Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT R15V0191

Grade crossing collision

Canadian National Railway Company
Langley, British Columbia
11 September 2015

Canada

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Summary

On 11 September 2015, at approximately 1120 Pacific Daylight Time, Canadian National Railway train Q10251-11, travelling northward on the Canadian Pacific Railway Page Subdivision, collided with an ambulance at the Crush Crescent–Glover Road crossing (Mile 18.81) in Langley, British Columbia. The paramedic in the patient compartment and the patient suffered injuries and were airlifted to hospital. The driver was transported to hospital, treated, and released. The patient later died of injuries sustained in the accident.

Le présent rapport est également disponible en français.

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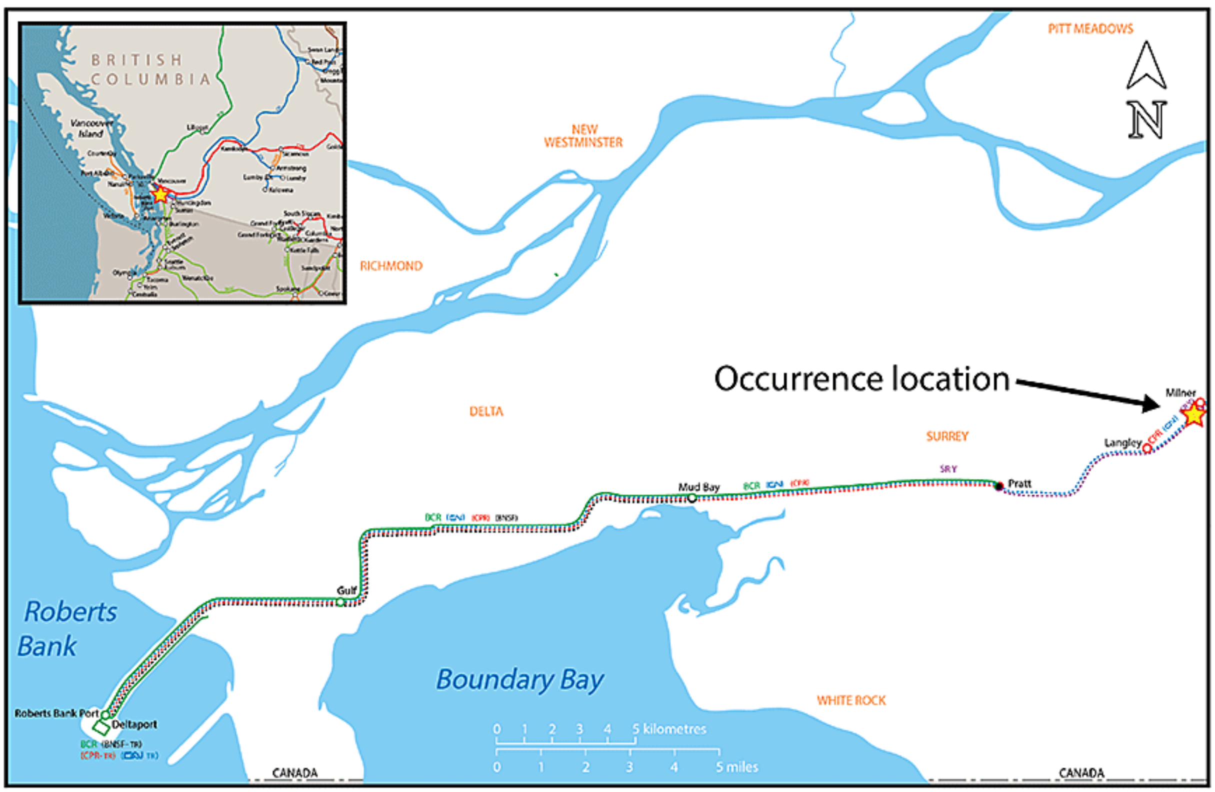
1.0 Factual information

1.1 The accident

On 11 September 2015, the ambulance crew of British Columbia Ambulance Service (BCAS) ambulance No. 62769 began its shift at 1000.[1] Shortly before the crew came on shift, a non-emergent[2] call had been received, requiring the transfer of a patient from a Langley, British Columbia, long-term care facility to the Abbotsford Regional Hospital in Abbotsford, British Columbia. When the ambulance arrived at the long-term care facility, the patient was loaded into the patient compartment of the vehicle. One of the paramedics remained in the patient compartment with the patient.

The chosen route to Abbotsford included traversing the grade crossing at the intersection of Crush Crescent and Glover Road (Figure 1). The ambulance driver had limited experience with this route.

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



At about 1120, the ambulance was travelling eastward on Crush Crescent, intending to turn left (north) at the Glover Road intersection. The left-turn traffic signal was green. The ambulance was proceeding slowly toward the crossing.

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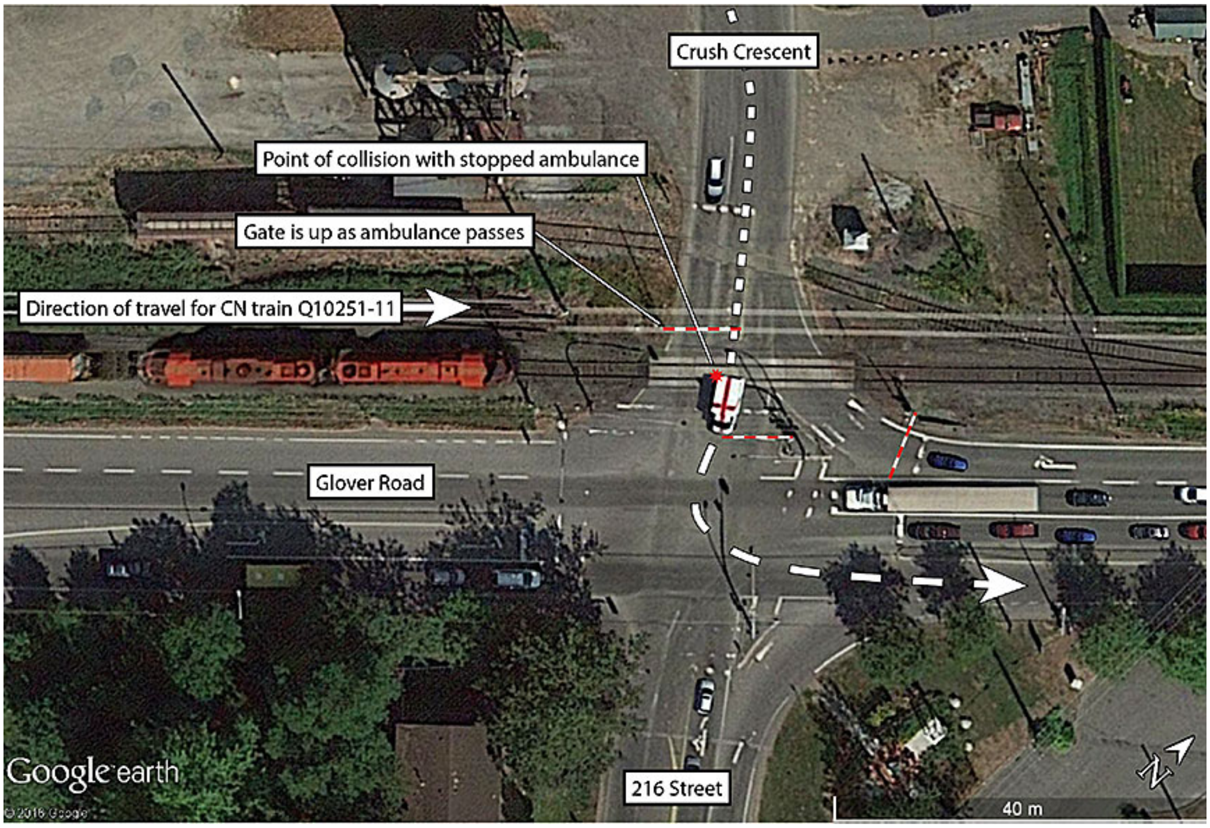
1 All times are Pacific Daylight Time (Coordinated Universal Time minus 7 hours).

2 A non-emergent call refers to a non-emergency situation that does not require emergency care.

During the approach to the crossing, the grade crossing warning system (GCWS) activated. The crossing bell was ringing, the flashing lights were activated, and the gates were descending. The ambulance stopped, but was on the track. Shortly after, with the gates fully descended for the train's arrival, the ambulance was moved forward to a position between the south rail of the main track and the crossing gate for the opposing traffic (westbound vehicles). However, even at this location, the ambulance was foul of the main track (Figure 2).

Figure 2. Occurrence site showing the location of the train and the ambulance prior to the collision (Source: Google Earth, with images of train and ambulance, as well as annotations, added by TSB)



On 11 September 2015, at about 0928, Canadian National Railway Company (CN) train Q10251-11 departed from Roberts Bank in Delta, British Columbia, on the Port Subdivision and proceeded eastward.[3] At Pratt, the train continued onto Canadian Pacific Railway's (CP's) Page Subdivision. At about 1120:05, while approaching the crossing at Mile 18.81, the train crew observed an ambulance proceeding onto and occupying the crossing.

At 1120:09, with the train about ¼ mile from the crossing, the locomotive horn was sounded, as required by *Canadian Rail Operating Rules* (CROR) Rule 14(l), which states (in part):

> (l) ____ ____ o ____ [2 long blasts, 1 short blast, 1 long blast]
>
> - (i) (#) At public crossings at grade:

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[3] All directions are true geographical directions and may not be consistent with railway timetable directions.

> A whistle post will be located 1/4 mile before each public crossing where required. Whistle signal must be sounded by movements:
>
> - exceeding 44 MPH, at the whistle post
> - operating at 44 MPH or less, in order to provide 20 seconds warning prior to entering the crossing.
>
> Whistle signal must be prolonged or repeated until the crossing is fully occupied.

The ambulance was observed to move slightly forward twice in an attempt to clear the crossing. Recognizing that the ambulance was still foul of the track, the train brakes were placed into emergency (i.e., maximum brake application) approximately 2 seconds before the train made contact with the ambulance. Table 1 provides further details of the events for this occurrence, including crew actions.

Table 1. Sequence of events and train crew actions*

Time	Event / Train crew actions
1120:05	Travelling at 34 mph, the train was about 1520 feet from the crossing. The ambulance first came into view and was observed proceeding slowly onto the crossing.
1120:09	The lead locomotive passed the whistle post for the crossing located about 1320 feet south of the crossing. The sounding of the whistle signal was initiated with the locomotive horn. The ambulance was stopped, fully occupying the crossing.
1120:13	At about 1120 feet from the crossing, the locomotive horn was sounded continuously.
1120:22	After having been stopped on the crossing for about 13 seconds (from 1120:09 to 1120:22), the ambulance moved forward slightly, in an attempt to clear the crossing.
1120:28	The ambulance was moved forward slightly a second time, until the rear of the ambulance was in line with the south rail of the main track and still foul of the crossing.
1120:33	About 100 feet from the crossing, travelling at 34 mph, the train brakes were placed into emergency.
1120:35	The train collided with the ambulance while travelling at 34 mph. The train contacted the rear of the ambulance. The resultant force spun the ambulance 180 degrees, with the train further contacting the front end of the ambulance.
1121:14	The train came to a stop approximately 1135 feet past the crossing.

* Times and events specified are correlated to the locomotive event recorder and the forward-facing video from the lead locomotive on the train.

As a result of the collision, the paramedic and the patient in the rear of the ambulance sustained injuries, requiring them to be transported by air ambulance to the hospital. The patient later died of the injuries sustained in the accident. The ambulance driver[4] was transported to hospital by ground ambulance, treated, and released.

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[4] The ambulance driver was also a paramedic.

The weather on the day of the occurrence was sunny. Although the sun was high in the sky at the time of the occurrence, there was no indication that the sun was affecting the ability of vehicle drivers at the Crush Crescent crossing approach to see the traffic signals or the crossing signals.

1.2 Recorded information

Forward-facing video from the lead locomotive and a dash-cam video from a vehicle travelling southbound on Glover Road were reviewed.

Based on the recorded information, it was determined that

- As the ambulance approached the main track, the crossing gate for the westbound traffic from 216th Street traversing Glover Road for Crush Crescent had already begun to descend.
- The ambulance, which was stopped foul of the main track, moved forward slightly twice (at 1120:22 and at 1120:28).
- Although the crossing gate closest to the front of the ambulance (the gate for westbound traffic) was down, the gate did not extend beyond the front of the ambulance and did not impede the ambulance's forward progress (red circle in Figure 3).

Figure 3. Front of ambulance beyond descended gate (Source: Dash-cam video)

1.3 The train

The distributed power[5] train comprised 3 locomotives and 62 cars consisting of 168 loaded container platforms.[6] There were 2 locomotives at the head end of the train and 1 locomotive at the tail end. The train was 10 615 feet long and weighed 10 403 tons.

1.4 The train crew

The 3-member train crew consisted of a locomotive engineer (LE), a conductor, and a locomotive engineer trainee (LE trainee). The LE trainee, who was operating the train at the time of the occurrence, was under the supervision of the LE. The LE and the conductor were qualified for their respective positions, met regulatory safety and rest requirements, and were familiar with operating over the Page Subdivision. The LE trainee, who was a qualified conductor, had been in the LE training program since March 2015. Over the previous months, the LE trainee had been working primarily with the LE.

1.5 Page Subdivision

The Page Subdivision starts at Riverside (Mile 0.0) and ends at Pratt (Mile 24.0), where it connects to the British Columbia Railway's Port Subdivision. On the Page Subdivision, between Mile 16.4 (Livingstone) and Mile 24.0, train movements are governed by the centralized traffic control system, as authorized by the CROR, and controlled by a British Columbia Railway rail traffic controller located in Roberts Bank, British Columbia. The authorized train speed in the vicinity of the crossing was 35 mph.

CP is the owner of the Page Subdivision. However, CN and the Southern Railway of British Columbia also operate trains over this subdivision. In 2015, on the Page Subdivision, there were 2806 train movements, increasing from 2715 train movements in 2014.

1.6 The crossing

The occurrence crossing (the crossing) is located in Langley at Mile 18.81 of the Page Subdivision. The crossing, which intersects Crush Crescent and runs parallel to Glover Road, is equipped with a GCWS consisting of flashing lights, bell, and gates. The GCWS was working as intended at the time of the occurrence.

The crossing signal system, which is linked to the traffic signal system at the intersection, uses a grade-crossing predictor to provide a constant warning time and advanced pre-emption for the roadway traffic signal controller.

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5 Distributed power allows for the physical distribution of locomotives at points through the train. These distributed power locomotives are remotely controlled from the leading locomotive.

6 Intermodal container cars can be made up of 1, 3, or 5 platforms.

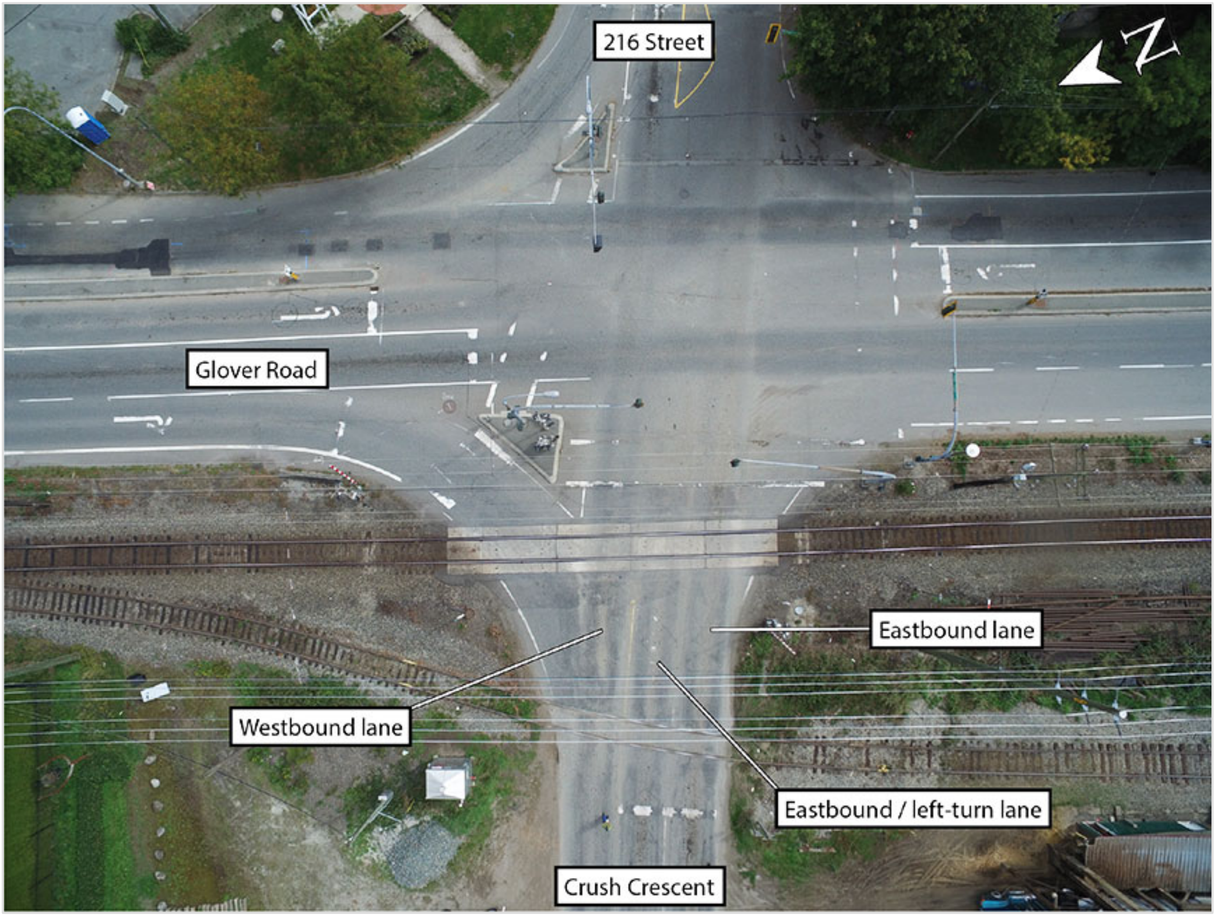
A second crossing for the Milner storage track is positioned approximately 13 m to the west of the occurrence crossing. The second crossing is equipped with a railway crossing sign (RCS).

The crossing and the connected roadways are under a number of jurisdictions. Crush Crescent and 216th Street are under the jurisdiction of the Township of Langley. The British Columbia (BC) Ministry of Transportation and Infrastructure (MOTI) has responsibility for Glover Road (Highway 10) and the traffic signals on Glover Road, which also control movements to and from these adjoining roads. MOTI shares responsibility with CP for the interconnection of the traffic signals with the GCWS at the railway crossing that intersects Crush Crescent. The operation and maintenance of the GCWS at the grade crossing is the responsibility of CP. Responsibility for the application and the maintenance of the roadway markings at this crossing is unclear.[7]

At the time of the occurrence, the roadway markings on Crush Crescent were faded and not clearly visible (Figure 4). The 3 lanes (eastbound, left turn, and westbound) at the crossing were not clearly marked with lines and arrows. The stop line for eastbound traffic (located west of the Milner storage track crossing) was visible but severely degraded.

[7] The Township of Langley, referencing the BC Ministry of Transportation and Infrastructure Jurisdictional Atlas, does not believe it has responsibility for applying and maintaining the roadway markings at this crossing. However, MOTI indicates that a clause in a CTC Order (No. 1993-R-330, for the relocation of the crossing from Mile 18.81 to Mile 18.83 of the CP Page Subdivision) establishes the Township of Langley as the entity responsible for the crossing and the highway approaches to the crossing. As of the writing of this report, the crossing is still located at Mile 18.81 of the CP Page Subdivision.

Figure 4. Faded road markings at the occurrence site (Source: RCMP, with TSB annotations)



Since 1993, there have been 3 other TSB-reportable occurrences at the Crush Crescent–Glover Road crossing:

- R93V0066 – On 07 April 1993, CP freight train 824-061, travelling northward, struck a vehicle on the Crush Crescent–Glover Road public crossing, which was equipped with flashing lights and bell. The occupant of the vehicle sustained minor injuries. There were no gates at the crossing at the time.
- R06V0240 – On 12 November 2006, while travelling northward on the Page Subdivision, Southern Railway of British Columbia West Turn Train No. 2 struck a vehicle that was positioned under the crossing gates at the Crush Crescent–Glover Road crossing. There were no injuries.
- R09V0241– On 19 November 2009, CP freight train 819-109, proceeding southward on the Page Subdivision, struck a vehicle at the Crush Crescent–Glover Road crossing, which was equipped with flashing lights, bell, and gates. The driver was taken to hospital with undetermined injuries.

In 2015, using the Transport Canada (TC) Pacific Region's risk model, this crossing was identified as one of the crossings of highest concern in British Columbia.

1.7 Grade crossing warning systems at grade crossings

In Canada, GCWS are installed at many railway crossings. The primary function of a GCWS is to provide visual and audible warnings of an approaching train to vehicle drivers and pedestrians. TC's *Grade Crossings Standards* (GCS)[8] identify various criteria for determining whether a GCWS is required at a railway crossing. These criteria include the speed of the trains, the frequency of trains, the number of tracks, the volume of road traffic, and the railway sightlines for vehicle drivers.

GCWS are designed and configured to provide adequate warning times, ensuring that approaching vehicles can safely stop prior to the railway tracks and/or safely egress from the crossing. The GCS specify a minimum warning time of 20 seconds. Additional warning time may be required, depending on the geometry of the intersection between the roadway and railway corridor. In some cases, additional warning time is required to ensure that vehicles can move clear of the intersection prior to a train's arrival.

Flashing lights and bells are the primary warning devices employed with a GCWS. Pairs of flashing lights are always employed. The number and position of flashing light pairs is determined by the geometry of the roadway at the railway crossing and any nearby roadways intersecting this road. If 1 bell does not provide adequate audible warning level to pedestrians and cyclists, more than 1 bell can be used.

Gates, which are a component of a GCWS, are used as a stop enforcement mechanism to block vehicles and pedestrians on the approach to a crossing. Gates are flexible and breakable to enable vehicles to clear the tracks if trapped between a gate and a track. The GCS regulate the use of gates at railway crossings.

Short warning times can result in drivers being unable to clear the railway prior to the arrival of a train. In contrast, longer than necessary warning times can also pose dangers. Nuisance operation[9] of a GCWS can lead drivers to believe that the GCWS has malfunctioned. With the expectation that no train is approaching, some drivers may decide to traverse the crossing, even while the GCWS is activated.

The need for sufficient warning times has led to the development of technology to predict the time it will take for an approaching train to arrive at the railway crossing. Grade crossing predictors use special track circuits to determine the distance and speed of a train within the track circuit (distance from the crossing) at any time. The minimum warning time required is programmed into the predictor during the installation of the crossing. To allow for the potential change in train speed and other factors in arrival time calculation, more warning time is usually added to the required minimum time—typically, 5 seconds. This additional time is referred to as "buffer time."

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[8] The *Grade Crossings Standards* are mandatory engineering standards and are incorporated by reference in the *Grade Crossings Regulations*.

[9] Nuisance operations occur when the GCWS is activated, but with no train approaching or in the immediate vicinity.

1.8 Grade Crossings Regulations *and* Grade Crossings Standards

The new *Grade Crossings Regulations* (GCR) came into force on 28 November 2014. Before the implementation of the new GCR, TC had issued a guidance document relating to railway crossing design.[10] As it was only a guidance document, it was not enforceable.[11]

With the new GCR, clarity was provided in a number of areas, including

- the responsibilities of the road authority and the railway with regards to grade crossings;
- the sharing of grade crossing information between the railway and the road authority (i.e., for existing grade crossings, the information must be shared within 2 years of the regulations coming into force); and
- the requirement to incorporate new sightline and design standards at the crossing (i.e., for existing grade crossings, the new standards must be in place within 7 years of the regulations coming into force, or earlier if modifications are made to the crossing).

The *Grade Crossings Standards* include the following requirements:

Section 15.1.4:

> All bells must continue to operate for the same duration as the light units.

Section 15.2.2:

> The descent of the gate arm must take 10 to 15 seconds and its ascent must take 6 to 12 seconds.

Section 16.1:

> 16.1 Warning Time
>
> 16.1.1 The time during which the warning system must operate, before the arrival of railway equipment at the crossing surface, must be the greatest of:
>
> a) 20 seconds, unless the grade crossing clearance distance is more than 11 m (35 ft.), in which case, the 20 seconds must be increased by one second for each additional 3 m (10 ft.), or fraction thereof;
>
> b) the Departure Time for the design vehicle[[12]] (article 10.3.2);

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10 TC's draft technical standards, entitled Road/Railway Grade Crossings: Technical Standards and Inspection, Testing and Maintenance Requirements (RTD 10), were issued in 2002. They set out the minimum safety criteria for the construction or alteration, and maintenance (including inspection and testing) of grade crossings and their road approaches. The RTD 10 draft standards were not enforceable, but they were being used as guidelines by TC and the rail industry / road authorities when reviewing safety at grade crossings.

11 Transport Canada Railway Safety Inspectors are empowered by the *Railway Safety Act* to take regulatory action in the event of a threat or an immediate threat to safe railway operations.

12 A design vehicle is the longest vehicle permitted by statute of the road authority on that roadway.

> c) the Departure Time for pedestrians, cyclists, and persons using assistive devices (article 10.3.3);
>
> d) the gate arm clearance time,[[13]] plus the time to complete the gate arm descent, plus 5 seconds;
>
> e) the minimum warning time required for traffic signal interconnection as referred to in article 19.3(a);
>
> f) the time for the design vehicle to travel from the stopping sight distance,[[14]] and pass completely through the clearance distance.[[15]]

Section 19.1:

> Interconnection is to be provided at grade crossings where the railway design speed is 15 mph or more and where there is less than 30 m between the nearest rail of a grade crossing and the travelled way of an intersection.

Section 19.3:

> The interconnection of traffic signals with a warning system must:
>
> a) Provide sufficient time for vehicles to clear the grade crossing before the arrival of railway equipment at the crossing surface.
>
> b) Prevent movement of road traffic from the intersection towards the grade crossing.

1.9 Site examination at crossing

During site examination, operation of the GCWS was observed with a train approaching the crossing. With traffic already stationary at the stop line before the crossing (due to a red highway traffic light), the GCWS started to activate and, simultaneously, the traffic light turned green. This design is to enable vehicles queued at the crossing to vacate the area prior to the train's arrival. However, drivers were presented with both a green light inviting them to enter the crossing area, when in fact it was not safe to do so, and the activation of the GCWS giving warning of an approaching train. The green light could continue until after the train had occupied the crossing.

It was observed that some vehicle drivers were confused when they were presented with the conflicting stop and go commands from the GCWS and the road traffic signals.

On 17 March 2016, the TSB issued Railway Safety Advisory 07/16 concerning the operation of the GCWS and the road traffic signals at the occurrence crossing.[16]

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13 The gate arm clearance time is the time from the initial activation of the GCWS to the time the gate arm begins to descend.

14 The stopping sight distance means the sum of the distance travelled during the perception and reaction time of a vehicle driver to a signal, plus the vehicle braking distance.

15 The clearance distance is the distance between the departure point, in advance of a grade crossing, and the clearance point beyond the farthest rail (e.g., 7.9 metres beyond the farthest rail).

1.10 Crossing geometry at Crush Crescent–Glover Road

Subsequent to the accident, TC determined that this crossing did not conform to the new definition of a grade crossing as specified in the 2014 GCR:

> a road crossing at grade, or two or more road crossings at grade where the lines of railway are not separated by more than 30 m.

At the accident location, Crush Crescent crosses 2 tracks that are separated by about 13 m (the main track and the Milner storage track). However, the 2 tracks had 2 different crossing warning systems: the main track crossing had a GCWS, and the Milner storage track crossing had an RCS. By definition, both tracks should have been treated as 1 crossing. While the crossing warning systems met requirements at the time they were installed, with the RCS as the only warning for the Milner storage track, the crossing sightlines did not meet the new GCS. Further, under the graduated implementation of the GCR, unless modifications are being made to the crossing, the crossing warning systems do not have to meet the new requirements until the year 2021.[17]

The following was determined during site examination and review of the crossing:

- The centreline of the road depicted on the engineering drawings prepared by MOTI had possibly been interpreted as the line separating the lanes of opposite direction of travel in the railway's crossing plans (Appendix A). As a result, when the crossing gate arm for eastbound vehicles was installed, it did not extend fully across both lanes of eastbound road traffic. In comparison, the crossing gate arm for westbound vehicles extended past the single lane for westbound vehicles. However, the crossing arms for both east- and westbound traffic met regulatory requirements as specified in Section 12.1(5)[18] of the GCS (Figure 5).
- The distance of the warning system (flashing lights) to the centreline of the road (measured perpendicular to the road) exceeded 7.7 m,[19] requiring a cantilevered light unit.

For eastbound traffic approaching the crossing, the GCWS flashing lights were at times partially obscured for vehicle drivers due to the position of the RCS for the Milner storage track and the stop line sign (Figure 6).

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16 Transportation Safety Board of Canada, Rail Safety Advisory Letter 07/16: Crossing Safety at Crush Crescent–Glover Road in Langley, BC (17 March 2016), available at http://www.bst-tsb.gc.ca/eng/medias-media/sur-safe/letter/rail/2016/r15v0191/r15v0191-617-07-16.asp (last accessed on 21 May 2017).

17 *Grade Crossings Standards*, section 7, Sightlines 7.1.1, 7.2 (a) (b) (c), Figure 7.1 (a) (b).

18 Section 12.1(5) of the *Grade Crossings Standards* states (in part), "…for grade crossings used by vehicles, gate arms must extend to within 1 m (3 ft.) of the farthest edge of that portion of the road approach." The gate configuration is considered acceptable if the gate arms are within 1 m of the centreline of the road approach.

19 *Grade Crossings Standards*, section 13.3, Cantilevered Light Units 13.3.1 (a).

Figure 5. Crossing gate extending past centreline

Figure 6. Partially obscured grade crossing warning system at crossing for approaching eastbound traffic

1.11 *Interconnection between crossing signals and vehicle traffic signals*

Where an intersection between 2 roadways exists adjacent to the railway crossing and the intersection is controlled by traffic signals, information must be provided to the traffic control system to help ensure that vehicles do not remain waiting on or near the railway crossing due to a red light while a train is approaching. From the interconnection between crossing signals and vehicle traffic signals, traffic pre-emption can be performed. These are some of the design issues to consider when implementing traffic pre-emption:

- Depending on the layout of the road intersection and the railway crossing, it may only be necessary to ensure that traffic cannot approach the railway tracks. However, at some locations, the traffic control system may be required to provide a green light to allow cars that are queued in the vicinity of the crossing to vacate the crossing prior to the arrival of the train. This activity is referred to as "queue flushing."
- During the design of the traffic control system, the road authority will typically advise the railway on the amount of time required by the system to ensure that road traffic at the crossing can be cleared safely. For some traffic control systems, the system can mitigate traffic risk without activating the crossing GCWS. This function is referred to as "simultaneous pre-emption." However, the traffic control system will normally require some time to finish the current traffic phase before it can react to the pre-emption request from the crossing signal system.
- Providing the traffic system with advance notification of an approaching train is referred to as "advanced pre-emption." Advanced pre-emption is used in conjunction with a grade crossing predictor. In these situations, the crossing predictor is designed to detect, predict, and react to a train approaching at maximum allowable speed. With the grade crossing predictor, the GCWS can be configured to react sooner, making pre-emption more consistent.

1.12 *Timing of the grade crossing warning system controller and the traffic control system at the crossing*

When a crossing warning system is interconnected with traffic signals, certain parameters (as specified in the GCS) must be met relating to the timing of functions, including traffic pre-emption, gate drop delay, and traffic queue clear-out.

The Safetran GCP 62660 MS/GCP controller, which operated the warning devices at the time of the occurrence, had no integrated provisions for data recording. However, this controller did include an external data-logging device. The external data-logging device provides a log file containing pertinent information presented against time.

The GCWS controller was configured to provide 30 seconds of warning time and 50 seconds of total approach time.[20] This 50-second period was broken up as follows:

- 20 seconds of basic operating time
- 3 seconds of clearance time
- 5 seconds of equipment response time (this occurs before the advanced pre-emption)
- 15 seconds of advanced pre-emption (notification to the traffic signals of approaching train)
- 5 seconds of buffer time
- 2 seconds of gate down time prior to train arrival.

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20 This information was taken directly from CP's circuit plan for the configuration of the GCWS controller.

The traffic signals for vehicle drivers were controlled by an LMD 8000 controller, which had a built-in recorder capable of recording signal events, limited by the recorder's storage capacity and by its 24-hour overwrite cycle.

For the traffic control system,[21] when the clearance queue[22] was first established, the new GCR were not in effect. The clearance queue calculations were therefore not based on the current design vehicle calculations. Instead, the methodology was based on reviewing the best- and worst-case scenario for the right-of-way transfer time of the traffic lights and on ensuring that an adequate clearance (green) time is provided prior to the arrival of a train. Using this methodology, the clearance green time provided was sufficient to accommodate the required design vehicle for this crossing.

For the occurrence crossing, during the advanced pre-emption phase, the traffic signals prepare to clear the traffic queue on Crush Crescent. The particular phase that the traffic signals are in when the advanced pre-emption starts determines the length of time required:

- The worst-case scenario occurs when the traffic signals are green for traffic on Glover Road. In this case, it would take about 15 seconds for the right-of-way to be transferred and to initiate the queue clearance on Crush Crescent.
- The best-case scenario occurs when there is an all-red situation for both Glover Road and Crush Crescent. The traffic control system would receive the advanced pre-emption call from the railway signal controller. The right-of-way transfer would occur in about 2 seconds, followed by the beginning of the clearance queue on Crush Crescent.

1.13 Regulatory requirements for inspection of crossings

Section 17.1, Table 17-2, of the GCS specifies the elements of a crossing warning system that must be inspected and tested and the frequency of the required inspection and testing. When the crossing warning system is interconnected with the traffic control system, the inspection and testing must be conducted once per year. Although this is not stipulated as such in the regulations, these inspections and tests should be performed jointly by the road authority and the railway.

To perform testing and inspection of interconnected systems, TC developed a document entitled *Guideline For Inspecting and Testing Preemption of Interconnected Traffic Control Signals*

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21 MOTI considers that the traffic control system met the following requirements:

- Section 19.3(a) and 19.3(b) of the 2014 *Grade Crossings Standards*;
- Section 400 of the ministry's *Electrical and Traffic Engineering Manual*;
- Texas DOT "Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings," version 6 10-04;
- AREMA *Communications and Signals Manual*, Part 3.1.10.E.1 and 4; and
- the green time for clearing the traffic queue from the track area was sufficient to accommodate a WB-20 design vehicle.

22 The clearance queue is the calculated duration required for the design vehicle to clear the crossing.

and Railway Crossing Warning Systems. This document and the GCR do not require real-time observation or the use of recorded information as part of the recommended inspection and testing processes.

1.13.1 Railway and road authority testing and inspection results for the Crush Crescent–Glover Road Crossing

Table 2 summarizes the inspection and test results since 2010 for the interconnection between the GCWS and the traffic signals at the occurrence crossing.

Table 2. Inspection and test results for interconnection between grade crossing warning system and traffic signals

Year	Inspection and test results	Comments
2010	A sign-off sheet indicating that the interconnection operation between the GCWS and the traffic signal was observed	No observations were recorded at the time of the inspection.
2011	A sign-off sheet with a checklist of 4 tasks to perform: 1. Have rail authority simulate a train crossing 2. Confirm with the rail authority that the pre-emption/warning devices and control operate as intended 3. At a signal with a 6-wire supervisory circuit, simulate an interconnected failure and ensure the signal goes into flash 4. Have the attending rail representative sign off below	All items were completed except for item 3, which was not applicable to the GCWS interconnection at this crossing. No real-time observations (such as approach of a train) of the GCWS–traffic signal system interconnection were made.
2012	A sign-off sheet with a checklist of 7 items for evaluation: 1. Constant warning approach timing 2. Fixed distance approach timing 3. Motion sensing 4. Does test switch feature deactivate pre-emption of traffic signals 5. Does test switch feature activate pre-emption of traffic signals 6. Road/railway grade crossing system activation warning time 7. Advanced pre-emption time* if required by the road authority is ___ seconds in order to provide the total required pre-emption time** of ____ seconds to the traffic signal controller (traffic values)	All items were completed except for item 2 (there was no fixed distance approach timing) and item 7 (no pre-emption design or observed times were recorded). No real-time observations (such as approach of a train) of the GCWS traffic signal system interconnection were made.
2013	A sign-off sheet with the 7 items for evaluation identified in 2012	All 7 items were marked as completed. No real-time observations (such as approach of a train) of the GCWS traffic signal system interconnection were made. For item 7, 41 seconds was recorded for both values.
2014	A sign-off sheet with the items for evaluation identified in 2012 and resubmitted in 2013	The checklist had recorded all items with the exception of item 1. No real-time observations (such as approach of a train) of the GCWS traffic signal system interconnection were made. For item 7, 0 seconds was recorded for both values.

2015	A duplicate sign-off sheet as in 2012, 2013, and 2014 with all items having been completed	No real-time observations (such as approach of a train) of the GCWS / traffic signal system interconnection were made. For item 7, 0 seconds was recorded for the advanced pre-emption time, and 33 seconds was recorded for the pre-emption time (this inspection was completed 3 days after the occurrence).

* Advanced pre-emption time is the period of time that is the difference between the required maximum highway traffic signal pre-emption time and the prescribed warning time.

** The maximum amount of time needed following initiation of the pre-emption sequence for the highway traffic signals to complete the timing of the right-of-way transfer time, queue clearance time, and separation time.

The typical method of testing the interconnection operations was to apply a track shunt within the crossing approach that would simulate the approach or arrival of a train. However, the use of a shunt in this manner did not allow for detailed observation of the full operation and interaction between the GCWS and the traffic controller. This method of testing would simulate a train that a grade crossing predictor can evaluate only as moving quickly, rather than at the varying speeds that could be encountered during normal train operation to the crossing.

1.13.2 Other available data sources for inspection and testing

The traffic signal pre-emption recorders used by MOTI use a date and time stamp to log 2 types of events during rail pre-emption: when pre-emption is initiated and when the pre-emption call is terminated. Other events unrelated to rail pre-emption are also recorded.

In 2015, at the occurrence crossing, there were 2806 train movements that generated about 6000 lines of data solely for rail pre-emption events.

1.14 U.S. National Transportation Safety Board investigations and recommendations relating to crossing safety

On 25 October 1995, at 0710, commuter train 624 of the Northeast Illinois Regional Commuter Railroad Corporation (Metropolitan Rail) struck the rear left side of a stationary school bus at a grade crossing in Fox River Grove, Illinois. While in the process of traversing the crossing, the school bus stopped for a red traffic signal, with its rear extended about 3 feet into the path of the train. As a result of the accident, there were 7 fatal injuries, 24 serious injuries, and 5 minor injuries.

As part of this investigation, the U.S. National Transportation Safety Board (NTSB) issued the following recommendations on 14 November 1996:

> Require the use and maintenance of railroad and highway/traffic signal recording devices on all new & improved installations at railroad/highway grade crossings that have active warning train detection systems and are interconnected/pre-empted to highway signal systems. These devices record

> sufficient parameters to allow railroad and highway personnel to readily determine that the highway signals and railroad-activated warning devices are coordinated and operating properly. Require that the information from these devices be used during comprehensive and periodic joint inspections.
>
> NTSB Recommendation I-96-10
>
> Require that existing recording devices for railroad & highway signals systems at interconnected/preempted grade crossings be retained or upgraded as necessary. Require that these recording devices be maintained & that the information from these devices be used during the comprehensive & periodic joint inspections.
>
> NTSB Recommendation I-96-11

In response to these recommendations, the U.S. Federal Railroad Administration issued Safety Advisory 2010-02 (Appendix B) and recommended the following actions:

> (1) Each State and local highway authority and railroad should conduct comprehensive joint inspections of highway traffic signal pre-emption interconnections when the highway-rail grade crossing active warning system is placed in service, whenever any portion of the system which may affect the proper function of the interconnection is modified or disarranged, and at least once every 12 months, during which observation of the actual pre-emption function and its effect on the highway traffic signal system can be made;
>
> (2) Each State and local highway authority and railroad should install railroad and highway traffic signal recording devices at all new and improved highway-rail grade crossings that have active warning systems which are interconnected with highway traffic signal systems;
>
> (3) Each State and local highway authority and railroad should maintain and upgrade existing railroad and highway traffic signal recording devices at highway-rail grade crossings that have active warning systems which are interconnected with highway traffic signal systems; and
>
> (4) Each State and local highway authority and railroad should use the data provided by railroad and highway traffic signal recording devices during their comprehensive periodic joint inspections of interconnected highway-rail grade crossing active warning systems and highway traffic signal systems to determine whether further investigation of any recorded operational anomalies may be warranted.
>
> States and local highway authorities and railroads are encouraged to take action consistent with the preceding recommendations to help ensure the safety of highway-rail grade crossings.

The NTSB considers recommendations I-96-10 and I-96-11 closed with an acceptable alternate action.

1.15 Train operations in the vicinity of a crossing

Train crews are expected to use good judgment and forward planning to deal with emergent situations. Railway guidance on the use of emergency braking is typically non-specific, in recognition that a wide range of circumstances can be encountered and that LE judgment is important.

In this occurrence, the train was being operated by an LE trainee under the supervision of an in-charge LE. Approaching the crossing, the train was travelling at 34 mph, below the maximum authorized speed of 35 mph. There were no speed restrictions for the train in the vicinity of the crossing. From the locomotive cab, there was clear visibility and an unobstructed view toward the crossing. The recorded information indicates that the train was operated in accordance with railway and regulatory requirements.

The train crew members observed the ambulance approach the crossing from the west and then stop on the crossing. The crew members also noted that the GCWS was activated. As required by the CROR, upon reaching the whistle post (about ¼ mile from the crossing), the crew members started to sound the locomotive horn. They observed the ambulance move forward twice. As the ambulance was still on the crossing, the locomotive horn was then sounded continuously. As there did not appear to be any obstruction preventing the ambulance from clearing the crossing, the LE opted to continue toward the crossing, sounding the horn.

Train crews are generally accustomed to encountering vehicles that are momentarily stopped at crossings and encountering unauthorized persons on the railway right-of-way. It is not uncommon for pedestrians and/or vehicles to remain on the track, including at crossings, until the last possible moment. As trains have the right-of-way and cannot stop quickly, crew members generally expect that the audible warning from the train and the activated GCWS will be complied with.

1.16 British Columbia Emergency Health Services

British Columbia Emergency Health Services (BCEHS), which operates under the Provincial Health Services Authority, oversees the British Columbia Ambulance Service (BCAS) and the British Columbia Patient Transfer Network (BCPTN). BCEHS has several offices located strategically across the province, along with 184 ambulance stations and over 4000 employees, including paramedics, dispatchers, and physicians.

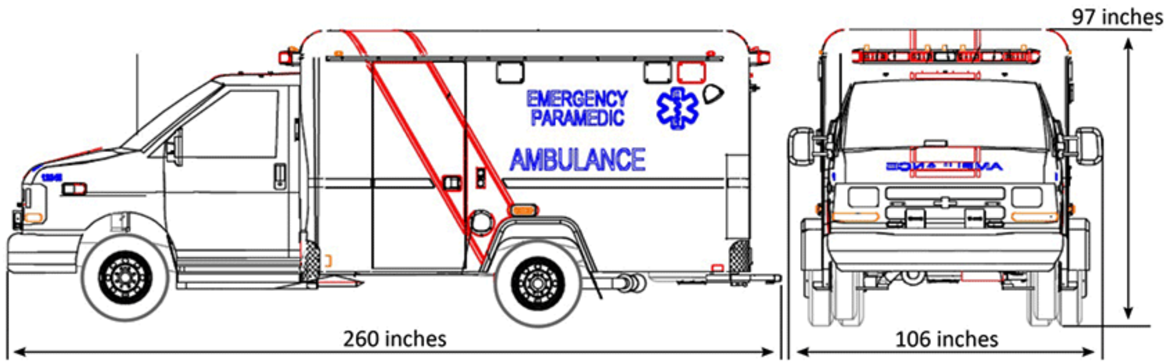
BCAS provides pre-hospital care to patients when arriving first at the scene of a medical emergency. With about 500 ground ambulances and a fleet of fixed wing and rotary wing aircraft located throughout British Columbia, BCAS provides both ground and air response.

Collaborating with physicians and health-care professionals, the BCPTN program provides transfer services for patients.

1.17 The ambulance

The occurrence ambulance, a 2009 Chevrolet Crestline series, measured 21.5 feet long (bumper to bumper) and 8.8 feet wide (outside mirror to outside mirror) (Figure 7). Based on the repair and inspection records, the ambulance was in serviceable condition. A post-occurrence teardown and inspection determined that there were no pre-existing defects that would have contributed to this occurrence.

Figure 7. Ambulance dimensions (Source: British Columbia Ambulance Service)



The occurrence ambulance was equipped with an event data recorder (EDR), a tachograph, and an automatic vehicle locator (AVL):

- The EDR was a function within the airbag control module. This manufacturer-installed device monitors and records information including the speed of the vehicle, the throttle position, the engine revolutions per minute, the use of brakes, seatbelt use status, airbag deployment, and the change of the vehicle's velocity during a collision. The type of EDR and the content of the recorded data depend on the make/model/year of the vehicle. The EDR from the occurrence ambulance was recovered.
- The tachograph, an on-board data recorder, records the vehicle speed and distance along with other driver vehicle inputs. For the occurrence ambulance, the tachograph had been disconnected from its power source approximately 1 month prior to the occurrence and therefore contained no relevant information.
- The AVL is a device that uses the global positioning system (GPS) to remotely track the ambulance's location. The AVL data from the occurrence ambulance was recovered.

1.18 The ambulance crew

The ambulance crew comprised 2 paramedics. Both crew members were qualified for their respective positions and met company work/rest requirements.[23] The ambulance crew had been working shifts of 4 days on duty (1000 to 2100), followed by 4 days off duty. The 2 crew members had worked together regularly and were alternating driving duties on a day-to-day basis during their 4-day shifts.

At BCAS, there are 4 levels of paramedics:

- Level 1 – Advanced Care Paramedic

[23] The company's work/rest policy requires that crew members have 8 hours off duty between duty periods.

- Level 2 – Primary Care Paramedic
- Level 3 – Emergency Medical Responder
- Level 4 – Critical Care Paramedic

Both the ambulance driver and the paramedic in the patient compartment were Level 2 paramedics with an Intravenous endorsement.

All 4 levels of paramedics were required to be licensed by the Emergency Medical Assistants Licensing Board. To drive an ambulance, a paramedic is required to have a minimum Class 4 unrestricted driver's licence. In this occurrence, the driver held a Class 4 driver's licence.

In British Columbia, ambulance drivers are also governed by the BCAS driving policy and procedure, as well as the *Motor Vehicle Act* and the *Emergency Vehicle Driving Regulation*.

1.18.1 Training for ambulance drivers at the British Columbia Ambulance Service

The driver training program at BCAS had the following elements:

- Fundamentals of Emergency Vehicles Operations (FOEVO): This 2-day orientation includes a half-day of on-track driving. The first day pertains to factors that affect driving skills, including drugs, fatigue, illness, and night driving, and distractions such as radios, cellphones, and patients. This training includes a video on distracted driving. The second day is spent outside with hands-on ambulance operation on a road course. Among the goals of the FOEVO training were
    - to explain the attributes of a professional driver;
    - to explain the factors affecting driving;
    - to explain the responsibilities when driving;
    - to demonstrate the ability to manoeuvre an ambulance in multiple situations;
    - to demonstrate a pre-trip inspection;
    - to demonstrate basic map reading; and
    - to explain the laws and policies around code 3[24] driving.
- *Emergency Vehicle Driving Regulation* training: This training is a 3½-hour course on the regulations pertaining to the operation of an emergency vehicle.
- Driving practicum: After successfully completing the 2-day FOEVO course, the ambulance driver takes part in a driving practicum that evaluates the employee's knowledge of safe driving practices, BCAS policy and procedure pertaining to driving, and the demonstration of safe driving practices during routine and code 3 ambulance responses. The practicum is conducted with a driving evaluator who assesses the employee's driving skills and knowledge. Feedback and coaching are provided throughout the assessment period. The assessment involves areas such as
    - reviewing BCAS policy and procedure

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[24] Code 3 is the ambulance response code relating to an emergency response with lights and siren.

  - vehicle inspection
  - navigation
  - routine driving
  - emergency driving
  - driver attitude

  The evaluation would typically take place over a number of shifts/days, where the driver is evaluated while driving in both emergent and routine driving situations. Upon completion, if the driver has not been successful, a remediation plan must be put in place. All new employees of BCEHS have 90 days to complete the driving practicum once they are issued an employee number. If an employee is unable to complete the FOEVO course and driving practicum during the 90-day period, the employee must contact their unit chief to discuss an alternative.
- Vancouver Post Orientation Program: Safe Driving Awareness: This course provides additional training to ambulance drivers in the Vancouver area. The course was developed in response to a 2006 examination of accident records showing that paramedics new to the Vancouver post were involved in a high number of motor vehicle incidents. The goal of this training was to raise awareness of the driving challenges that paramedics face every day. The module uses examples of investigative reports and incorporates the BCAS driving policies from the policy and procedure manual. The training consists of a 2-day course followed by a driver practicum that involves graduated driving responsibilities. The training requires paramedics to drive 8 shifts in code 2 response only, and 4 shifts of driving restricted to code 3 calls. A final evaluation shift would also be arranged with a driving evaluator.
- Driving orientation: This training consisted of 4 hours spent with the unit chief or designate, performing an orientation to the specific area that the driver would be operating. This training would occur when a driver is first assigned or if a driver transfers to another unit or area.

Driver training at BCAS did not specifically include training relating to operating the ambulance safely over railway crossings. However, as part of acquiring a Class 4 driver's licence, the Insurance Corporation of British Columbia provides drivers with some training on railway crossing safety.

Training records indicated that the occurrence ambulance driver had completed the *Emergency Vehicle Driving Regulation* course on 27 March 2011. There were no records to indicate that the driver had completed the FOEVO training or had participated in the driving practicum.

During the driver's long-standing employment[25] relationship with BCAS, the following additional training opportunities were available:

- Emergency Medical Assistant II training, which included 2 days of on-track driver training offered in the 1990s, and then again in December 2000; and
- On-track driving skills training, offered in September 2003.

1.18.2 Operation Lifesaver crossing awareness training for emergency responders

Operation Lifesaver produced a driver's training course aimed specifically at emergency responders who, as part of their duties, interact with railway crossings. The course is titled "Live to Help Another Day." This 60-minute instructor-led course focuses on the dangers at highway-railway crossings. The course teaches emergency responders the steps to ensure safety at highway-railway crossings, including the safety of the people in their care. The course includes

1. the different types of warning signs and devices that can be found at highway-railway crossings, including what they are designed to do;
2. the recommended procedures to be used by emergency responders at highway-railway crossings, including when travelling in emergency response mode; and
3. facts about trains and highway-railway crossings.

The course includes a 16-question safety quiz for the participants. This training was not part of the BCAS driver-training curriculum.

1.18.3 Supervision and performance monitoring of ambulance drivers

Most transportation industries routinely monitor their drivers' performance to ensure compliance with company policies and procedures and with regulatory requirements. Driver monitoring—such as downloading and reviewing onboard recording devices, real-time monitoring (ride-along) of the driver's performance, evaluation, and review with employees—is also used to assess the effectiveness of driver training programs.

At BCAS, front-line supervisors are responsible for ensuring that policies, procedures, and regulations are followed. Supervisors are expected to work with employees to address any driver concerns. If a skill or ability gap is identified, additional driver education and teaching is to be provided. However, no specific performance monitoring system had been implemented to evaluate drivers for compliance with provincial and company standards and to assess the effectiveness of company driver training.

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25 The driver started as a casual employee with the ambulance service in May 1989 and moved into a full-time role in October 1999.

1.19 *Use of cellphones while operating a motor vehicle*

Part 3.1, section 214.2 (1) of the *BC Motor Vehicle Act* states:

> A person must not use an electronic device while driving or operating a motor vehicle on a highway.

Section 214.1 (Definitions) states:

> "Electronic device" means;
>
> a) a hand-held cellular telephone or another hand-held device that includes a telephone function;
>
> b) a hand-held electronic device that is capable of transmitting or receiving electronic mail or other text-based messages; or
>
> c) a prescribed class or type of electronic device.
>
> "Use", in relation to an electronic device, means one or more of the following actions:
>
> a) holding the device in a position in which it may be used;
>
> b) operating one or more of the device's functions;
>
> c) communicating orally by means of the device with another person or another device; or
>
> d) taking another action that is set out in the regulations by means of, with or in relation to an electronic device.

Part 3.1, section 214.2 (2) states:

> Without limiting subsection (1), a person must not communicate by means of an electronic device with another person or another device by electronic mail or other text-based message.

Section 214.3 (Exceptions to prohibition – emergency personnel) states:

> Section 214.2 does not apply to the following persons who use an electronic device while carrying out their powers, duties or functions:
>
> a) a peace officer;
>
> b) a person driving or operating an ambulance as defined in the Emergency Health Services Act;[26]
>
> c) fire services personnel as defined in the Fire Services Act;

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[26] Ambulance services means the use of an ambulance to (a) provide emergency health services, or (b) transport an individual (i) under the care of, or (ii) who requires, or may require, a service provided by a medical practitioner, an emergency medical assistant, or another health-care provider.

Section 214.4 (Exceptions to prohibition – certain permitted activities) states:

> Section 214.2 does not apply to a person who uses an electronic device:
>
> a) while operating a motor vehicle that is safely parked off the roadway or lawfully parked on the roadway and is not impeding traffic;
>
> b) to call or send a message to a police force, fire department or ambulance service about an emergency; or
>
> c) that is configured and equipped to allow hands-free use in a telephone function, is used in a hands-free manner and is used in accordance with the regulations, if any.

1.20 *Policy of the British Columbia Ambulance Service on cellphone use*

In June 2009, BCAS implemented a policy on the use of cellphones while on company service. The policy, entitled Restrictions on Cellular Telephone Use, states (in part):

> **Purpose**
>
> Prohibitions or restrictions on the use of cellular telephones while operating motor vehicles will enhance the safety of patients, the public, and employees. Also, the professional image of the BCAS will be preserved by restricting personal cellular telephone calls to times when employees are not in the presence of the public.
>
> **Definition**
>
> In this policy:
>
> cellular telephone — "Cellular telephone" means any electronic telecommunications device used for wireless communications and includes, but is not limited to, devices used as personal organizers, and for text messaging, web browsing, personal scheduling or for similar services, but does not include a data terminal, two-way radio, or a portable radio supplied by the employer.
>
> hands-free accessory — "Hands-free accessory" means an attachment, add-on, built-in feature, or addition to a cellular telephone that, when used, allows the driver to maintain both hands on the steering wheel.
>
> **Policy**
>
> Employees must use cellular telephones provided by the employer as professional business tools required to do their work and to provide efficient service delivery. This use is subject to the same restrictions and management review process as any other Emergency and Health Services Commission resource provided to the BCAS. Research has revealed that the risk of a motor vehicle accident increases when using a cellular telephone because driver concentration and attention can be compromised. This risk can be reduced by restricted and appropriate use. Uniformed employees engaging in private

cellular telephone conversations while serving the public create an unprofessional image and this behaviour must be avoided.

Appropriate and Safe Communications

Employees must not use a cellular telephone while driving a vehicle during the course of their employment.

Employees must not use a personal cellular telephone for private communications during an ambulance call, in the presence of the public, or in the presence of other agencies attending at a scene.

Despite subsection A.(1), above, employees driving an ambulance may use the following devices when provided by the employer:

- a two-way radio, or a portable radio, for communicating with a BCAS Regional or Provincial Emergency Communications Centre; or
- a data terminal when used for status message updates and for navigation.

When practicable, the attending paramedic should relieve the driver from the need to communicate by radio or from the need to use a data terminal.

Paramedic attendants or paramedic drivers must not use a cellular telephone supplied by the employer for personal calls.

During an ambulance call all personal cellular telephones must be turned off, or have the ring tone muted, or have the cellular telephone forwarded to another number.

Employees must arrange their private cellular telephone calls in a manner that does not interfere with service delivery, and in a manner that does not detract from the professional image of the BCAS.

All cellular telephones or other wireless transmitting devices must be turned off in or near an intensive patient care area of a hospital or in any area that has signs or employees advising others that such devices must be turned off.

Employees must conduct themselves professionally and refrain from using cellular telephones, two-way radios, portable radios, or any communications device in any manner that would be considered inappropriate or offensive to co-workers, to employees of other agencies or to members of the public.

1.21 Use of cellphones while operating the ambulance

While operating the vehicle, the ambulance driver made 2 phone calls on the approach to the crossing (Figure 8).

Figure 8. Cellphone calls and locations (Source: Google Earth, with TSB annotations)

Both calls were made using a personal cellphone with which the driver was not familiar. It could not be definitively determined whether a hands-free device was used. The subject of both calls was considered to be complex. Tables 3 and 4 summarize the 2 phone calls and related communications earlier in the morning.

Table 3. Cellphone use before starting shift

Call time	Call duration (minutes:seconds)	Call details (caller 1 and caller 2)
0857:02	2:29	Outgoing call to caller 1
0909:52	0:02	Outgoing call to caller 2
0940:54	0:19	Outgoing call to caller 2
0941:31	0:14	Outgoing call to caller 2
0941:57	0:28	Outgoing call to caller 2
0942:40	3:00	Outgoing call to caller 2
0945:42	2:05	Incoming call from caller 1. Call redirected.
0946:19	3:55	Outgoing call to caller 1

Table 4. Cellphone use during patient pickup and while en route

Call time	Call duration (minutes:seconds)	Call details (caller 1 and caller 2)
1105:29	0:27	Incoming call from caller 1 during patient pickup. Call redirected.
1116:59	1:25	Outgoing call to caller 1 while ambulance was in transit.
1119:09	5:29	Outgoing call to caller 2. The call remained connected from prior to until after the crossing collision.
1125:00	0:02	Incoming call from caller 2. Call redirected.

1.22 *Driver distraction*

Driver distraction is the diversion of attention away from activities critical for safe driving toward a competing activity.[27] Although distraction can be transient, there is ample evidence that driver distraction impairs driving performance and is a significant cause of motor vehicle crashes worldwide.[28] Texting and dialling, or other activities that require the driver to handle and look at the device, result in the driver looking away from the road, leading to reduced vehicle control and increased missed events.[29] This physical and visual distraction is why it is illegal to use hand-held devices while driving.

Research into driver distraction indicates that

- Cognitive distraction occurs when a driver's attention is withdrawn from the processing of information necessary for the safe operation of a vehicle and applied instead to a non-driving–related activity.[30] Cognitive distraction caused by a hands-free cellphone conversation disrupts driving performance by diverting attention from the external roadway environment to the telephone conversation,[31] impairing attention to visual inputs.[32] In high-workload situations, such as when turning left at a busy intersection while distracted, such multitasking can compromise visual

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27 J.D. Lee, K.L. Young and M.A. Regan, "Defining driver distraction," in: M.A. Regan, J.D. Lee and K.L. Young (eds.), *Driver Distraction: Theory, Effects and Mitigation* (Boca Raton, FL: CRC Press, 2009), pp. 31–40.

28 World Health Organization, *Mobile Phone Use: A Growing Problem of Driver Distraction* (WHO, 2011), at http://www.who.int/violence_injury_prevention/publications/road_traffic/distracted_driving_en.pdf (last accessed on 22 May 2017).

29 K. Kircher, C. Patten and C. Ahlström, *Mobile Telephones and Other Communication Devices and Their Impact on Traffic Safety: A Review of the Literature* (Stockholm: VTI, 2011).

30 D.L. Strayer, J.M. Cooper, J. Turrill, J. Coleman, N. Madeiros-Ward and F. Biondi, *Measuring Cognitive Distraction in the Automobile* (AAA Foundation for Traffic Safety, 2013), at https://www.aaafoundation.org/sites/default/files/MeasuringCognitiveDistractions.pdf (last accessed on 22 May 2017).

31 D.L. Strayer and F.A. Drews, "Cell-phone-induced driver distraction," *Current Directions in Psychological Science*, Vol. 16, No. 3 (2007), pp. 128–131.

32 D.L. Strayer and W.A. Johnston, "Cell phone induced failures of visual attention during simulated driving," *Journal of Experimental Psychology: Applied*, Vol. 9, No. 1 (2003), pp. 23–32.

attention and alertness by decreasing neural activity in the areas of the brain responsible for critical visual processing.[33]

- Distracted drivers experience "inattention blindness" (meaning their field of view narrows).[34] They tend to look at but not see the information in their driving environment, and they miss visual cues important for safe driving. This can increase the likelihood that a driver will miss critical visual stimuli in the visual field and roadway ahead,[29, 31, 32, 33] such as a level crossing's warning lights.[35] Even if a driver looks at and detects external visual cues, cognitive distraction can slow a driver's reaction time.[29, 31, 32, 33]
- The complexity and emotional content of the conversation can vary the degree of these effects.[29, 36, 37, 38] Research has shown that cellphone conversations can have a negative effect on driving performance for up to 10 minutes after their termination.[39] Based on an assessment of collisions that occurred following a cellphone conversation, drivers were 4.8 times more at risk when a call was placed within 5 minutes of the collision, compared with 1.3 times more at risk for calls placed more than 15 minutes before the collision. The relative risk was similar for drivers who differed in personal characteristics such as age and driving experience. The ambulance driver's 2 cellphone calls occurred within 4 minutes of the collision.
- Driver experience with driving while using a cellphone can affect the degree of influence the distraction may have.[29] An experienced driver who frequently uses the phone while driving may have established coping strategies. Conversely, a driver who is unfamiliar with using a cellphone while driving and/or unfamiliar with the device itself may experience greater distraction effects.
- Drivers using hands-free phones are just as likely to experience vehicle crashes as those using hand-held devices.[39] A review of over 100 published studies on drivers'

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33 T.A. Schweizer, K. Kan, Y. Hung, F. Tam, G. Naglie and S.J. Graham, "Brain activity during driving with distraction: an immersive fMRI study," *Frontiers in Human Neuroscience*, Vol. 7 (2013), Article 53.

34 W.C. Maples, W. DeRosier, R. Hoenes, R. Bendure and S. Moore, "The effects of cell phone use on peripheral vision," *Optometry*, Vol. 79, No. 1 (2008), pp. 36–42. Referenced in reference 33.

35 V. Beanland and K. Pammer, "Looking without seeing or seeing without looking? Eye movements in sustained inattentional blindness," *Vision Research*, Vol. 50, No. 10 (2010), pp. 977–988.

36 G.F. Briggs, G.J. Hole and M.F. Land, "Emotionally involving telephone conversations lead to driver error and visual tunnelling," *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 14, No. 4 (2011), pp. 313–323. Referenced in reference 29.

37 C.S. Dula, B.A. Martin, R.T. Fox and R.L. Leonard, "Differing types of cellular phone conversations and dangerous driving," *Accident Analysis & Prevention*, Vol. 43, No. 1 (2011), pp. 187–193.

38 C.J.D. Patten, A. Kircher, J. Östlund, L. Nilsson and O. Svenson, "Driver experience and cognitive workload in different traffic environments," *Accident Analysis & Prevention*, Vol. 38, No. 5 (2006), pp. 887–894.

39 D.A. Redelmeier and R.J. Tibshirani, "Association between cellular-telephone calls and motor vehicle collisions," *New England Journal of Medicine*, Vol. 336, No. 7 (1997), 453–458.

use of cellphones concluded that there was no evidence that hands-free cellphone use is less risky than hand-held phone use.[29]

Following its investigation into a 2010 multi-vehicle highway accident in Gray Summit, Missouri, the NTSB in 2011 called for the nationwide ban on driver use of portable electronic devices while operating a motor vehicle. The NTSB stated (in part):

> In the last decade, the NTSB has identified the use of a portable electronic device as a factor in the probable cause of eight accidents and incidents across all transportation modes. "Forty-six people died and 181 were injured in these events," said Vice Chairman Hart. "In light of this and the growing penetration of portable electronic devices in the United States, the NTSB is concerned and believes that now is the time to act to preserve safety for everyone on our roadways."[40]

In addition, the NTSB concluded that talking or texting while driving, even on a hands-free device, distracts the driver from the driving task, increasing the risk of an accident. In 2015, the NTSB added the use of personal electronic equipment while driving to its "Most Wanted List."[41]

1.23 *Situational awareness*

Situational awareness can be divided into three levels: the perception of elements in the environment, the comprehension of their meaning, and the projection of their status.[42] If the first stage of perceiving the critical elements of the environment is not achieved, a vehicle driver may not be able to fully understand the context and the associated hazards.

In this occurrence, to have good situational awareness at the crossing, a vehicle driver would have to

- perceive the crossing features and geometry, including the GCWS;
- understand what these features meant and where they were in relation to each other and their vehicle; and
- predict what the information meant for them.

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40 National Transportation Safety Board, "NTSB Vice Chairman testifies on nationwide ban on driver cell-phone use," at http://www.ntsb.gov/news/press-releases/Pages/NTSB_Vice_Chairman_testifies_on_nationwide_ban_on_driver_cell-phone_use.aspx (last accessed on 2 June 2017)

41 National Transportation Safety Board, "Disconnect from deadly distractions," NTSB "Most Wanted List of Transportation Safety Improvements 2015," at http://www.ntsb.gov/safety/mwl/Pages/mwl1_2015.aspx (last accessed on 03 May 2017).

42 M.R. Endsley, "Toward a theory of situation awareness in dynamic systems," *Human Factors*, Vol. 37, No. 1 (1995b), pp. 32–64.

1.24 Driver information processing on approach to crossing

Driver workload associated with an approach to a level crossing depends on the crossing type and characteristics. A passive crossing[43] equipped with only RCS involves significant workload demands, as no indication is provided to the driver regarding the presence (or absence) of an approaching train. A crossing that is equipped with a GCWS reduces driver workload, as the device removes most of the decision-making demands,[44] especially if there are gates and the gates have already descended.

Approaching the crossing eastbound on Crush Crescent, a driver is initially presented with an RCS and stop line sign (Figure 9) for the Milner storage track. Prior to passing this line, the driver would need to ascertain the status of the GCWS for the main track. The GCWS features must therefore be both visible and sufficiently conspicuous to be seen and to capture the driver's attention:

- "Visibility" refers to the more passive state of merely being present in a viewer's visual field.
- "Sensory conspicuity" refers to the ability of an object to capture the attention of an observer who does not necessarily expect it to be present.[45]
- "Cognitive conspicuity" concerns the importance and relevancy of information to the driver's context.[46]

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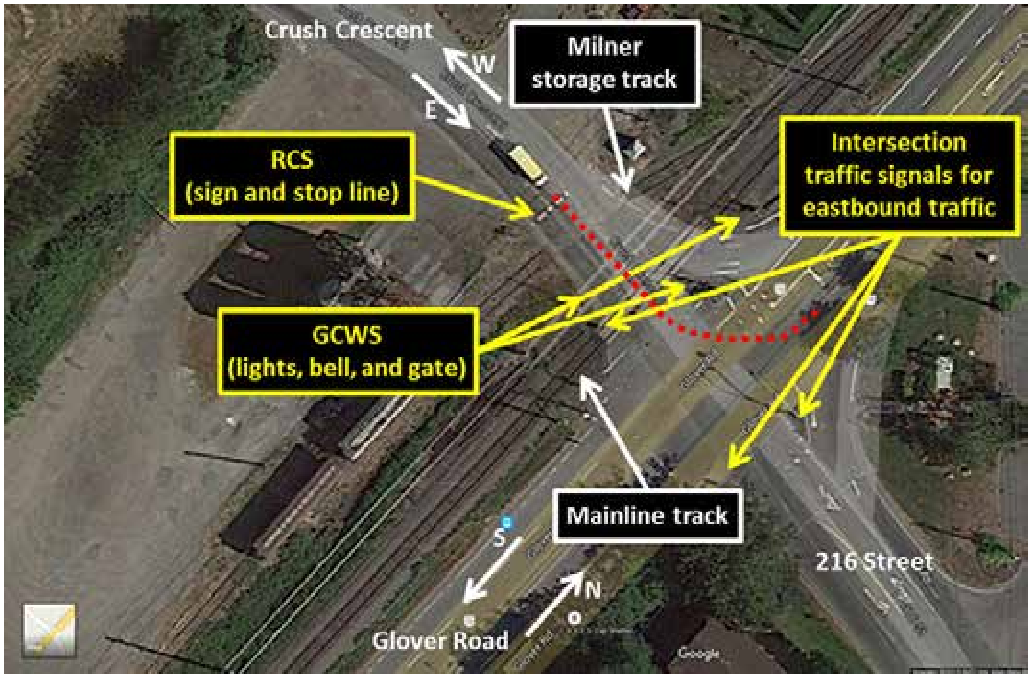
43 A passive crossing is a crossing without a GCWS (flashing lights or gates).

44 National Cooperative Highway Research Program, *Report 600: Human Factors Guidelines for Road Systems*, 2nd Edition (Transportation Research Board, 2012), available at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf (last accessed on 22 May 2017).

45 P.L. Olson, R. Dewar and E. Farber, "Vision, audition, vibration and processing of information," in: *Forensic Aspects of Driver Perception and Response*, 3rd Edition (Tucson, AZ: Lawyers & Judges Publishing Company, 2010).

46 P.A. Hancock, G. Wulf, D. Thom and P. Fassnacht, "Driver workload during differing driving maneuvers," *Accident Analysis & Prevention*, Vol. 22, No. 3 (1990), pp. 281–290.

Figure 9. Aerial view of crossing (Source: Google Earth, with TSB annotations)



1.24.1 *Sensory conspicuity*

Characteristics of warnings, objects, or conditions that are likely to attract a driver's attention include

- areas that contain a great deal of information, such as concentrations of lights, signs, and people;
- objects that differ greatly from their backgrounds in terms of brightness, colour, and texture;
- flickering or flashing stimuli;
- objects of large size; and
- objects that are moving.[47]

With respect to GCWS at crossings, red flashing lights and an audible bell are typical characteristics of warnings that are designed to attract attention. However, the primary purpose of crossing bells is to warn pedestrians and other non-vehicle road users of an approaching train. To attract attention, GCWS features should not be masked by other structures or weakened by the presence of other more notable cues.

Eastbound drivers on Crush Crescent who were turning left were presented with these cues in the vicinity of the crossing (figures 10 and 11):

1. dual lane approach (including a left lane for left turn)

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[47] P.L. Olson, R. Dewar and E. Farber, "Vision, audition, vibration and processing of information," in: *Forensic Aspects of Driver Perception and Response*, 3rd Edition (Tucson, AZ: Lawyers & Judges Publishing Company, 2010).

2. an RCS and stop line sign (just prior to the Milner storage track)
3. Milner storage track
4. GCWS positioned on the right side, including cross-buck sign, gate, lights, and bell
5. the main track
6. GCWS positioned on the left side, including cross-buck sign, gate, lights, and bell
7. a 4-way traffic intersection
8. multiple traffic signals, including the left-turn traffic signal
9. oncoming traffic from 216 Street

Figure 10. Drivers' cues eastbound

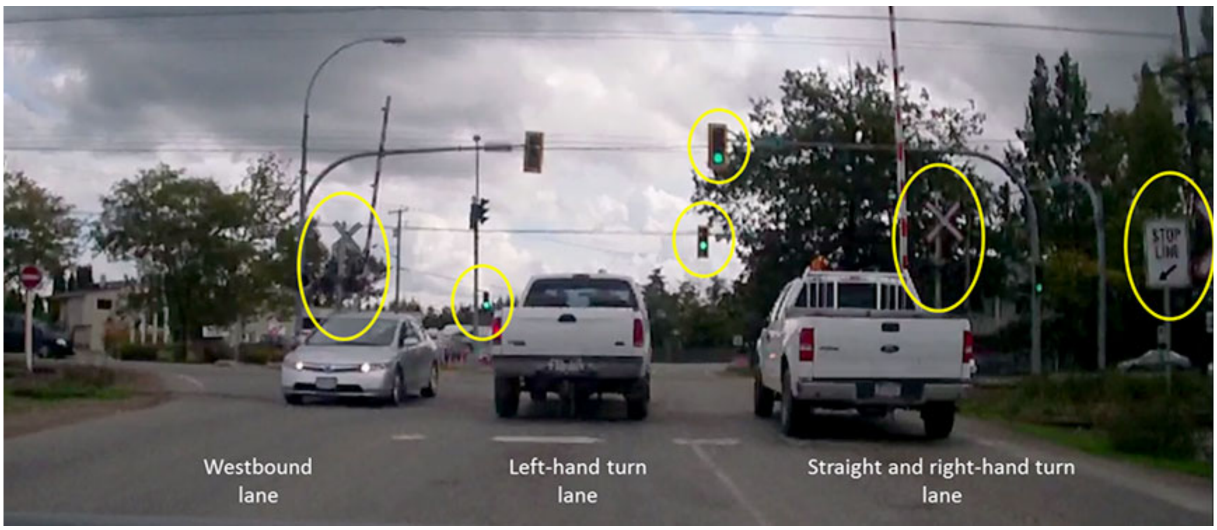

Figure 11. Visual cues with grade crossing warning system active

Approaching the crossing, a driver was presented with many different visual and auditory cues, which were dispersed across the driver's field of view. The GCWS flashing red lights and bell positioned initially to the right of the driver, and then subsequently to the left, had to compete for the driver's attention in the presence of other prominent cues, such as the traffic signals and movement of traffic in the intersection. In addition, as there was no stop sign at the initial RCS, drivers would normally have been moving when they were assessing the various cues and making a decision.

In 1998, as part of a safety study involving passive grade crossings, the NTSB determined that drivers who are fully stopped at a crossing are in a better position to and are more likely to look for an approaching train compared to drivers who are still moving. The NTSB recommended that stop signs be installed at all passive crossings.

1.24.2 Cognitive conspicuity

Drivers generally seek the most meaningful information needed for that particular road location and point in time,[48] fixating on the visual cues important to a scenario—often at the sacrifice of other available cues. This phenomenon is known as "perceptual bias."[49] It could include visually searching for traffic signals relevant for the driver's planned route or turn. To ensure that the driver sees the most important visual cues for that scenario, the driver would need to easily discriminate between the most relevant cues.

At the occurrence location, even with the interconnected traffic signals working as intended, drivers approaching the crossing eastbound can be presented with conflicting information. During site examination, it was noted that the traffic signals at the intersection remained green after the GCWS had initiated. In some situations, the traffic signals remained green throughout the GCWS sequence, and even upon arrival of a train at the crossing. There were also situations when the GCWS initiated at the same time as the traffic signals turned green, presenting stop and go indications simultaneously. Further, not only did red GCWS lights flash when there was an approaching train, but so did the green left-turn signals, indicating that both signal types were important.

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[48] Ibid.

[49] F.H. Allport, *Theories of Perception and the Concept of Structure* (Wiley, 1955).

1.25 Activation of schemas

Expectations and knowledge about a given situation are referred to as "schemas." Perceiving and thinking based on schemas allows humans to filter, organize, and act on large amounts of information quickly and without error, such as proceeding ahead at the sight of a left-turn green light. The activation of such a schema can reduce the probability of detecting subsequent signals, as the driver may be less likely to expect them. However, activation of schemas can also lead to discordance when a schema and situation do not match.[50] When drivers receive information *contrary* to their expectations, their performance tends to be slow or inappropriate.[51]

At this crossing, vehicle drivers sometimes received information that was contrary to their expectations, including a green traffic light with an activated GCWS. This may also occur at other similarly configured crossings.

1.26 Driver workload for left-hand turns

Driving is a complex task characterized by high demands on visual- and information-processing capacity. Certain driving manoeuvres are widely recognized by road safety researchers as being associated with increased driver workload. One such manoeuvre is a left turn across oncoming traffic, such as at an intersection, where a driver is required to (or expects to) wait for a gap in traffic before completing the turn. In-vehicle experimental research, using eye-tracking and other physiological (e.g., heart rate) and subjective measures of driver workload, has found that workload is greatest when drivers are making turns to the left across potential oncoming traffic.[46, 52]

If drivers are negotiating a complex manoeuvre, such as a left-hand turn at a busy and unfamiliar intersection, drivers may focus only on cues relevant for that manoeuvre. Such "inattention blindness"[53] can result in a driver mistakenly filtering out other important information that is available to the senses, something that also occurs with cellphone-related cognitive distraction.[31, 34, 35, 41, 43, 44, 45, 54] The TSB has previously identified inattention blindness as a contributory factor in other accidents at level crossings equipped with GCWS.[55]

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50 K. Smith and P.A. Hancock, "Situation awareness in adaptive, externally directed consciousness," *Human Factors*, Vol. 37, No. 1 (1995), pp. 137–148.

51 G.J. Alexander and H. Lunenfeld, "Driver expectancy in highway design and traffic operations," U.S. Department of Transportation report no. FHWA-TO-86-1 (April 1986).

52 L. Harms, "Variation in drivers' cognitive load: effects of driving through village areas and rural junctions," *Ergonomics*, Vol. 34, No. 2 (1991), pp. 151–160.

53 A. Mack and I. Rock, *Inattentional Blindness* (MIT Press, 1998).

54 P.M. Salmon, G.J. Read, N.A. Stanton and M.G. Lenné, "The crash at Kerang: investigating systemic and psychological factors leading to unintentional non-compliance at rail level crossings," *Accident Analysis & Prevention*, Vol. 50 (2013), pp. 1278–1288.

55 TSB Railway Investigation Report R13T0192.

In this occurrence, the ambulance driver had intended to turn left when approaching the crossing eastbound on Crush Crescent. The driver slowed to acquire traffic sightlines to ensure it was safe to proceed. At that time, the crossing was free of traffic, as all other traffic had been stopped by red traffic signals. On the approach and while in the left-hand lane, the driver’s main cue was a green left-turn arrow, positioned ahead of the left-turn lane and in the direction of the turn.

2.0 Analysis

In this occurrence, neither the ambulance nor the train had any pre-existing mechanical defects that would have contributed to the collision. The analysis will focus on the crossing complexity and its operation, on driver distraction, driver training, and supervision, as well as on the operation of the train to the crossing.

2.1 The accident

The collision occurred when the northbound train struck the eastbound ambulance that was foul of the main track at the crossing. The ambulance had proceeded onto the crossing and was stopped on the track in front of the approaching train. In an attempt to fit the ambulance between the main track and the descended gate for westbound traffic, the ambulance was moved forward, but was still not clear of the approaching train. While the driver perceived that the descended gate was impeding the forward progress of the ambulance, the crossing gate was to the north of the front of the ambulance and was not blocking the ambulance's forward progress. Moreover, crossing gates are designed to be easily broken to allow vehicles to force their way through to clear the crossing area if required.

2.2 Driver preparedness for the crossing and intersection

A number of cellphone connections between the ambulance driver and caller 1 and caller 2 had occurred that morning. These cellphone calls were important and/or complex for the ambulance driver, as indicated by the frequency of the calls, the promptness of the returned calls, and the ambulance driver's decision to use the cellphone while driving.

When operating a motor vehicle, a complex conversation can result in cognitive distraction both during the call and after the call. Due to the proximity of the calls to the occurrence crossing, the ambulance driver had likely become cognitively distracted while approaching and traversing the crossing. This distraction would have reduced the driver's capacity for visual scanning and visual processing. Other performance effects on driving included potential inattention blindness with "looked but failed to see" errors and slowed reaction times. In addition, the driver's lack of familiarity with the particular model of cellphone would have contributed to the level of distraction. The distraction of cellphone use likely decreased the driver's ability to detect warning stimuli in the environment while traversing the crossing.

2.3 Recognizing the activation of the grade crossing warning system

An active crossing with a grade crossing warning system (GCWS) is associated with less driver workload compared to a passive crossing, as the GCWS features reduce the demands on decision making. On approaching the crossing eastbound, the driver would have to make a stop/go decision, but this would have required only an assessment of the GCWS status. The ambulance driver perceived the GCWS to be inactive (that it was safe to proceed). As a result, the ambulance proceeded over the Milner storage track. However, the GCWS had begun to activate by this time.

The ambulance driver initially missed the activated GCWS signals as a result of a combination of factors, notably

- Distraction (looked but did not see) — The driver's capacity for visual processing may have been reduced due to distraction, resulting in an increased propensity for "looked but failed to see" errors.
- Left-turn focus (was not looking for GCWS) — The driver may have been focused on cues related to the higher workload task of turning left, such as green left-turn signals and traffic at the intersection (perceptual bias).
- Conspicuity (did not notice) — The GCWS flashing red lights may not have been sufficiently conspicuous to attract attention in the presence of several other visual cues at this complex crossing/intersection (e.g., flashing green left-turn signals in the centre of the driver's field of view).
- Obstruction (looked but could not see) — During the approach to the crossing, the red flashing lights on the right-hand side may have been momentarily obscured by the railway crossing sign (RCS) and stop line sign. During a visual scan at this time, these obstructions may have prevented the ambulance driver from seeing the GCWS lights. As the eastbound gate was still in a relatively raised position, the driver would have missed the only visual cue (red flashing lights) on the eastbound approach that the GCWS was active.

Once the stop/go decision was made prior to the initial RCS, the driver would not likely have been scanning for or expecting GCWS-related signals, increasing the probability that they would not be detected.

2.4 *Activation of schemas*

2.4.1 *Activation of "green light" schema*

A green traffic signal is likely to activate an "it is safe to proceed" schema. However, the interconnection between the traffic signals and the GCWS can result in a scenario where green lights are continually presented even though the GCWS is active.

Having observed the green traffic light at the Crush Crescent–Glover Road intersection, the ambulance driver's initial assessment that the GCWS was inactive would have been reinforced. The reduced available cognitive resources as a result of cellphone-related distraction would have reduced the probability that the driver noticed a discrepancy in the cues presented.

2.4.2 *Activation of "gate descent" schema*

Upon reaching the second set of tracks (mainline track), the ambulance driver's focus continued to be on the left-hand-turn green arrow. However, with the crossing gate for westbound/opposing traffic now descending directly in the driver's line of sight, the ambulance was brought to a stop. This crossing gate was not intended for the eastbound left-turn lane. However, the positioning of the ambulance, in part due to the faded road lane markings, had resulted in the ambulance being in close proximity to this crossing gate. The ambulance driver perceived that the crossing gate protruded directly in front of the ambulance when it did not.

Typically, a descended crossing gate will activate an “it is not safe to proceed” schema. Consistent with this schema, the driver stopped at the gate, even though it was feasible to go around the gate or to drive the ambulance past the gate. Even upon seeing and hearing the train, the driver attempted limited vehicle inputs, choosing to remain at a position that the driver thought was securely behind the gate. The driver had likely perceived the descended crossing gate as an indicator that it was not safe to proceed.

2.5 The complexity of the crossing

For eastbound vehicles on Crush Crescent approaching the crossing, drivers were presented with many different visual cues, which were dispersed across their field of view. In addition, as there was no stop sign at the RCS, the vehicles would typically be moving when the drivers were required to assess the cues and to make decisions relating to the operation of the vehicle.

Drivers will generally seek the most meaningful information needed for a particular road location (such as a road crossing) and specific point in time, often fixating on the visual cues important to a scenario to the detriment of other available cues. In this occurrence, the complexity of the two crossings and the adjacent intersection likely reduced the conspicuity of the crossing signals, decreasing the driver’s ability to detect warning stimuli in the environment.

2.6 Situational awareness

It is likely that any cellphone-related distraction, coupled with the workload/focus from the more complex task of turning left at an unfamiliar intersection, limited the driver’s ability to effectively achieve the first stage of situational awareness: perception of all the relevant elements in the environment. It is also likely that factors related to GCWS conspicuity and obstruction reduced the probability of the driver achieving this first stage.

In the absence of perceiving the relevant elements in the environment, such as the crossing geometry, GCWS signals, left-turn lane positioning, and purpose of the westbound gate, it is likely the driver was unable to have effectively achieved the next stage of situational awareness: assimilation and understanding of the context and associated hazards.

Once the driver positioned the ambulance on the tracks, the driver would not likely have had effective situational awareness of the geometry or features of the crossing and would not be aware of the hazard of the ambulance’s position.

2.7 Crossing geometry and design

The crossing installation comprised two road crossings that were within 13 m of each other. The main track was equipped with a GCWS, and the Milner storage track had an RCS. This design did not conform to the definition of a grade crossing, nor did the sightlines for the

Milner storage track meet the requirements specified in Transport Canada (TC)'s 2014 *Grade Crossings Regulations*. This configuration did meet the previous regulatory requirements. The requirements of the *Grade Crossings Regulations* must be met by 2021.

The engineering drawings prepared by the BC Ministry of Transportation and Infrastructure identified 3 lanes of traffic at the crossing:

1. The eastbound lane for traffic proceeding across or making a right-hand turn onto Glover Road;
2. The eastbound left-hand turn lane for traffic turning left onto Glover Road; and
3. The westbound lane for opposing traffic.

With two eastbound lanes and a single westbound lane, the line separating the two directions of travel is not coincident with the true centreline of the road. However, when the railway's site plan drawing for this crossing and its related GCWS was prepared, the centreline depicted on the BC Ministry of Transportation and Infrastructure drawing may have been interpreted by the railway as the line separating the lanes of opposite direction of travel. As a result, the crossing gate for the 2 eastbound lanes was designed shorter than necessary, and the crossing gate for the opposing westbound lane was designed longer than necessary. However, these gate arms met the regulatory requirements as specified in Section 12.1(5) of the *Grade Crossings Standards*. In addition, the distance from the warning system (flashing lights) to the centreline of the road (measured perpendicular to the road) exceeded 7.7 m, requiring a cantilevered light unit.

TC's *Grade Crossings Regulations* and, by reference, the *Grade Crossings Standards* came into effect in November 2014. Railways and road authorities have 7 years from the coming into force of these regulations to upgrade their crossings to comply with the new regulations. While the full impact of the improvements required by the new *Grade Crossings Regulations* will not be immediate, the risk of crossing accidents will incrementally reduce as the required crossing upgrades are implemented.

2.8 Roadway lane markings at the crossing

Roadway lane markings are designed to keep vehicles on the correct portion of the roadway. The roadway markings at the crossing at the time of the occurrence were worn and degraded, making it difficult for vehicle drivers to appropriately position their vehicle for the intended route. It is likely that the ambulance was out of position in part due to the lack of a clearly marked left-turn lane, leading to the ambulance coming in close proximity to the westbound gate arm. If roadway lane markings at railway crossings are not clearly visible, vehicles may be out of position when traversing the crossing, compromising the effectiveness of the GCWS and the traffic signals, and increasing the risk of a crossing accident.

2.9 *Testing the interconnection between the grade crossing warning system and traffic signals*

The U.S. Federal Railroad Administration, in its safety advisory of 2010, highlighted 4 items regarding the inspection and testing of the interconnection of traffic signals with a GCWS at highway grade crossings, including the following:

- Conduct comprehensive joint inspections of highway traffic signal pre-emption interconnections […] during which observation of the actual pre-emption function and its effect on the highway traffic signal system can be made.
- Install railroad and highway traffic signal recording devices at all new and improved highway-rail grade crossings that have active warning systems that are interconnected with highway traffic signal systems.
- Highway authority and railroad should maintain and upgrade existing railroad and highway traffic signal recording devices at highway-rail grade crossings that have active warning systems that are interconnected with highway traffic signal systems.
- Use the data provided by railroad and highway traffic signal recording devices during their comprehensive periodic joint inspections […] to determine whether further investigation of any recorded operational anomalies may be warranted.

For the occurrence crossing, the 5 previous years of inspections conducted for the interconnection between the GCWS and the traffic controller system were reviewed. During this period, the completeness of these inspections varied, both in quality and in the data that was documented. There was no indication that the review of any recorded information from the GCWS or the traffic controller system was part of the annual inspection, nor was it required by regulation. When this information is synchronized and compared, certain functions of the interconnection can be verified.

The interconnection testing was, at times, conducted by applying a track shunt within the crossing approach to simulate the approach of a train. However, the use of a shunt in this manner did not allow for detailed observation of the full operation and interaction between the GCWS and the traffic controller. Using this method of testing, a grade-crossing predictor can evaluate the simulated train only as a quick-moving train that will arrive at the crossing in a short period of time. Only real-time observation at the crossing will allow a full verification of the interconnection function between the GCWS and the traffic controller system. When yearly joint inspections are completed without the use of available recorded data and real-time observation, there is an increased risk that failures or inconsistencies in the interaction of GCWS with traffic signals may not be identified and corrected.

2.10 *Train operation and crew actions in the vicinity of the crossing*

The train was being operated at 34 mph, below the maximum authorized speed of 35 mph, as it approached the crossing. The train was not subject to any speed restrictions in the vicinity of the crossing. During the approach to the crossing, there was clear visibility and an unobstructed view from the locomotive cab.

The train crew observed the ambulance approach the crossing from the west and stop on the crossing. From their position, they could also visually verify that the GCWS was activated. They began sounding the locomotive horn as the train neared the whistle post (about ¼ mile from the crossing) as required by the CROR, and they observed the ambulance move forward twice. The train crew then sounded the horn continuously.

The train was being operated by the locomotive engineer trainee under the supervision of the in-charge locomotive engineer. The locomotive engineer opted to continue toward the crossing sounding the horn, as there did not appear to be any obstruction preventing the ambulance from clearing the crossing. Train crews are generally accustomed to encountering unauthorized persons on the railway right-of-way and vehicles that are momentarily stopped at crossings. It is not uncommon for pedestrians and/or vehicles to remain on the track until the last possible moment. As trains cannot stop quickly and they have the right-of-way on the track, train crew members generally expect that drivers and pedestrians will comply with audible warnings of an approaching train and activated GCWS at crossings. Given the absence of any apparent impediment to the ambulance clearing the crossing, along with observing the 2 short consecutive eastward movements of the ambulance and their past experience with vehicles occupying crossings, the train crew expected the ambulance to safely clear the crossing.

2.11 Driver training

The training program for new drivers at the British Columbia Ambulance Service (BCAS) provides instructions on many aspects of the operation of an emergency vehicle, including both practical (hands on) and theory (regulations and policies). However, there was no specific information or instructions concerning grade crossing safety. Operation Lifesaver's driver's training course is specifically aimed at emergency responders, who, through the course of their duties, interact with railway crossings. This information was not a part of BCAS driver training. The Operation Lifesaver course provides important information specific to safely traversing railway grade crossings and conducting emergency response activities in proximity to an active railway crossing. BCAS driver training did not include information specific to the safe operation of emergency vehicles over railway crossings or the safe conduct of emergency response activities at crossings.

For any training program to be effective, it must cover the necessary information and be available to all employees who require the training. This is particularly important for employees working in safety-sensitive positions, including ambulance drivers / paramedics. Even when performing patient transfers that are not emergency situations, paramedics are responsible for the well-being of colleagues and vulnerable individuals.

Effective and practical training in all aspects of vehicle operations is important for professional drivers to acquire the knowledge and skills they need to safely and effectively perform their work. In this occurrence, the ambulance driver had completed only 1 part of the driver training requirements (the *Emergency Vehicle Driving Regulation* course), which allowed the driver to operate in code 3 situations (emergent).

2.12 Driver supervision and performance monitoring

In addition to driver training, regular evaluation of driving skills through performance monitoring is necessary to ensure that the training has been effective, the drivers are putting into practice what they have learned, and the drivers maintain the knowledge and driving skills they have developed. Performance monitoring also provides a tool to ensure that drivers are adhering to policies, procedures, and applicable regulatory requirements.

At BCAS, the expectation was that supervisors would ensure that policies, procedures, and regulations were being followed and that supervisors were working with the employees to address any concerns. However, BCAS did not have a performance monitoring system in place to evaluate drivers for compliance with provincial and company standards and to assess the effectiveness of company driver training.

3.0 Findings

3.1 Findings as to causes and contributing factors

1. The collision occurred when the northbound train struck the eastbound ambulance that was foul of the main track at the crossing.

2. The ambulance had proceeded onto the crossing and was stopped on the track in front of the approaching train.

3. In an attempt to fit the ambulance between the main track and the descended gate for westbound traffic, the ambulance was moved forward, but was still not clear of the approaching train.

4. While the driver perceived that the descended gate was impeding the forward progress of the ambulance, the gate was to the north of the front of the ambulance and did not block its forward progress.

5. The distraction of cellphone use likely decreased the driver's ability to detect warning stimuli in the environment while traversing the crossing.

6. Once the stop/go decision was made prior to the initial railway crossing sign, the driver would not likely have been scanning for or expecting grade crossing warning system (GCWS)–related signals, increasing the probability that they would not be detected.

7. Having observed the green traffic light at the Crush Crescent–Glover Road intersection, the ambulance driver's initial assessment that the GCWS was inactive would have been reinforced.

8. The reduced available cognitive resources as a result of cellphone-related distraction would have reduced the probability that the driver noticed a discrepancy in the cues presented.

9. The complexity of the 2 crossings and the adjacent intersection likely reduced the conspicuity of the crossing signals, decreasing the driver's ability to detect warning stimuli in the environment.

10. The driver had likely perceived the descended crossing gate as an indicator that it was not safe to proceed.

11. Once the driver positioned the ambulance on the tracks, the driver would not likely have had effective situational awareness of the geometry or features of the crossing and would not be aware of the hazard of the ambulance's position.

12. It is likely that the ambulance was out of position in part due to the lack of a clearly marked left-turn lane, leading to the ambulance coming in close proximity of the westbound gate arm.

3.2 Findings as to risk

1. If roadway lane markings at railway crossings are not clearly visible, vehicles may be out of position when traversing the crossing, compromising the effectiveness of the grade crossing warning system and the traffic signals, increasing the risk of a crossing accident.

2. When yearly joint inspections are completed without the use of available recorded data and real-time observation, there is an increased risk that failures or inconsistencies in the interaction of grade crossing warning systems with traffic signals may not be identified and corrected.

3.3 Other findings

1. While the full impact of the improvements required by the new *Grade Crossings Regulations* will not be immediate, the risk of crossing accidents will incrementally reduce as the required crossing upgrades are implemented.

2. The recorded information indicates that the train was operated in accordance with railway and regulatory requirements. Given the absence of any apparent impediment to the ambulance clearing the crossing, along with observing the 2 short consecutive eastward movements of the ambulance and their past experience with vehicles occupying crossings, the train crew expected the ambulance to safely clear the crossing.

3. British Columbia Ambulance Service driver training did not include information specific to the safe operation of emergency vehicles over railway crossings or the safe conduct of emergency response activities at crossings.

4. The ambulance driver had completed only 1 part of the driver training requirements (the *Emergency Vehicle Driving Regulation* course), which allowed the driver to operate in code 3 situations (emergent).

5. British Columbia Ambulance Service did not have a performance monitoring system in place to evaluate drivers for compliance with provincial and company standards and to assess the effectiveness of company driver training.

4.0 Safety action

4.1 Safety action taken

4.1.1 Transport Canada

On 10 February 2016, Transport Canada (TC) performed a detailed inspection at the crossing and determined that

- The design vehicle did not correspond to the use of the existing grade crossing.
- The current timing configuration for traffic light pre-emption and warning system gate delay was inadequate for longer vehicles to safely clear the crossing on the approach of a train.
- Roadway pavement markings were either absent or faded, such that drivers were not provided with adequate information.

On 11 February 2016, TC issued a Notice to Canadian Pacific Railway (CP), the BC Ministry of Transportation and Infrastructure (MOTI), and the Township of Langley regarding the occurrence crossing. The Notice highlighted concerns with the railway controller, traffic controller, and pre-emption interconnection. In addition, the Notice identified concerns with timing configuration for traffic light pre-emption and warning system gate arm clearance time due to the selection of an incorrect design vehicle. The Notice also expressed concern that the roadway pavement markings were either absent or faded, such that drivers were not provided with adequate information.

In compliance with the Notice, the following changes were made:

- The gate drop delay was changed to 12 seconds from 8 seconds to facilitate an 18 m vehicle instead of a 6 m passenger car.
- The advanced left clear-out was extended to facilitate a longer queue.
- The total crossing warning time was extended from 50 seconds to 54 seconds.

Table 5 – Grade crossing warning system and traffic signal timing

Seconds to train	Grade crossing warning system (GCWS) activity	Traffic signal response worst case: Green, Glover Road	Traffic signal response best case: All red, Glover Road and Crush Crescent
54	Equip resp.	Equip resp.	Equip resp.
53	Equip resp.	Equip resp.	Equip resp.
52	Equip resp.	Equip resp.	Equip resp.
51	Equip resp.	Equip resp.	Equip resp.
50	Equip resp.	Equip resp.	Equip resp.
49	Adv. preempt	Min entry green	RR all red
48	Adv. preempt	Min entry green	RR all red
47	Adv. preempt	Advance warning	Crush clearance queue begins moving
46	Adv. preempt	Advance warning	Crush clearance

Seconds to train	Grade crossing warning system (GCWS) activity	Traffic signal response worst case: Green, Glover Road	Traffic signal response best case: All red, Glover Road and Crush Crescent
45	Adv. preempt	Advance warning	Crush clearance
44	Adv. preempt	Advance warning	Crush clearance
43	Adv. preempt	Advance warning	Crush clearance
42	Adv. preempt	Yellow	Crush clearance – design vehicle begins moving
41	Adv. preempt	Yellow	Crush clearance
40	Adv. preempt	Yellow	Crush clearance
39	Adv. preempt	Yellow	Crush clearance
38	Adv. preempt	Yellow	Crush clearance
37	Adv. preempt	Red	Crush clearance
36	Adv. preempt	All red	Crush clearance
35	Adv. preempt	All red	Crush clearance
34	Flashers	Crush Crescent – queue begins moving	Crush clearance
33	Flashers	Crush clearance	Crush clearance
32	Flashers	Crush clearance	Crush clearance
31	Flashers	Crush clearance	Crush clearance
30	Flashers	Crush clearance	Crush clearance
29	Flashers	Crush clearance – design vehicle begins moving	Crush clearance
28	Flashers	Crush clearance	Crush clearance – design vehicle clears crossing
27	Flashers	Crush clearance	Crush clearance
26	Flashers	Crush clearance	Crush clearance
25	Flashers	Crush clearance	Crush clearance
24	Flashers	Crush clearance	Crush clearance
23	Flashers	Crush clearance	Crush clearance
22	Gates dropping	Crush clearance	Crush clearance
21	Gates dropping	Crush clearance	Crush clearance
20	Gates dropping	Crush clearance	Crush clearance
19	Gates dropping	Crush clearance	Crush clearance
18	Gates dropping	Crush clearance	Crush clearance
17	Gates dropping	Crush clearance	Crush clearance
16	Gates dropping	Crush clearance	Crush clearance
15	Gates dropping	Crush clearance – design vehicle clears crossing	Crush clearance
14	Gates dropping	Crush clearance	Crush clearance
13	Gates dropping	Crush clearance	Crush clearance
12	Gates dropping	Crush clearance	Crush clearance

Seconds to train	Grade crossing warning system (GCWS) activity	Traffic signal response worst case: Green, Glover Road	Traffic signal response best case: All red, Glover Road and Crush Crescent
11	Gates dropping	Crush clearance	Crush clearance
10	Gates down	Crush clearance	Crush clearance
9	Gates down	Crush clearance	Yellow
8	Gates down	Crush clearance	Yellow
7	Gates down	Crush clearance	Yellow
6	Gates down	Crush clearance	Yellow
5	Gates down	Crush clearance	Yellow
4	Gates down	Crush clearance	Red
3	Gates down	Crush clearance	Hwy 10
2	Gates down	Crush clearance	Hwy 10
1	Gates down	Crush clearance	Hwy 10
0	Train	Crush clearance	Hwy 10
	Train	Crush clearance	Hwy 10
	Train	Crush clearance	Hwy 10
	Train	Crush clearance	Hwy 10
	Train	Crush clearance	Hwy 10
	Train	Yellow	Hwy 10
	Train	Yellow	Hwy 10
	Train	Yellow	Hwy 10
	Train	Yellow	Hwy 10
	Train	Yellow	Hwy 10
	Train	Red	Hwy 10
	Train	Hwy 10	Hwy 10

Source: Transport Canada

In addition, TC is updating its guidance material (*Guideline For Inspecting and Testing Preemption of Interconnected Traffic Control Signals and Railway Crossing Warning Systems* [TP13755]) for industry stakeholders relating to the maintenance/testing of interconnected traffic signals with GCWS.

4.1.2 Ministry of Transportation and Infrastructure

In June 2016, MOTI upgraded the traffic signal controller from an LMD 8000 to an Econolite Cobalt with a 10-wire interconnection with the railway signal bungalow. This upgrade provided additional safety features such as the following:

- Double break and supervisor circuits that would place the signal into flash if a fault in the rail pre-emption circuit occurs. In these situations, the signal would flash red in all directions.
- Another circuit would communicate to the railway controller when the signal is in flash for any reason. Therefore, when a train is detected, the railway controller would

omit the advanced pre-emption time and begin to activate the railway automated warning devices immediately.
- The 10-wire interconnection provides a circuit to communicate to the controller when the railway gate is horizontal. Therefore, the signal can remain green until a few seconds after the gate physically restricts passage onto the railway tracks. This would avoid inadvertently trapping vehicles in the track area with an early red traffic signal display if they had advanced contrary to the "stop indication" of the railway automated warning devices.

In addition, MOTI installed a blank out LED sign in advance of the cantilevered signal on Crush Crescent that would activate immediately upon receiving a rail pre-emption call. This would provide notification to oncoming Crush Crescent eastbound drivers of an approaching train 15 seconds prior to the activation of the railway automated warning devices. A "No Right Turn" blank out LED sign was added on Glover Road approaching Crush Crescent.

To improve the visual conspicuity of the intersection traffic signal displays for Crush Crescent drivers, 2 other displays were added, providing 6 displays in total. Three of the displays are on the near side of the intersection, and 3 are on the far side of the intersection (east side of Glover Road).

At the time of the occurrence, the additional green time for the far-side signals was 4 seconds. This additional clearance green time was increased to 7.1 seconds to accommodate the relocated stop line, the increased gate drop delay, and a clearance travel speed of 15 km/h over the tracks.

4.1.3 Transportation Safety Board Railway Safety Advisory

On 17 March 2016, the TSB issued a Railway Safety Advisory (RSA) concerning the operation of the automatic warning device (AWD)[56] and the road traffic signals at the occurrence crossing.[57]

The RSA noted that the AWD and the road traffic signals may present conflicting information to queued motorists eastbound on Crush Crescent:

> This location presents a complex signaling challenge in which the interconnection of the AWD with the traffic signal system must safely protect vehicular traffic from passing trains. At the same time, the road traffic signals must regulate the safe flow of vehicles through this intersection. With eastbound vehicles being presented with "Stop" and "Go" commands simultaneously from the AWD and the road traffic signals, motorists may become confused. Therefore, Transport Canada, the BC Ministry of Transportation and the Canadian Pacific Railway may wish to conduct a

[56] AWD is called "grade crossing warning system (GCWS)" in this report.

[57] Transportation Safety Board, Rail Safety Advisory Letter 07/16: Crossing Safety at Crush Crescent–Glover Road in Langley, BC (17 March 2016).

> review of the design and function of the Crush Crescent/Glover Road crossing, including a review of the interconnection between the crossing AWD and the road traffic signal system, to ensure that the risks to motorists at this crossing are minimized.

As a result of the RSA, the crossing design was reviewed again by TC. Through this review, TC determined that with the GCWS signal and gate at the mainline crossing, and the Milner storage track protected by the standard railway crossing sign, there were effectively 2 separate crossings. Since the mainline track and the Milner storage track were separated by about 13 m, these 2 tracks should have been treated as 1 crossing, as per the definition of a single-grade crossing in the *Grade Crossings Regulations*, which states: "… two or more road crossings at grade where the lines of the railway are not separated by more than 30 m."

On 10 May 2017, the TSB issued a second RSA concerning the jurisdictional responsibility for roadway markings at the Crush Crescent – Glover Road crossing. The RSA noted that:

> Roadway lane markings are designed to keep vehicles on the correct portion of the roadway. While some of the roadway markings were recently re-painted by CP, these markings will inevitably fade, which may place motorists at risk. With no clear jurisdictional responsibility for roadway markings at this crossing, it is unknown if the roadway markings will be effectively maintained in the future. In addition, it is unknown if there are other grade crossings with adjoining road authorities in the province of BC that have resulted in unclear jurisdictional responsibility for roadway markings.
>
> Given the importance of maintaining roadway markings, particularly in the vicinity of grade crossings, the jurisdictional responsibility for this activity should be resolved in a timely manner for the Crush Crescent - Glover Road crossing, and for other crossings in the province of BC where this responsibility is unclear.

On 26 June 2017, MOTI responded indicating (in part) that:

> It is important to identify any locations where jurisdictional responsibility is unclear. While we are unaware of any other locations subject to jurisdictional dispute, ministry staff are currently undertaking a detailed review of all crossings within municipalities that adjoin provincial roads and highways.

4.1.4 Canadian Pacific Railway

On 18 February 2016, Canadian Pacific Railway upgraded the crossing control equipment from a Safetran GCP 62660 predictor to a GETS HXP-3R Unit AH that is capable of operating longer approach lengths to accommodate the additional times requested. On 09 June 2016, the crossing control equipment was further upgraded to a GETS XP4 Unit.

In June 2016, the GCWS located on the west side of the main track was relocated to the west side of the Milner storage track. The flashing lights were incorporated into a cantilever at the same location. These changes resulted in aligning the crossing with the definition of a grade crossing found in the *Grade Crossings Standards*, as well as addressing some sightline issues that would have had to be addressed by 2021.

In March 2016, while it was not the responsibility of the railway, Canadian Pacific Railway updated (repainted) some of the pavement markings at the crossing.

4.1.5 British Columbia Emergency Health Services

Following the occurrence, British Columbia Emergency Health Services (BCEHS) made the following changes to driver education:

- In July 2016, BCEHS appointed an education officer for the BCEHS Driver Training Program with responsibility for oversight of content and implementation of changes/updates to the program curriculum.
- BCEHS developed a new driver evaluation form, which was implemented in July 2016. For new hires, the evaluation will occur between 2 and 4 weeks following the Fundamentals of Emergency Vehicle Operation course, which provides time to practise driving with unit chiefs. Vancouver Post Orientation Program evaluations will occur after drivers have completed at least 8 routine code 2 drive shifts and 4 restricted code 3 shifts. The new evaluation form provides BCEHS with the ability to analyze and measure statistics for successful and unsuccessful drivers. Results from the analysis will be used to inform changes to the educational curriculum.
- The New Employee Orientation course (including Fundamentals of Emergency Vehicle Operation) was updated to include information on trains and railway crossings, driver fatigue, and distracted driving. As of November 2015, this training also reinforces the Insurance Corporation of British Columbia's content for Class 4 and Class 5 licences with respect to trains.
- In January 2017, BCEHS added the Operation Lifesaver course to the training program.
- The Vancouver Post Orientation Program was updated to include information on trains and railway crossings.

To highlight the roadway lane marking deficiencies at the crossing, BCEHS sent a letter to the Township of Langley on 11 December 2015, and to the Ministry of Transportation and Infrastructure on 03 August 2016.

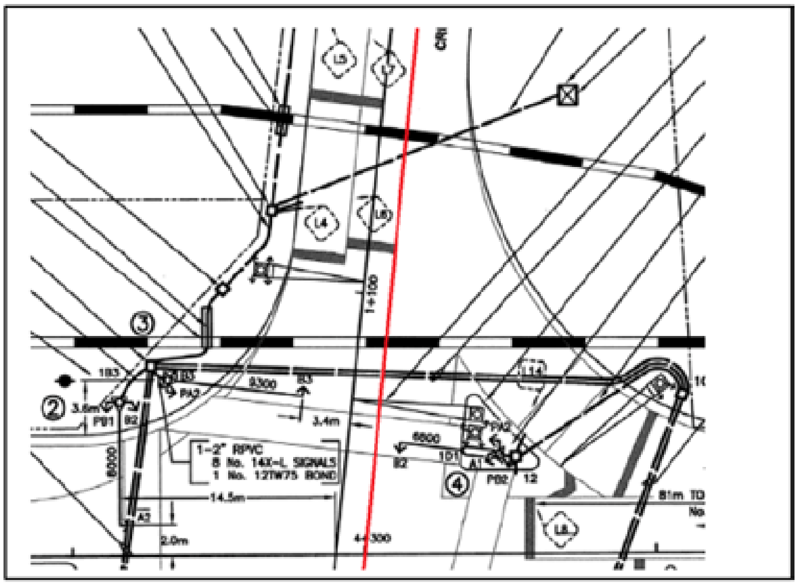
This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 17 May 2017. It was officially released on 13 July 2017.

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 key safety issues that need to be addressed to make Canada's transportation system even safer. 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.

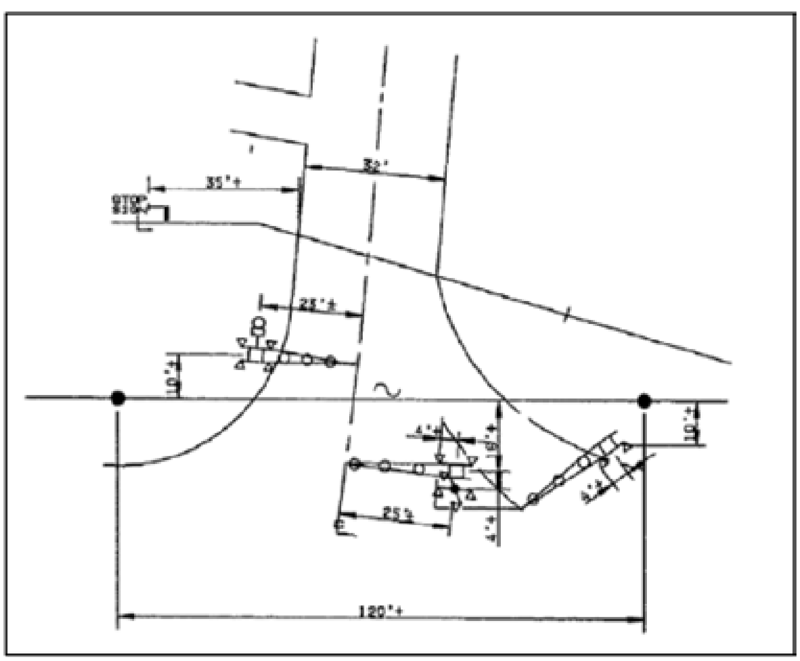
Appendices

Appendix A – Schematics of the crossing and intersection, prepared by BC Ministry of Transportation and Infrastructure and Canadian Pacific Railway

BC MOTI drawing of the intersection



CP signal layout plan



Appendix B – Safety Advisory 2010-02

US Federal Register / Vol. 75, No. 190 / Friday, October 1, 2010 / Notices

DEPARTMENT OF TRANSPORTATION
Federal Railroad Administration
Safety Advisory 2010–02

AGENCY: Federal Railroad Administration (FRA), Department of Transportation (DOT).

ACTION: Notice of Safety Advisory; Signal Recording Devices for Highway-Rail Grade Crossing Active Warning Systems that are Interconnected with Highway Traffic Signal Systems.

SUMMARY:

FRA is issuing Safety Advisory 2010–02 to address Safety Recommendations I–96–10 and I-96–11, issued by the National Transportation Safety Board (NTSB) that relate to railroad and highway signal recording devices at highway-rail grade crossings equipped with active warning systems that are interconnected with highway traffic signal systems. This safety advisory recommends that States, local highway authorities, and railroads install, maintain, and upgrade railroad and highway traffic signal recording devices at these types of grade crossings. This safety advisory also recommends that States, local highway authorities, and railroads conduct comprehensive periodic joint inspections of highway traffic signal pre-emption interconnections and use information obtained from any railroad and highway traffic signal recording devices during those inspections.

SUPPLEMENTARY INFORMATION:

In Safety Recommendation I–96–10, the NTSB recommended that DOT require the use and maintenance of railroad and highway traffic signal recording devices at all new and improved highway-rail grade crossings equipped with active warning systems that are interconnected with highway traffic signal systems. These devices should be capable of recording sufficient parameters to allow railroad and highway personnel to readily determine that the highway traffic signals and railroad active warning systems are operating properly and in a coordinated manner. The NTSB further recommended that DOT require the use of information obtained from these railroad and highway traffic signal recording devices during comprehensive and periodic joint inspections.

In Safety Recommendation I–96–11, the NTSB recommended that DOT require the retention or upgrading of existing recording devices installed at highway-rail grade crossings equipped with active railroad warning systems that are interconnected with highway traffic signal systems. In addition, the NTSB recommended that DOT require maintenance of these recording devices and the use of information obtained from the devices during comprehensive and periodic joint inspections.

Highway traffic signal pre-emption interconnections, when present, play a critical role in the proper functioning of a highway-rail grade crossing active warning system. By changing the sequence of the traffic signal to allow highway traffic to exit the crossing prior to the arrival of a train, they can prevent vehicle entrapment on the highway-rail grade crossing. Also, the changed traffic signal sequence prevents conflicting visual traffic control messages for motorists approaching highway-rail grade crossings located in close proximity to highway traffic control signals (i.e., a proceed highway traffic signal display into a nearby highway-rail grade crossing active warning system which is activated to indicate the approach or occupancy of a train).

In order to facilitate the proper functioning of the highway traffic signal pre-emption interconnection, 49 CFR 234.261 requires that railroads test each highway traffic signal pre-emption interconnection at least once each month. Therefore, States, local highway authorities, and railroads should identify which highway-rail grade crossings are equipped, or intended to be equipped, with a highway traffic signal pre-emption interconnection. If so equipped, railroads should ensure that the circuit plan shows the actual interconnection and the designed pre-emption time. Railroads should also ensure that the interconnection is in place and the train detection device (or equivalent) is programmed or equipped to provide the appropriate designed pre-emption function.

While FRA regulations require the testing of highway traffic signal pre-emption interconnections at least once a month, this requirement has historically only been applicable to the proper functioning of the railroad's control circuit to the highway traffic controller. While inspecting the highway traffic signal pre-emption interconnection, the actual operation of the highway traffic signal should be observed. Railroads should not rely solely on the operation of a relay or the opening of a control circuit to the traffic signal control housing. In fact, the preferred method of testing highway traffic signal pre-emption is by observation of a train movement and of the actual pre-emption function. Therefore, FRA recommends that railroads conduct comprehensive joint inspections of the highway traffic signal pre-emption interconnection with State and local highway authorities. These comprehensive joint inspections should be conducted when the highway-rail grade crossing active warning system is placed in service, whenever any portion of the system which may affect the proper function of the interconnection is modified or disarranged, and at least once every 12 months, during which observation of the actual pre-emption function and its effect on the highway traffic signal system can be made. These comprehensive periodic joint inspections should also include an inspection of the timing and operation of highway traffic signal systems that are interconnected with highway-rail grade crossing active warning devices, in order to ensure that the highway traffic signal system responds appropriately to the railroad control circuit and as designed. By conducting comprehensive periodic joint inspections, the railroad and State and local highway authorities can work together to observe and verify proper functioning of all necessary components of the highway traffic signal pre-emption upon activation of the highway-rail grade crossing active warning system.

Neither the Federal Highway Administration (FHWA) nor FRA require the retention or installation of railroad or highway signal recording devices at highway-rail grade crossings.

However, in recognition of the critical role served by highway traffic signal pre-emption interconnections with respect to the proper functioning of a highway-rail grade crossing active warning system, States, local highway authorities, and railroads are encouraged to install railroad and highway traffic signal recording devices at all new and improved highway-rail grade crossings that have (or will have) active warning systems which are (or will be) interconnected with highway traffic signal systems. Railroad and highway traffic signal recording devices can provide a record of any anomalies associated with the operation of the highway-rail grade crossing active warning system and/or the highway traffic signal system, which may prompt further investigation. Thus, as noted by the NTSB, these recording devices should be capable of recording sufficient parameters to allow railroad and highway personnel to readily determine that the highway traffic signals and railroad-activated warning systems are coordinated and operating properly.

States, local highway authorities, and railroads are also encouraged to maintain and upgrade existing railroad and highway traffic signal recording devices at highway-rail grade crossings that have active warning systems which are interconnected with highway signal systems. With respect to signal recording devices for highway-rail grade crossing active warning systems, older devices can record basic information such as approach time and estimated train speed. However, current signal recording devices for highway-rail grade crossing active warning systems can monitor a variety of system functions and provide reports on the ''health'' of the warning system, such as the status of the flashing light units, gate position, power supply, the presence of any grounded circuits, etc. Many modern traffic signal systems feature software that includes various event logs that get recorded in the traffic signal controller itself. These event logs are periodically retrieved by the central system software. Among the data retrieved would be any observed conflicts or preempts, as well as logs and diagnostics on the vehicle detector in-pavement ''loops''. Recognizing that data provided by signal recording devices can assist States, local highway authorities, and railroads with the maintenance of interconnected highway-rail grade crossing active warning systems and highway traffic signal systems, FRA recommends that States, local highway authorities, and railroads use the data provided by these recording devices during their comprehensive periodic joint inspections to determine whether further investigation of any recorded operational anomalies may be warranted. It should be noted that railroad and highway traffic signal recording devices may be eligible for funding through FHWA's Railway-Highway Crossings Program (23 USC 130).

Recommended Action:

Based on the foregoing discussion and to promote the safety of highway-rail grade crossings on the Nation's railroads, FRA recommends the following:

(1) Each State and local highway authority and railroad should conduct comprehensive joint inspections of highway traffic signal pre-emption interconnections when the highway-rail grade crossing active warning system is placed in service, whenever any portion of the system which may affect the proper function of the interconnection is modified or disarranged, and at least once every

12 months, during which observation of the actual pre-emption function and its effect on the highway traffic signal system can be made;

(2) Each State and local highway authority and railroad should install railroad and highway traffic signal recording devices at all new and improved highway-rail grade crossings that have active warning systems which are interconnected with highway traffic signal systems;

(3) Each State and local highway authority and railroad should maintain and upgrade existing railroad and highway traffic signal recording devices at highway-rail grade crossings that have active warning systems which are interconnected with highway traffic signal systems; and

(4) Each State and local highway authority and railroad should use the data provided by railroad and highway traffic signal recording devices during their comprehensive periodic joint inspections of interconnected highway-rail grade crossing active warning systems and highway traffic signal systems to determine whether further investigation of any recorded operational anomalies may be warranted.

States and local highway authorities and railroads are encouraged to take action consistent with the preceding recommendations to help ensure the safety of highway-rail grade crossings. FRA may modify this Safety Advisory 2010–02, or take other appropriate action necessary, to ensure the highest level of safety on the Nation's railroads.

Issued in Washington, DC, on September 27, 2010.

Jo Strang,
Associated Administrator for Railroad Safety/Chief Safety Officer.