail.

Equipment inspection

The train had received a certified car inspection on 11 June 2014, before departure from McLennan. No defects were noted during the inspection. Prior to the derailment, the train had passed over a hot box detector at Mile 203.8 of the Slave Lake Subdivision. No alarms were reported.

Following the derailment, the derailed cars were inspected; no car components were found to have had a pre-derailment defect.

Subdivision and track information

The Slave Lake Subdivision is a secondary main line that extends from Smith (Mile 130.9) to McLennan (Mile 263.5). This subdivision, along with the Westlock Subdivision to the south, was part of the former Northern Alberta Railways, which operated a segment between Edmonton, Alberta, and Peace River, Alberta. Northern Alberta Railways was owned and operated jointly by CN and Canadian Pacific until it was purchased outright by CN in 1981. In 1996, the Slave Lake Subdivision was sold to a short line operator and became part of the Mackenzie Northern Railway. In 2006, CN reacquired the subdivision.

Train movements on the Slave Lake Subdivision are controlled by the occupancy control system as authorized by the *Canadian Rail Operating Rules*. Train movements are supervised by a rail traffic controller located in Edmonton. In the vicinity of the derailment site, the maximum freight train speed was 25 mph, making it a Class 2 track according to the Transport Canada (TC)-approved *Rules Respecting Track Safety* (TSR).[5] There was a 10 mph temporary slow order (TSO) at Mile 206.6.

Traffic on the Westlock and Slave Lake corridor

Rail traffic on the Westlock and Slave Lake corridor consisted of general merchandise, fuel, grain, drilling supplies, and oil field equipment. The volume of rail traffic (measured in million gross ton miles, MGTM) increased significantly between 2012 and 2014. For the Slave Lake Subdivision in the vicinity of the derailment site, rail traffic increased from about 5.5 MGTM in 2012 to about 9.0 MGTM in 2014 (Figure 2).

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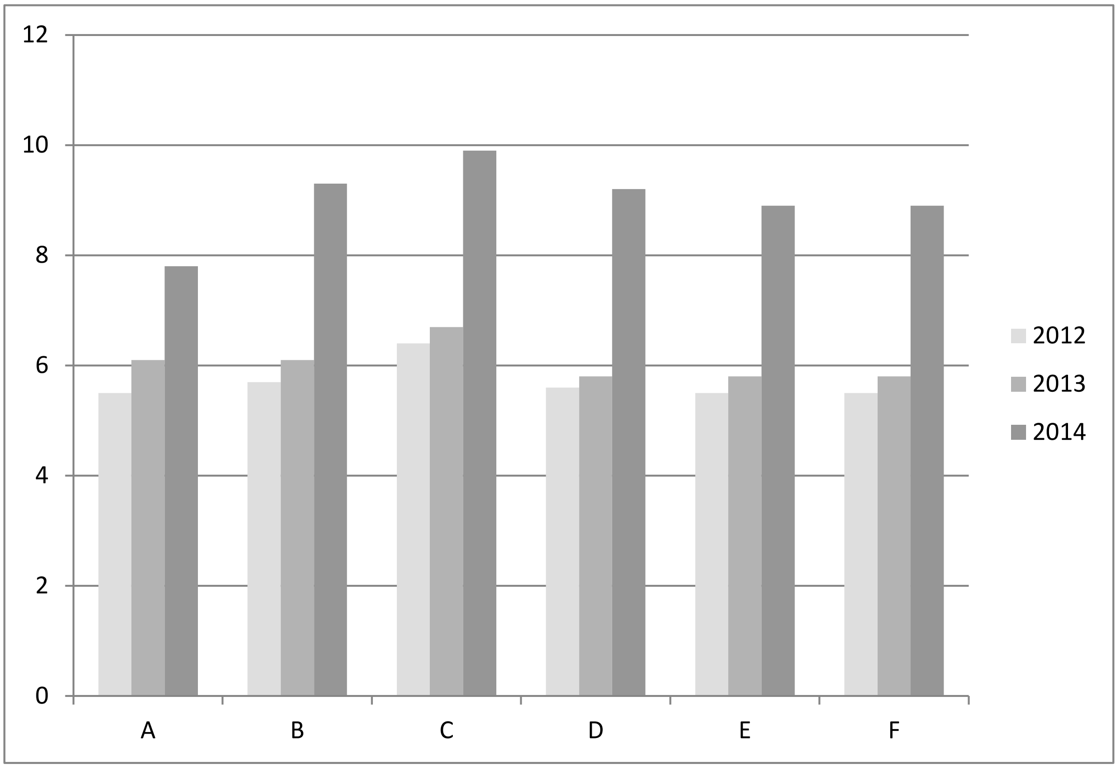
[5] The *Rules Respecting Track Safety* (TSR) prescribe minimum safety requirements for railway track that is part of the general railway system of transportation. Part II, Subpart A, establishes the maximum allowable operating speeds (in miles per hour) for various classes of track.

Figure 2. Traffic on the Slave Lake Subdivision, by line segment (in million gross ton miles)*



* Based on data from Canadian National

A Winagami – McLennan
B McLennan – High Prairie
C High Prairie – Faust
D Faust – Slave Lake
E Slave Lake – Mitsue
F Mitsue – Smith

Loaded dangerous goods (DG) tank cars accounted for the largest portion of the increased traffic on these lines, with crude oil shipments making up most of this increase. Table 1 shows the increase in annual shipments of loaded DG cars on the Westlock and Slave Lake subdivisions between 2010 and 2014.

Table 1. Loaded tank cars transporting dangerous goods on the Slave Lake and Westlock subdivisions (Source: data from Canadian National)

Year	Slave Lake	Westlock
2010	4 138	4 061
2011	6 224	6 224
2012	6 771	6 726
2013	10 259	10 259
2014	23 820	24 241

The volumes of other commodities, most notably grain, have increased as well. Annual grain shipments on these 2 subdivisions have more than doubled since 2010, from 3176 carloads in 2010 to 6600 in 2014.

Rail transportation of dangerous goods

Following the July 2013 railway accident in Lac-Mégantic, Quebec,[6] the TSB issued Recommendation R14-02 in January 2014, which addressed the need for the railways to do better planning before DG movements, as well as ongoing risk assessments during such movements. The Board recommended that

> The Department of Transport set stringent criteria for the operation of trains carrying dangerous goods, and require railway companies to conduct route planning and analysis as well as perform periodic risk assessments to ensure that risk control measures work.

As a result, on 23 April 2014, TC issued an emergency directive pursuant to section 33 of the *Railway Safety Act* (RSA), regarding Rail Transportation of Dangerous Goods.[7] (See Appendix A for full text of the directive.) This was re-issued on 23 November 2014, remaining in effect until 23 April 2015. On 23 April 2015, with no new approved rules for key trains and key routes, and in the interest of ensuring continued safety, TC issued a new emergency directive regarding the rail transportation of dangerous goods, which remained in effect until 17 August 2015, when it was renewed.[8]

The 23 April 2014 Emergency Directive, in part, ordered all railway companies to have key trains[9] hold the main track at meeting or passing points unless the siding track meets TC Class 2 requirements as per the TSR. Otherwise, the key train can operate on the siding at a speed not exceeding 15 mph. The directive also required railway companies to inspect any key route[10] main track on which a key train is operated. The directive further stipulated that, within 6 months from the date of the directive, the company had to complete a risk assessment to determine the level of risk associated with each key route over which a key train is operated taking a number of risk factors into account. The risk assessment also must identify and compare alternative routes for safety and security, and factor in potential or future railway operational changes.

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6 TSB Railway Investigation Report R13D0054.

7 Transport Canada, *Emergency Directive Pursuant to Section 33 of the* Railway Safety Act, *Rail Transportation of Dangerous Goods, 23 April 2014*.

8 Emergency directives can be issued for no more than 6 months.

9 For the purpose of the Emergency Directive, "key train" is defined as "an engine with cars … that includes 20 or more loaded tank cars or loaded intermodal portable tanks containing dangerous goods, as defined in the *Transportation of Dangerous Goods Act, 1992* …"

10 For the purpose of the Emergency Directive, "key route" is defined as "any track on which, over a period of one year, is carried 10,000 or more loaded tank cars or loaded intermodal portable tanks containing dangerous goods, as defined in the *Transportation of Dangerous Goods Act, 1992* …"

In 2013, the Slave Lake and Westlock subdivisions met the criteria established for a key route. In this occurrence, the train was transporting 20 loaded cars of petroleum crude oil (UN 1267), making it a key train. CN conducted a risk assessment as required by the emergency directive, which was submitted to TC on 26 November 2014, 3 days after the date specified in the original emergency directive. The Westlock and Slave Lake subdivisions were at the bottom of CN's list of key routes, based on the 2013 traffic levels, with approximately 10 259 DG loads. Priority was given to the key routes with the highest volumes of DG traffic. The risk assessment identified the track as low-speed territory, but did not specifically identify the condition of the main track as a risk factor. The risk assessment did indicate the railway's intention to recommend this corridor for increased capital investment to upgrade the track.

TSB Watchlist

TSB Watchlist 2014 – Transportation of flammable liquid by rail

The Watchlist is a list of issues posing the greatest risk to Canada's transportation system; the TSB publishes it to focus the attention of industry and regulators on the problems that need addressing today.

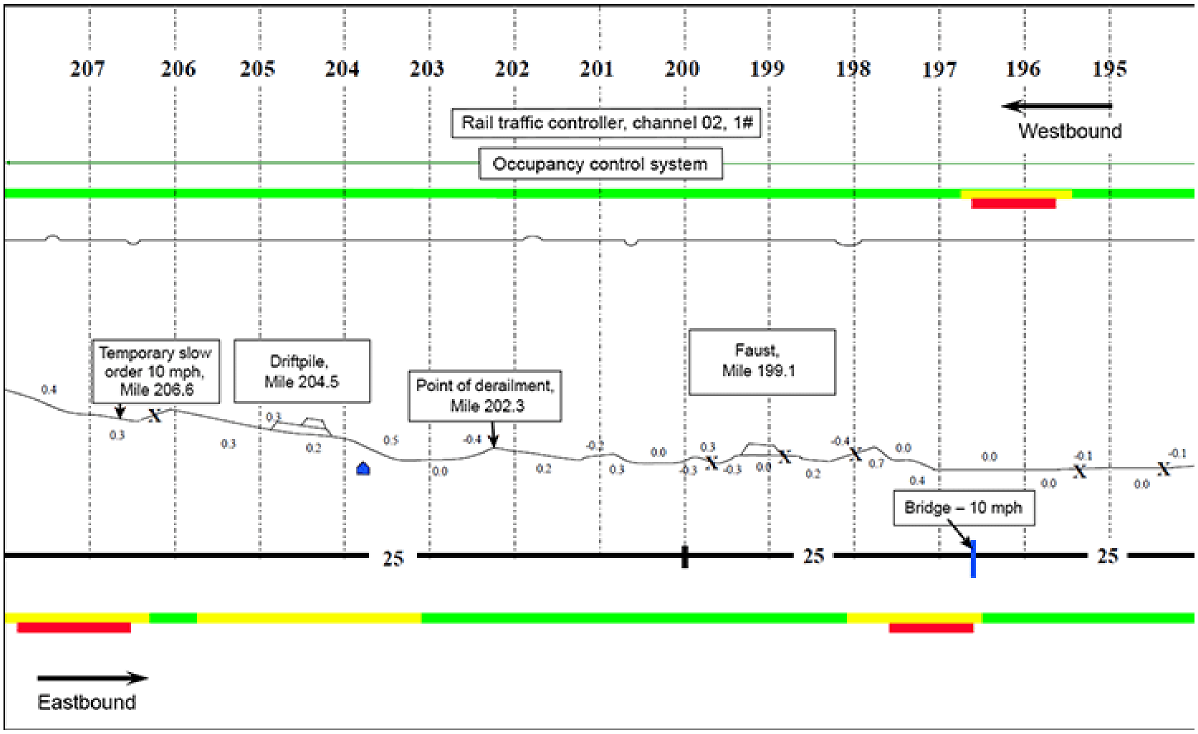
As this occurrence demonstrates, the increase in the transportation of flammable liquids—such as crude oil—by rail across North America has created emerging risks that need to be effectively mitigated.

The TSB has called on railway companies to conduct route planning and analysis, and perform risk assessments to ensure that risk-control measures are effective.

Particulars of the track

The track in the area of the derailment is tangent single main track, oriented east-west. In the direction of travel (west to east), between Mile 206.0 and 203.5, there is a descending grade varying between 0.2% and 0.5%. The track then levels off for about 1 mile (Mile 203.5 to Mile 202.5), and then transitions into a short ascending 0.4% grade (Figure 3).

Figure 3. Track profile (Source: Canadian National, with TSB annotations) (Note: Colour references, green for throttle manipulation, yellow for dynamic braking, and red for automatic brake are based on an optimum train run.)



In the vicinity of the derailment site, the rail was a mix of 100-pound and 115-pound continuous welded rail (CWR) and jointed rail manufactured by Sydney Steel Corporation (SYSCO) in the 1970s and 1980s. The rail was laid on 11-inch, double-shouldered tie plates, with 3 spikes per plate. Tie condition was fair. Some new ties with 14-inch double-shoulder tie plates and 4 spikes per plate had recently been installed to break up a number of defective tie clusters. The rail anchor pattern was irregular. Ballast was a mix of crushed gravel and pit run gravel, with some crushed stone on the surface. The cribs were full, and the shoulders were a minimum of 12 inches wide and were in fair condition (Photo 5). The subgrade in the vicinity of the derailment site is peat bog.[11]

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11 A peat bog subgrade consists of saturated, compressed organic material that may provide lower track stability than a more rigid subgrade, especially in summer months.

Photo 5. Ballast and rail anchoring conditions leading up to the derailment site

Track inspection and maintenance

Based on the TC-approved TSR, Class 2 track requires twice-weekly inspections. In this occurrence, a certified track inspector had visually inspected the track 15 times between 12 May and 10 June 2014, the day before the derailment. No defects were reported in the area of the derailment. However, further east, a cracked compromise joint bar (Mile 191.1) and a transverse rail defect (Mile 196.7) had been changed out following the 03 June track inspection.

The track had been inspected by a track geometry test vehicle 3 times in 2013 (19 July, 27 July and 29 October) and once in 2014 (16 May). Recurring priority wide gauge defects[12] had been detected in all 4 tests in the area of the derailment (Mile 201.4 to Mile 202.8). Priority wide gauge defects are difficult to repair with poor ties. In such circumstances, maintenance forces typically resort to plugging the defective ties which allows them to make temporary repairs to keep gauge. Permanent repairs cannot be made until a tie program replaces enough

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12 "Gauge" is defined as the distance, measured at right angles to the track, between points on the opposite insides of rails. Standard gauge is 56½ inches. A priority defect is a deviation exceeding CN-recommended maintenance tolerances. The condition must be monitored until it is repaired, to ensure it does not escalate to an urgent defect. For Class 2 to Class 5 track, the limit for a priority wide gauge defect is 57¼ inches.

defective ties so that proper gauging can be completed. There was a priority left profile defect[13] detected at Mile 203.1 on the 19 July test, which was repaired.

The rail was being tested monthly by a rail flaw detection vehicle. The most recent rail flaw detection test had been performed on 29 April 2014. During this test, a bolt hole defect[14] was detected at Mile 201.2. The rail was subsequently repaired.

CN capital investments to track are normally prioritized by the railway based on

- the availability of capital,
- traffic volumes (both historical and anticipated), and
- the condition of existing infrastructure.

Most of CN's annual capital expenditures are devoted to the principal main track corridors that handle the bulk of the traffic and generate most of the revenue. CN indicates that traffic volumes on secondary main track corridors are difficult to predict over the long term. Consequently, increases to capital expenditures to improve track on these corridors usually take place subsequent to increased traffic volumes.

Regulatory track inspections

In 2013, portions of the Slave Lake Subdivision had been inspected by TC including:

- Mile 235.01 to Mile 263.50 on 27 August,
- Mile 198.81 to Mile 235.03 on 28 August, and
- Mile 155.96 to Mile 199.58 on 23 October.

While no exceptions were identified in the vicinity of the derailment site during these inspections, ballast and surface defects and inadequate/displaced anchors were noted at 7 locations between Mile 162.3 and Mile 198.9.

In addition, between Mile 207.0 and Mile 266.0, TC inspections noted 7 locations where the deviation from zero cross level[15] on tangent track exceeded the thresholds specified by the TSR. Furthermore, there were 31 locations identified as a concern, where the deviations were approaching, but did not exceed, the thresholds. Similarly, the inspection report did not identify any location where the difference in cross level between 2 points less than 62 feet

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13 "Profile" (also called "surface") is the maximum positive or negative mid-ordinate of a 62-foot chord measured along the top surface of the rail. For Class 2 track, the limit for a priority surface defect is 1½ inches.

14 A bolt hole defect is one of the most common defects and is typically defined as a crack that originates from holes in the web of the rail.

15 Cross level is the difference in elevation between the 2 rails. On tangent track, there should be zero cross level between the 2 rails. In a curve, the difference in cross level will depend on the degree of curvature.

apart exceeded the thresholds identified by the TSR. Nonetheless, there were 8 locations identified as a concern, where the measurements were nearing, but did not exceed, the thresholds. TC issued letters of non-compliance to CN relating to these track defects on 04 September 2013 and on 08 November 2013.

The 04 September letter of non-compliance stated, in part:

> On August 27-28, 2013, a rail safety infrastructure compliance inspection was conducted on portions of the CN Smoky and Slave Lake Subdivisions by the undersigned inspector […] The inspection revealed Track Safety Rule non-compliance and other observations and concerns […]
>
> During the inspection there was evidence of very poor quality welding/grinding repair work. These poor and possibly improper welding repairs may lead to broken rails or turnout components that may jeopardize rail operations.

The 08 November letter of non-compliance stated, in part:

> On October 23, 2013, a rail safety infrastructure compliance inspection was conducted on portions of the CN Slave Lake Subdivision by the undersigned inspector […] The inspection revealed Track Safety Rule non-compliance and other observations and concerns […]

On 13 November 2013, CN reported to TC that it had taken remedial action for each of the defects noted in TC's letters of non-compliance. Anchors were added/replaced, some ties were changed, and track locations with cross-level defects were surfaced.[16]

Track buckles

A track buckle is a lateral shift of the track that occurs when longitudinal compressive stresses in the rail overcome the lateral resistance of the track structure. The potential for a track buckle increases when the longitudinal compressive stresses in the rail increase or when the lateral resistance of the track structure diminishes. Most track buckles occur on curves in CWR as a result of thermal expansion of the rail in hot weather. However, track buckles can also occur in tangent track and jointed rail when at least one of the following factors is present:

- high thermal compression stresses in the rail,
- weakened track structure,
- forces applied by a passing train, or
- poor track geometry.

[16] Track maintenance activities, such as tamping, that eliminate cross-level variations in track.

According to CN's Engineering Track Standards, tight track, rail creep, insufficient anchors, and alignment deviations constitute an increased likelihood of track buckling. The standards further indicate that special attention should be paid to areas at the bottom of a grade, where heavy train braking occurs and where the rail is running.[17]

CN's Engineering Track Standards provide detailed information on the installation and maintenance of CWR, including the steps required to prevent track buckling.

Continuous welded rail

Ideally, CWR is installed at the "preferred rail-laying temperature." When installed at this neutral temperature, the rail is free of any tensile or compressive stress. Whenever the CWR exceeds the neutral temperature, longitudinal compressive forces develop, and these increase as the temperature differential increases. Extremely high or low ambient air temperatures, mechanized track maintenance activities, and traffic-induced movements of the rail can cause a change or redistribution of the rail's internal stresses, which in turn will modify the neutral temperature. In general, the rail neutral temperature decreases over time.

Joint-free CWR depends on having sound ties, sufficient anchors,[18] and clean, crushed rock ballast to restrain it longitudinally and laterally. If any of these components is not contributing the expected resistance, the potential for a track buckle increases. For CWR track, knowledge of the neutral temperature of the rail is critical to properly managing the risks of buckling.

CN has developed a wireless rail neutral temperature measurement system that uses a strain sensor mounted on the web of the rail. There was no record of rail neutral temperature monitoring or rail destressing having been conducted in the vicinity of the derailment site.

Rail anchors

CN Engineering Track Standards TS 3.1 - 14 states that:

> In CWR track, rail anchors will be installed in a box pattern on every other tie except:
>
> a. At permanent joints within CWR (joints that will not be welded), then every tie will be box anchored for a minimum distance of 200′ in each direction from the joint.
>
> b. When jointed rail abuts CWR, a minimum of 200′ of rail on either side immediately adjacent to the joint will have every tie boxed [*sic*] anchored.

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17 "Running" is an industry term for longitudinal rail movement, or creep.

18 Part II, Subpart D (VII) of the *Rules Respecting Track Safety* (TSR) states that "a sufficient number of anchoring devices will be applied to provide adequate longitudinal restraint" of the rail.

> c. At turnouts, non-glued insulated joints and crossing frogs, every tie will be box anchored for a minimum distance of 200′ each way from the turnout or joint.

Between Mile 200 and Mile 205 (i.e., a distance of 5 miles), there were about 200 joints, most of which were permanent. For comparison purposes, 5 miles of newly installed CWR would be expected to have only a few joints. A large number of track joints in a section of CWR indicates that track has not been maintained to a level required to take full advantage of the benefits of CWR, such as track being less susceptible to surface defects, a smoother ride, lower maintenance costs, and higher operating speeds.

Canadian National Locomotive Engineer Operating Manual

The CN *Locomotive Engineer Operating Manual*, Form 8960, Section G, Train Handling, specifies, in part:

Section G1.2, Policy, provides a summary of the best practices for train handling, as follows:

> (i) Use forward planning for planned stops and speed control.
>
> (ii) Make only incremental/gradual throttle and brake adjustments.
>
> (iii) Control speed using throttle manipulation to the greatest extent possible.
>
> (iv) Select and adjust the throttle, dynamic brake, and air brake in a manner which minimizes in-train and track-train forces.
>
> (v) Allow slack to gradually adjust within the train before increasing throttle, dynamic brake, or air brake applications.

Section G2.12, Use of Dynamic Brake, indicates that although DB is an excellent method of speed control, it is capable of generating high in-train and track-train forces, and that because DB concentrates the retarding force at the head-end of the train, there are limits to the amount of braking which should be applied using DB. It also indicates that “To avoid excessive force, it may be necessary to use a combination of DB and automatic brake, and/or to implement speed control tactics further in advance”, and that “For any given DB handle position, maximum retarding forces occur in the 5 to 30 MPH speed range. Extra care must be exercised in this speed range.” It further states that adjustments of the DB handle are to be made in a smooth and steady manner.

Section G2.13, Dynamic Brake Limitations, indicates that

> locomotives can develop very high levels of DB retarding forces capable of damaging the track structure and/or generating excessive buff forces in the train. Either situation can lead to a derailment and therefore, the use of DB must be limited. To respect these limitations, the locomotive engineer must

employ speed control strategies farther in advance, and/or use a combination of DB and automatic brake.

Section G2.13 (1) restricts a head-end locomotive consist to 18 axles with operative DB. In comparison, when operating one or more alternating current (AC) locomotives, the number of operative DB axles in the consist must not exceed 12 axles. High horsepower (4400) AC locomotives are capable of generating up to 98 000 pounds of DB braking effort per locomotive.

The track gradient for eastward trains is predominantly descending from Mile 208.5 to the point of derailment at Mile 202.3, a distance of about 7 miles. DB is known to be a useful method of train control on long descending grades. The railway's Best Practices Train Handling Guide for the Slave Lake Subdivision indicates that the use of DB is the preferred method of control on this grade. The occurrence train did not have operative DB available. Nonetheless, the use of DB for eastward trains through this portion of the Slave Lake Subdivision had been common practice.

Train handling in the vicinity of the derailment site

A review of the locomotive event recorder information obtained from one of the trailing locomotives determined that:

- Train speed was gradually brought down to the required 10 mph by the time the train was at the temporary slow order (TSO) (Mile 206.6).
- Shortly after the train cleared the TSO, and the entire train was on the descending grade through Driftpile (Mile 206.6 to 203.5), the throttle was applied.
- When train speed reached about 25 mph, the throttle was placed in idle. The train accelerated up to about 30 mph (5 mph above track speed) before a minimum train brake application was made.
- The brake application made to control the train's speed on the descending grade reduced the train's speed to 20 mph. The descending tail end of the train was pushing the head end up the short ascending grade from Mile 202.5 to the point of derailment at Mile 202.3.
- The brakes were released and throttle was again applied to pull the train over the undulating territory. As more of the train traversed the undulating territory, speed continued to decrease.
- While the train was travelling at about 17 mph at maximum throttle, a train-initiated emergency brake application occurred, bringing the train to a stop.

Other occurrences on the Slave Lake and Westlock subdivisions

From 2010 to 2013, there were 2 derailments on the Slave Lake and Westlock subdivisions. During the spring and summer of 2014, there were 5 other main track derailments on CN's Slave Lake and Westlock subdivisions:

R14E0064: On 08 May 2014, CN conventional freight train A41851-08 derailed 9 cars at Mile 162.5 of the Slave Lake Subdivision within the Town of Slave Lake, Alberta. The conventional train consisted of 3 locomotives, 108 loaded cars, 9 empty cars, and 5 residue tank cars. It weighed 14 489 tons and was 7247 feet long. The railway indicated that the derailment resulted from a broken joint bar. There were no dangerous goods released and no injuries.

R14E0082: On 12 June 2014, CN freight train L41851-12 derailed 4 cars at Mile 202.2 of the Slave Lake Subdivision. The conventional train consisted of 2 locomotives, 111 loaded cars, and 5 residue tank cars. It weighed 14 562 tons and was 6808 feet long. This was the first train travelling over the restored track at Faust after the 11 June derailment. The railway indicated that the train derailed due to ties failing to hold gauge under load, resulting in wide gauge. There were no dangerous goods released and no injuries.

R14E0099: On 27 June 2014, CN freight train A41851-27 derailed 10 cars at Mile 108.9 of the Westlock Subdivision. The conventional train consisted of 3 locomotives, 106 loaded cars, 5 empty cars, and 13 residue tank cars. It weighed 14 060 tons and was 7602 feet long. The railway determined that the derailment resulted from a broken rail. There were no dangerous goods released and no injuries.

R14E0130: On 31 August 2014, CN freight train A42051-30 derailed 15 cars at Mile 118.0 of the Westlock Subdivision. The conventional train consisted of 3 locomotives, 112 loaded cars, and 1 empty car. It weighed 14 302 tons and was 6656 feet long. The railway determined that the derailment resulted from rail and joint bar defects. There were no dangerous goods released and no injuries.

R14E0136: On 16 September 2014, CN freight train L41951-16 derailed 4 locomotives and 26 cars at Mile 156.26 of the Slave Lake Subdivision. The conventional train consisted of 4 locomotives, 17 loaded cars, 35 empty cars, and 103 residue tank cars. It weighed 7287 tons and was 9869 feet long. The railway determined that the derailment resulted from a broken joint bar. There were no dangerous goods released and no injuries.

Analysis

No defects on the locomotive or cars were identified. The analysis will focus on train operations, track maintenance, and the condition of the track on the Slave Lake Subdivision.

The accident

The derailment occurred when the track shifted laterally under the passing train. The loaded cars were able to negotiate the track buckle without derailing, but the lighter empty cars and residue cars were not. There was a gentle descending grade for almost 7 miles through Driftpile, followed by a short ascending grade from Mile 206.5 to Mile 206.1. Normal train-handling practices for eastbound trains through this area would include the use of dynamic braking (DB), throttle, and train brake. While DB is an effective tool for controlling train speed on grades and for fuel conservation, its use is known to build a wave of longitudinal force in the track structure. DB effort is concentrated at the locomotives, particularly in conventionally powered trains. The occurrence train did not have access to DB. However, normal train-handling practice through this location included DB, which other trains would have likely used. Therefore, the track structure in the vicinity of the derailment site would have been repeatedly exposed to longitudinal forces generated during DB use.

Track conditions

Continuous welded rail (CWR) stability depends on rail anchors, rail fasteners, tie plates, ties, and ballast all restraining the rail from moving longitudinally and laterally. If one or more of these components is not providing the expected resistance to rail compressive forces, the risk of a track buckle increases. Although CWR had been installed in the area of the derailment site, over time the track evolved into a mix of CWR and jointed rail. Considering the number of joints, the irregular rail anchoring pattern, and the relatively unstable peat bog subgrade, the track was not maintained to the sufficiently high standard required of CWR.

High compressive stress had likely accumulated in the track structure as a result of repeated exposure to longitudinal forces from previous trains that had used DB at this location. The forces exerted on the track structure by trains, and the resulting compressive forces, could not be contained by the track structure, causing the track to shift out of alignment. The track buckled as a result of the irregular rail anchoring pattern, a build-up of compressive stress in the rail, and a relatively unstable peat bog subgrade, which was unable to restrain the longitudinal forces generated by trains descending the grade.

Minor speed variances above maximum allowable speed

In this occurrence, the train exceeded the maximum speed (25 mph) by as much as 5 mph prior to the derailment, although at the time of the derailment, the speed was at the maximum. Maximum operating speeds are established, in part, to match the capacity of the track structure, while ensuring that trains are moved expeditiously and safely. A temporary slow order may be applied when a track anomaly emerges that makes train operations at normal speed unsafe. Although it is not desirable to exceed the maximum operating speed, such events can happen when forward planning is inadequate and/or complex. In circumstances where gradual adjustments (i.e., throttle or train brake) are used to bring a train's speed back under control, minor speed variances above the maximum track speed are unlikely to cause damage to the track or precipitate a derailment. Immediately preceding this occurrence, the minor speed variance above the maximum track speed did not likely cause damage to the track or precipitate the derailment.

Other occurrences

Since 2013, there had been a significant increase in traffic levels over the Westlock and Slave Lake subdivisions. During the spring and summer of 2014, there were 6 derailments in the area, including this occurrence, all of which involved track-related failures. These caused concern for the local communities, particularly those living on the shore of Lesser Slave Lake. The Slave Lake Subdivision runs along the south shore of the lake for approximately 50 miles. The lake is an important water and recreation resource for the area.

The condition of the track could not handle the traffic levels that had increased significantly on this corridor since 2013, in advance of the recommended infrastructure improvements. If the impact of increased traffic levels on track infrastructure is not adequately assessed or mitigated, the risk of derailments will increase.

Rail transportation of dangerous goods

The Westlock and Slave Lake subdivisions met the criteria to be designated as a "key route" as per Transport Canada's Emergency Directive on Rail Transportation of Dangerous Goods. In addition, the occurrence train was handling a sufficient number of cars loaded with dangerous goods to be designated a "key train" under the same directive. The emergency directive established the requirement for comprehensive risk assessments, and it placed speed and other operating restrictions on key trains, but it did not require an appraisal of the track infrastructure or specify further track safety requirements beyond those in the current *Rules Respecting Track Safety*. These rules define track safety requirements based on train speed, and not on the commodity being transported.

Limitations to controlling in-train forces

Given the length (7945 feet) and weight (14 581 tons) of the train, the absence of functioning dynamic braking on the lead locomotive, and the absence of distributed power configuration, a combination of throttle modulation and train brake was used effectively by the crew to minimize in-train forces to the extent possible.

Findings

Findings as to causes and contributing factors

1. The derailment occurred when the track shifted laterally under the passing train.

2. The track buckled as a result of the irregular rail anchoring pattern, a build-up of compressive stress in the rail, and a relatively unstable peat bog subgrade, which was unable to restrain the longitudinal forces generated by the train descending the grade.

3. High compressive stress had likely accumulated in the track structure as a result of repeated exposure to longitudinal forces from previous trains that had used dynamic braking at this location.

4. The condition of the track could not handle the traffic levels that had increased significantly on this corridor since 2013, in advance of the recommended infrastructure improvements.

Findings as to risk

1. If the impact of increased traffic levels on track infrastructure is not adequately assessed or mitigated, the risk of derailments will increase.

Other findings

1. Given the length (7945 feet) and weight (14 581 tons) of the train, the absence of functioning dynamic braking, and the absence of distributed power configuration, a combination of throttle modulation and train brake was used effectively by the crew to minimize in-train forces to the extent possible.

2. Immediately preceding this occurrence, the minor speed variance above the maximum track speed did not likely cause damage to the track or precipitate the derailment.

Safety action

Safety action taken

On 19 September 2014, the Transportation Safety Board of Canada (TSB) issued Rail Safety Advisory 617-13/14 indicating that there may be track infrastructure and/or operational issues (e.g., train design, train handling) on the Westlock and Slave Lake subdivisions, given the significant increase in rail traffic (including an increase in the shipment of petroleum products).

On 19 September 2014, Transport Canada (TC) issued a Letter of Safety Concern to Canadian National (CN) stating that the high frequency of incidents in 2014 had highlighted a potential risk to the safety of railway operations on the Westlock and Slave Lake subdivisions. CN was asked to identify the cause of the incidents and to implement mitigation measures to address safety concerns.

Upon receiving CN's letter of response of 07 October 2014, TC asked CN to

- provide a copy of the risk assessment and mitigation proposed to address risks associated with the significant increase in train tonnage/traffic and in accordance with the Emergency Directive issued on 23 April 2014;
- evaluate the track, document the locations where longitudinal movement of track or track displacement was observed, and apply speed restrictions to reduce the stress state of the infrastructure, and protect the safety of operations until track strengthening mitigation is completed;
- monitor the use of dynamic braking to ensure that employees are operating in accordance with *Locomotive Engineer Operating Manual*, Form 8960, Section 02.13 (2), Dynamic Brake Limitations; and
- forward results of track geometry, rail flaw, and broken joint bars discovered by machine testing, and summaries of broken rail and broken joint bar service failures, for ongoing compliance monitoring.

A risk assessment for the Edmonton, Alberta–Hay River, Northwest Territories Corridor, which includes the Slave Lake Subdivision, was conducted in response to the TC Emergency Directive on the Rail Transportation of Dangerous Goods issued 23 April 2014. CN also conducted a focused risk assessment specifically to address the increase in traffic on this corridor (dated 04 November 2014). This assessment looked at the risks associated with track infrastructure, including broken rail, broken joint bars, geometry defects, ballast issues, and ground hazards. Mitigation approaches for each item were identified. On 28 November 2014, CN submitted both of these risk assessments to TC.

On 28 November 2014, CN issued General Notice DST–019, reinforcing existing dynamic braking restrictions to prevent track damage to secondary main lines.

For the 2015/2016 track maintenance season, CN increased the number of ultrasonic and geometry tests on the Westlock and Slave Lake subdivisions. Surfacing, rail relay, and other track-renewal programs have been planned for 2015/2016.

CN has added 2 new hot box detectors to the Slave Lake Subdivision, at Mile 236 and Mile 258.5, and an update to CN's Best Practices Train Handling Guide–Slave Lake Subdivision was published in November 2014 to show the location of the new equipment.

On 17 August 2015, when TC renewed the Emergency Directive on key trains and key routes, railway companies operating key trains were ordered, within 30 days of receipt of the Emergency Directive, to file with the Minister of Transport all measures that had been put in place or that were being used to ensure track was compliant with the *Rules Respecting Track Safety*, including those measures that ensured that maintenance practices were being followed.

Also on 17 August 2015, TC issued Ministerial Order MO 15-06, requiring "all railway companies and local railway companies listed in Appendix A […] to formulate rules respecting the safe and secure operations of trains carrying certain dangerous goods and flammable liquids."

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 10 November 2015. It was officially released on 22 December 2015.

Visit the Transportation Safety Board's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendices

Appendix A – Transport Canada, Emergency Directive (Rail Transportation of Dangerous Goods), dated 23 April 2014

Emergency Directive Pursuant to Section 33 of the Railway Safety Act *Rail Transportation of Dangerous Goods*

To: All Railway Companies and Local Railway Companies

Section 33 of the Railway Safety Act (RSA) gives the Minister of Transport the authority to issue an Emergency Directive to any company when the Minister is of the opinion that there is an immediate threat to safe railway operations or the security of railway transportation.

The July 2013 accident in Lac-Mégantic and recent rail incidents in Canada and the United States (US) have demonstrated that when accidents involving the transportation of dangerous goods occur, there is significant risk for loss of life and damage to communities and the environment.

Although these rail occurrences are under investigation and, for this reason, their exact causes remain unknown at this time, I remain confident in the strength of the regulatory regime applicable to railway transportation in Canada. However, I am of the opinion that, in the interest of ensuring the continued safety and security of railway transportation, there is an immediate need for railways to improve their operating practices for the safe and secure transportation of dangerous goods.

Pursuant to section 33 of the RSA, all companies are hereby ordered to:

1. Not operate a Key Train at a speed that exceeds 50 miles per hour (MPH).

2. Have Key Train hold the main track at meeting or passing points unless the siding track meets Transport Canada Class 2 requirements as per the *Rules Respecting Track Safety*. In situations where the siding does not meet Transport Canada Class 2 requirement as per the *Rules Respecting Track Safety,* the Key Train may operate on the siding at a speed not exceeding 15 MPH instead of holding the main track when it is operationally infeasible or the non-Key Train is a passenger train.

3. Not operate a Key Train with any cars not equipped with roller bearings.

4. Perform an inspection of any bearing on a Key Train reported defective by a Wayside Defective Bearing Detector. If any such inspection confirms that a bearing on a car of a Key Train is defective, companies are to set off that car from the Key Train or must only operate the Key Train at a safe speed not exceeding 15 MPH until the car with the defective bearing is set off. If the inspection performed on a bearing of a car of a Key Train reported by a Wayside Defective Bearing

Detector fails to confirm a defect in a bearing, companies must not operate the Key train at a speed exceeding 30 MPH until the next Wayside Defective Bearing Detector. If a defect in a bearing of the same car of a Key Train is reported by two consecutive Wayside Defective Bearing Detectors, companies must set off that car from the Key Train or must only operate the Key Train at a safe speed not exceeding 15 MPH until the car with the defective bearing is set off.

5. Before the expiration of this emergency directive, inspect any Key Route main track on which a Key Train is operated using a heavy track geometry vehicle and rail flaw detector. In situations where a heavy track geometry vehicle is unavailable, companies must, before the expiration of this emergency directive, inspect any Key Route main track on which a Key Train is operated at least once with a rail flaw detector and at least twice, with no more than 100 days between inspections, with light track geometry vehicle.

6. Limit, where reasonable, speed to 4 MPH when coupling loaded tank cars of dangerous goods.

7. Complete within six months from the date of this emergency directive, a risk assessment that will determine the level of risk associated with each Key Route over which a Key Train is operated by the company. The risk assessment must:
   - Identify safety and security risks associated with that route, including the volume of goods moved on that route, the class of track on that route, the maintenance schedule of the track on that route, the curvature of the track on that route, the environmentally sensitive or significant areas along that route, the population density along that route, emergency response capability along that route and the areas of high consequence along the route;
   - Identify and compare alternative routes for safety and security; and
   - Factor potential or future railway operational changes such as new customers moving good[s] subject to an Emergency Response Assistance Plan under the *Transportation of Dangerous Goods Act* or municipal changes due to population growth, for routing restrictions.

For the purpose of this Emergency Directive,

"Key Train" means an engine with cars

a) that includes one or more loaded tank cars of dangerous goods that are included in Class 2.3, Toxic Gases and of dangerous goods that are toxic by inhalation subject to Special Provision 23 of the *Transport of Dangerous Goods Regulations;* or
b) that includes 20 or more loaded tank cars or loaded intermodal portable tanks containing dangerous goods, as defined in the *Transportation of Dangerous Goods Act, 1992* or any combination thereof that includes 20 or more loaded tank cars and loaded intermodal portable tanks.

“Key Route” means any track on which, over a period of one year, is carried 10,000 or more loaded tank cars or loaded intermodal portable tanks containing dangerous goods, as defined in the *Transportation of Dangerous Goods Act, 1992* or any combination thereof that includes 10,000 or more loaded tank cars and loaded intermodal portable tanks.

Pursuant to section 33 of the RSA, this emergency directive takes effect immediately and is to remain in effect until 2359 EST on October 23, 2014.