



Transport Accident
Investigation
Commission

Final report

Rail inquiry RO-2020-102

Express freight Train 932

***strikes hi-rail vehicle at Limeworks Road public
level crossing between Milton and Henley***

24 April 2020

September 2021



About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas.

The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. It is not the Commission's purpose to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. However, the Commission will not refrain from fully reporting on the circumstances and factors contributing to an accident because fault or liability may be inferred from the findings.

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Citations and referencing

This draft report does not cite information derived from interviews during the Commission's inquiry into the occurrence. Documents normally accessible to industry participants only and not discoverable under the Official Information Act 1982 are referenced as footnotes only. Publicly available documents referred to during the Commission's inquiry are cited.

Photographs, diagrams, pictures

The Commission has provided, and owns, the photographs, diagrams and pictures in this report unless otherwise specified.

Verbal probability expressions

This report uses standard terminology to describe the degree of probability (or likelihood) that an event happened, or a condition existed in support of a hypothesis. The expressions are defined in the table below.

Terminology*	Likelihood	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

*Adopted from the Intergovernmental Panel on Climate Change



Figure 1: Train 932 and hi-rail vehicle after collision
(Credit: KiwiRail)

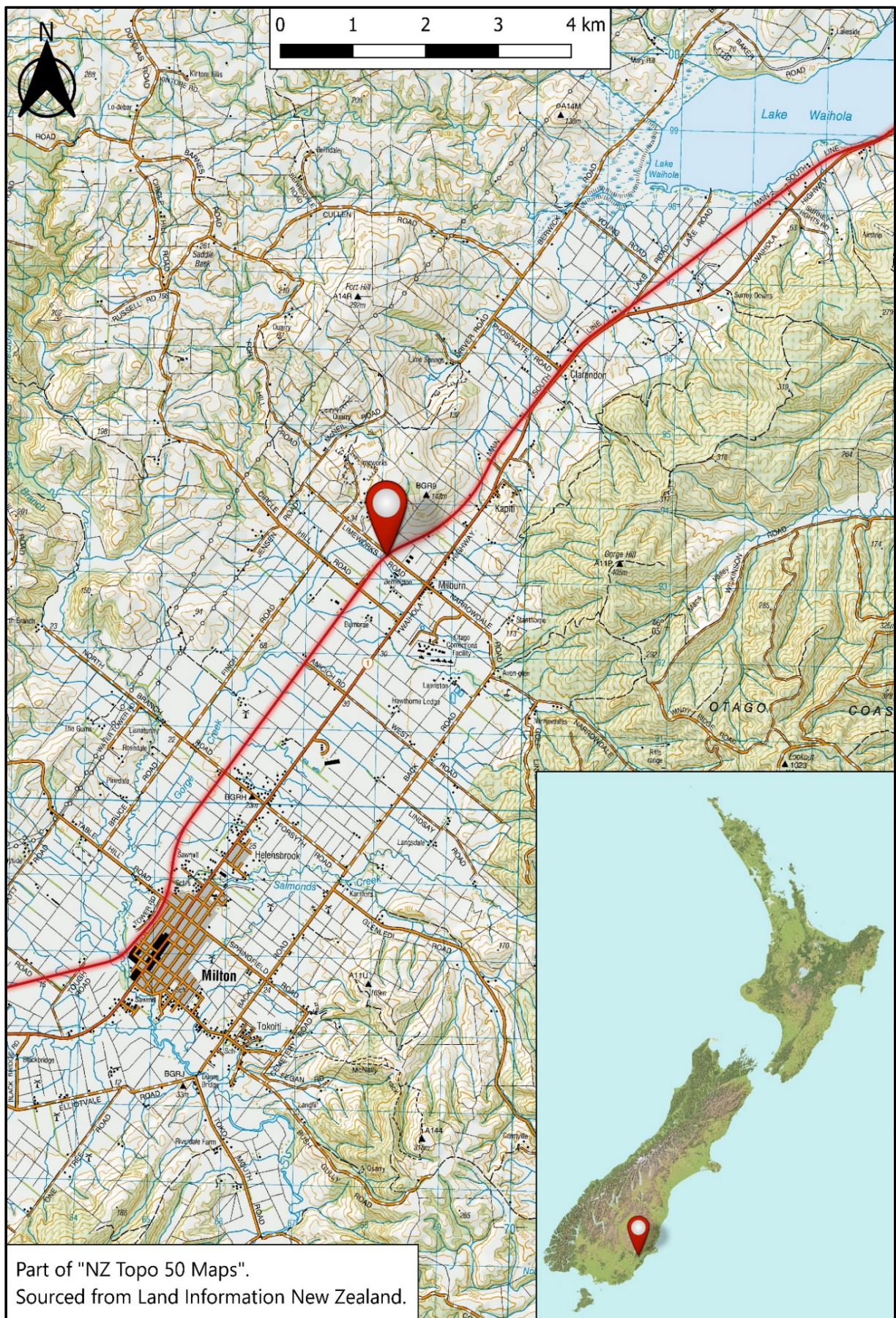


Figure 2: Location of accident

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1 Executive summary

What happened

- 1.1 At about 1501 on Friday 24 April 2020, the track ganger – driver of hi-rail vehicle 36783 – received a track warrant conditional on the departure of Train 932 from 429 km Main South line, near Limeworks Road between Milton and Henley.
- 1.2 The track ganger started to place the hi-rail vehicle on the track, and was at the vehicle's rear, when they heard Train 932's horn sound and then saw the train approaching head-on.
- 1.3 The track ganger attempted to raise the hi-rail vehicle wheels but was unsuccessful and jumped clear of the hi-rail vehicle before it was struck by the train at 1504.
- 1.4 The train driver, on realising the hi-rail vehicle was on the track, applied full-service braking and prepared for impact. The train collided with the hi-rail vehicle at a speed of 44 kilometres-per-hour and pushed it 139 metres before coming to a stop.
- 1.5 The hi-rail vehicle was extensively damaged and the locomotive sustained minor damage.
- 1.6 There were no injuries.

Why it happened

- 1.7 The track warrant control rules allowed the train controller to issue a track warrant to a hi-rail vehicle operator conditional on the departure of a train from the location of where the track warrant was accepted.
- 1.8 The track ganger did not verify that Train 932 had passed before the hi-rail vehicle was placed on the track.
- 1.9 The collision speed could have been reduced if the train driver had applied emergency braking rather than full-service braking.

What we can learn

- 1.10 Issuing track warrants to infrastructure staff, hi-rail vehicles or trolley users that are conditional on the arrival or departure of trains is likely to endanger lives by causing accidents if the track warrant holders fail to confirm train locations.
- 1.11 Applying the train brake in its emergency position will achieve a shorter stopping distance than applying it to its full-service position.

Who may benefit

- 1.12 Rail operators may benefit from the key lessons.

2 Factual information

Narrative

- 2.1 At 1209¹ on Friday 24 April 2020, the train controller² managing the Main South line³ issued track warrant⁴ 51 (see Appendix 1) to the driver of express freight Train 932 (the train). The track warrant authorised the north-bound train to proceed from North Edendale Siding to Mosgiel on the Main South line, a journey of about 170 kilometres (km) (see figure 3). A condition of the track warrant required the train driver to make mandatory radio calls to train control at Matura, Balclutha and Henley.

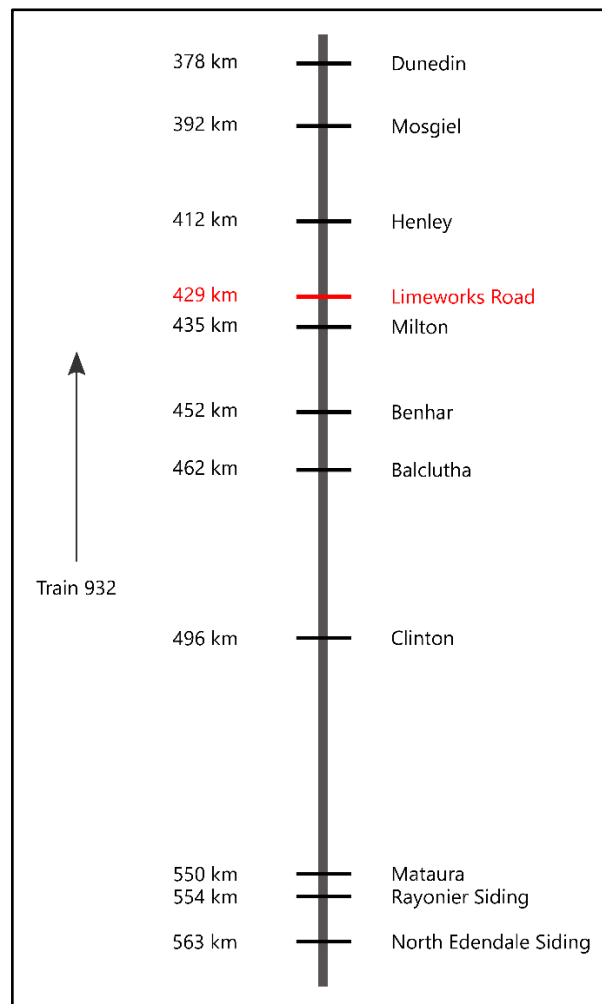


Figure 3: Schematic diagram of train's route

- 2.2 The train departed from North Edendale Siding at 1212, hauling 16 wagons loaded with milk powder. An additional 16 wagons loaded with custom wood were uplifted from Rayonier Siding, about 10 kilometres north of North Edendale Siding. The 541-metre-long train consisted of 2 DXC-class locomotives hauling 32 wagons with a total weight of 1856 tonnes.

¹ Times in this report are New Zealand Standard Times and expressed in the 24-hour mode.

² A person qualified to authorise train movements and track occupations.

³ A 601-kilometre-long line that runs from Lyttelton, near Christchurch, to Invercargill. The 0.00 km peg is at Lyttelton.

⁴ A written instruction issued by train control to authorise the occupation of a defined section of track.

- 2.3 At about 1230 a track inspector identified a 30-millimetre-long pull-apart⁵ within the set of mainline points⁶ at the north end of Milton crossing station. The inspector determined that the line could remain open with a 40-kilometre-per-hour temporary speed restriction⁷ in place over the set of points until the pull-apart had been repaired. The inspector was not in possession of temporary speed boards⁸ so phoned the track ganger⁹ to arrange the siting of these boards to mark the start and finish of the temporary speed restriction.
- 2.4 The track ganger was not on active duty that day because of the COVID-19 Alert Level 4 lockdown and did not respond to the call immediately.
- 2.5 At about 1245 the track inspector informed the train controller of the new 40 kilometres-per-hour temporary speed restriction from 434.415 km to 434.525 km on the Main South line, adding that the boards were not in place.
- 2.6 At about 1250 the train controller radioed the train driver, before the train had departed from Rayonier Siding, to advise of the new temporary speed restriction over the set of points at the north end of Milton. The train controller also stated that there were no boards in place at that time. The train driver then wrote "40 Milton" on the track warrant form.
- 2.7 At 1322 the track ganger returned the phone call to the track inspector and discussed the track fault at Milton. The track ganger agreed to collect temporary speed boards from their Dunedin depot and drive a hi-rail vehicle¹⁰ to Milton to erect them.
- 2.8 At 1338 the track ganger phoned the train controller for an update. The train controller confirmed the 40 kilometres-per-hour temporary speed restriction over number seven points at the north end of Milton and that there were no boards in place. The train controller said that Train 932 had a track warrant through to Mosgiel and was expected to arrive at Milton just after 1500. The track ganger signed off by stating they expected to be there in about an hour.
- 2.9 At 1350 there was a shift hand-over on the Main South line train control desk. During the handover the incoming train controller was made aware of the 40 kilometres-per-hour temporary speed restriction at Milton and that the boards had yet to be erected.
- 2.10 At 1403 the track ganger phoned the track inspector to confirm the location of the track fault.
- 2.11 At 1408 the track ganger departed from the Dunedin Depot, driving the hi-rail vehicle and bound for Limeworks Road public level crossing.
- 2.12 At 1439 the train driver made the mandatory radio call to the train controller to advise the train was on the move through Balclutha (462 km).
- 2.13 At 1445 the track ganger arrived at Limeworks Road public level crossing, 429 km on the Main South line. This was established by data recorded on the hi-rail vehicle's onboard global positioning system (GPS).

⁵ A situation that happens when two sections of rail separate at a rail joint.

⁶ A mechanical installation that enables a train to be guided from one track to another.

⁷ A reduction of permissible speed, imposed to protect trains from substandard track conditions.

⁸ Line-side signs that mark the start and finish of a temporary speed restriction.

⁹ The person in charge of a track maintenance work group.

¹⁰ A road vehicle fitted with retractable rail trolleys so that it can be driven along a rail track and can also be driven on or off track at level crossings.

- 2.14 At 1447 the track ganger radioed train control, stating "I will be at the 429 km in about five minutes to work between Henley and Benhar to put the boards up".
- 2.15 The train controller acknowledged the call and repeated back, "Working between Henley and Benhar."
- 2.16 At 1449 the track ganger accepted a phone call. The conversation ended after 6 minutes and 12 seconds.
- 2.17 At 1458 the track ganger base-called¹¹ train control for a track warrant so that they could hi-rail south from Limeworks Road public level crossing and erect the temporary speed restriction boards at Milton.
- 2.18 The train controller confirmed over the open radio channel that track warrant 60 (see Appendix 2), issued to the driver of hi-rail vehicle 36783 at 429 km on the Main South line (the Limeworks Road public level crossing), had been repeated correct at 1501. The track warrant authorised the driver of the hi-rail vehicle to work between Henley and Benhar after the departure of Train 932 from 429 km. A 'clause 8' condition of the track warrant required the driver to verify that Train 932 was clear of 429 km before acting on the track warrant.
- 2.19 The train driver recalled during interview that the train had been approaching Milton when the train controller was overheard issuing the track warrant to the driver of the hi-rail vehicle (the track ganger).
- 2.20 The hi-rail vehicle's management system download data showed that the track ganger started to on-track the vehicle at Limeworks Road public level crossing almost immediately after reading the track warrant back to the train controller.
- 2.21 The train approached Limeworks Road public level crossing on a 1000-metre-radius right-hand curve with a gentle rising gradient changing from 1 in 300 to 1 in 185. When the train was about 370 metres from the level crossing the driver sounded the train horn for about one second as a precautionary measure for what he thought was a hi-rail vehicle parked clear of the track. At that time the track ganger was at the rear of the hi-rail vehicle, checking that the rear hi-rail wheels had lowered and engaged correctly between the rails.
- 2.22 Upon hearing the train horn, the track ganger ran to the driving compartment. The track ganger then attempted to raise the rear hi-rail wheel set so that he could drive the vehicle clear of the track.

¹¹ a radio call where the caller's unique identifier is displayed on the train controller's radio screen. Activated by a pushbutton on the caller's radio unit.



**Figure 4: Sight line when the driver sounded the train horn
(Credit: KiwiRail)**

- 2.23 The train was travelling at 57 kilometres-per-hour and was about 200 metres from the level crossing when its driver realised that the hi-rail vehicle was not trackside but on the track. The train driver made a full-service brake application at 1504:02, before vacating the driver seat and taking refuge behind the control stand.



**Figure 5: Sight line when full-service brake application made
(Credit: KiwiRail)**

- 2.24 The track ganger abandoned the hi-rail vehicle on the track when they realised that it could not be driven clear of the track before the train reached the level crossing. The train had slowed to 44 kilometres-per-hour when it struck the hi-rail vehicle on the

level crossing at 1504:16. The train movement stopped at 1504:33, about 120 metres past the level crossing.



**Figure 6: Impact damage
(Credit: KiwiRail)**

- 2.25 At 1505:20 the train driver pressed the emergency radio button for the required two seconds to send an emergency alert to train control. The train driver removed the portable hand-held radio at 1505:34 and went to check on the wellbeing of the track ganger.
- 2.26 At 1505:34, after receiving the emergency call, the train controller waited the required time before making the first attempt to contact the train driver. The train controller made two further attempts before the train driver radioed train control at 1507:21 stating that he was at 429 km and the train had just struck the track ganger's hi-rail vehicle. The train driver reported the track ganger to be clear of the hi-rail vehicle at the time of the collision and appeared to be uninjured.
- 2.27 At 1508:54 a Fire and Emergency New Zealand call centre dispatcher phoned train control to confirm that a crew was on its way and should be on site soon. The dispatcher sought clarification of the accident site and enquired about the injury status.

Personnel information

The train driver

- 2.28 The train driver had received full and final certification for locomotive engineer freight (A) duties on 19 February 2015. The driver's certification, competencies and mandatory safety observations were current.
- 2.29 The train driver underwent a mandatory post-accident drug and alcohol test that gave a negative/clear result.

The track ganger – driver of the hi-rail vehicle

- 2.30 The track ganger had first passed initial Track Safety Rules certification in September 2013 before receiving full and final hi-rail vehicle sign-off in June 2014. The two-yearly re-certification for these qualifications had last been achieved in July 2019. The track ganger's certification and safety observations were current.
- 2.31 The track ganger's normal shift was 0700 to 1530 Monday to Friday. However, the COVID-19 Alert Level 4 lockdown had been in place for the previous four weeks, meaning that they had carried out a weekly track inspection on a Wednesday and had been available to attend any call outs. For the week starting Monday 20 April 2020, the track ganger had been on paid isolation leave on Monday and Tuesday, had carried out the scheduled track inspection on Wednesday, had been on isolation leave on Thursday and had been called out to erect the temporary speed boards on Friday 24 April 2020.
- 2.32 The track ganger had a mandatory post-accident drug and alcohol test that gave a negative/clear result.

Vehicle information

Hi-rail vehicle

- 2.33 The hi-rail vehicle was a 2012 model Mitsubishi Fuso Canter.
- 2.34 The radio call sign for the hi-rail vehicle at the time of the accident was 36783.

Train

- 2.35 Train 932 consisted of 2 DXC class locomotives hauling 32 wagons and was loaded with a combination of milk powder and custom wood.
- 2.36 Total train length was 541 metres and total train mass was 1856 tonnes.

Meteorological information

- 2.37 The weather was fine and clear at the time of the accident.

3 Analysis

Introduction

- 3.1 Track warrant control is used on lines carrying relatively low numbers of train movements per day to protect trains, equipment and personnel operating on the main line (including the main line within station limits). This is achieved by train control issuing written instructions (track warrants) to 'addressees', authorising the occupancy of defined sections of track. Track warrants are numbered consecutively, from one, at the start of each day.
- 3.2 Safe operations under track warrant control are achieved by permitting only one movement to occupy a defined section of the main line at one time, except where the regulations make special provision for shared occupancy. No such special provisions were in place at the time of this accident.
- 3.3 Train controllers use TWACS¹², a computer-based system, to ensure that no conflicting warrants are issued. However, the track warrant control system is reliant on the level of compliance by addressees with all the conditions written on track warrant forms and read back to train controllers. The issue and read-back process has no additional technological defences to mitigate the risk of human error.
- 3.4 Although the likelihood of a collision between a train and a hi-rail vehicle within track-warrant-controlled territory is low, the consequences can be severe.
- 3.5 The following section analyses the circumstances surrounding the event to identify those factors that increased the likelihood of the event occurring. It also examines the activation of the emergency train brake as a non-contributory safety issue that had the potential to reduce the severity of the accident.

The track warrant form and its clauses

Safety issue: The track warrant control method of protection was reliant on the addressee (the holder of the track warrant) complying with all instructions.

The train controller copy of the track warrant (Mis. 87 form, see Figure 7) and the addressee's copy (Mis. 88 form, see

- 3.6 Figure 8) are identical, except that the train controller's copy has a space to insert details of when and through whom a track warrant has been relayed. In this case, track warrant 60 was issued directly from the train controller to the operator of hi-rail vehicle 36783 (its radio call sign). See Appendix 2 for track warrant 60 as recorded.

¹² Track Warrant Assisted Computer System. A computer-based system used by train controllers to prepare and issue track warrants safely. It does so by checking against previous prepares, issues and cancellations to ensure that conflicts do not exist.

Track Warrant

Mis. 87

Track Warrant Number **M** _____ day _____ (Date)
(Desk No.) (Warrant No.)

To _____
Driver / Locomotive Engineer Operator / Rail Protection Officer *
(Designation, Name, Train, etc.)

At _____

1. ☐ Track Warrant Number _____ is cancelled
*departure *from
2. ☐ After arrival of _____ at _____
3. ☐ Proceed from _____ to _____
4. ☐ Work between _____ and _____
5. ☐ Enter _____ at _____ *to cross _____
6. ☐ Main line reported clear _____ *(except for _____)
7. ☐ No other warrants issued between these limits after _____
8. ☐ Verify _____ is clear of _____ before acting on this warrant
9. ☐ Not in use
10. ☐ Call Train Control at _____

11. ☐ Clear main line before _____ hours
12. ☐ Other instructions _____

Relayed to _____ at _____ hours
 _____ Train Controller

Repeat correct at _____ hours

DAS ☐ DAS Target Location set to: _____ ☐ DAS not Operating

TC cross check by	_____	_____
	<small>print name</small>	<small>Initials</small>

Limits reported clear by
Driver HRV / Operator / Rail Protection Officer * _____ at _____ hours
(Mark "X" in box for each item instructed) (* Delete words not required) June 2015

Figure 7: Track warrant form Mis. 87 - train control's copy

KiwiRail		Mis. 88
Track Warrant		
Track Warrant Number _____		day _____ (Date) _____
To <u>Driver / Locomotive Engineer / Operator / Rail Protection Officer*</u>		
<small>(Designation, Name, Train, etc.)</small>		
At _____		
1. <input type="checkbox"/> Track Warrant Number _____ is cancelled		
2. <input type="checkbox"/> After ^{*departure} arrival of _____ ^{*from} at _____		
3. <input type="checkbox"/> Proceed from _____ to _____		
4. <input type="checkbox"/> Work between _____ and _____		
5. <input type="checkbox"/> Enter _____ at _____ ^{*to cross} _____		
6. <input type="checkbox"/> Main line reported clear _____ ^{*(except for} _____)		
7. <input type="checkbox"/> No other warrants issued between these limits after _____		
8. <input type="checkbox"/> Verify _____ is clear of _____ before acting on this warrant		
9. <input type="checkbox"/> Not in use		
10. <input type="checkbox"/> Call Train Control at _____		
11. <input type="checkbox"/> Clear main line before _____ hours		
12. <input type="checkbox"/> Other instructions _____		
_____ Train Controller		
Repeat correct at _____ hours		
Locomotive Engineer use only	<input type="checkbox"/> DAS Target Location set to _____ <input type="checkbox"/> DAS Not in Use	
RPO use only	All locked off in Safe Place and Work Site Clear at _____ hrs	
Limits reported clear by _____ at _____ hours		
<small>(Mark "X" in box for each item instructed) (*Delete words not required)</small>		
<small>June 2015</small>		

Figure 8: Track warrant form Mis. 88 – addressee's copy

- 3.7 Before issuing a track warrant, a train controller must:
- establish positively the exact purpose for which the authority is to be issued and the limits that will be applied
 - carry out checks to establish that it is safe to issue the track warrant
 - plot the movement on the train control diagram
 - prepare the track warrant

- transmit the track warrant to the addressee and listen for a correct repeat
 - record the time the track warrant is read back correctly.
- 3.8 Track warrant 60 was issued on Friday 24 April to the driver of hi-rail vehicle 36783 at 429.00 km Main South line.
- 3.9 Clause 1 is used only when it is necessary to alter the instructions contained in a track warrant before the limits of that warrant have been cleared.
- 3.10 Clause 2 is used when a movement is authorised behind a departing train or when a movement must not take place until an incoming movement has arrived. In either case the relevant phrase “after departure/arrival of ... from/at” must be completed.
- 3.11 Clause 4 is used for work or for a movement that may need to work in either direction within the limits of the warrant. Clause 4 can also be used with clause 2 to allow for a movement to take place after the arrival of an opposing train.
- 3.12 Either clause 6 or clause 7 must be used on every track warrant issued. Clause 7 must be used when the last occupancy of all the area covered by the track warrant was by the movement referred to in clause 2.
- 3.13 Clause 8 must be used whenever clause 2 (after arrival/departure) is used on a track warrant for an addressee.
- 3.14 Clause 12 (other instructions) must be used when it is necessary to include additional instructions not provided for in clauses 1 to 11. These include details that provide safe working, such as the “at location” of the addressee.
- 3.15 The KiwiRail Rail Operating Rules, issue 7, effective from 6 October 2019, section 4, track warrant control rule 402, stated in part:

3. Conditional – All cases

NOTE: It is not possible for a train to be issued with a track warrant conditional upon the arrival or departure of a Hi-Rail Vehicle or MTMV [Motor Trolley Maintenance Vehicle].

A track warrant which specifies that a movement or work is authorised “after” a movement, may only be issued when:

- the addressee is at the location at which the train is to arrive at or depart from,
- the movement after which the movement is to take place has been authorised to proceed in one direction only, and
- is due at that location within the next 15 minutes.

5. Conditional – After departure of

When the movement is to be carried out after the departure of a train, the addressee must ensure that the departing train has cleared the area far enough for the movement or work to be safely performed.

- 3.16 The KiwiRail Rail Operating Procedures, section 10.1 – Operating Instructions for Train Control, clause 13.8.8 [Rule 402(c)] that provided instructions to train controllers stated in part:

The purpose of this “after” provision is to save time by giving Train Control the opportunity of issuing a track warrant while the movement is waiting for an opposing train or the track warrant for that train is still in effect. However the issue of such track warrants too far in advance of the arriving or departing train should be avoided and generally should not be more than 15 minutes in advance.

A train which is to arrive or depart before the movement for which a track warrant is being issued takes place, must be the next train at the time of issue.

- 3.17 Clause 13.8.9 [Rule 402(d) and (e)] of these same operating instructions also stated in part:

Clause 8 is used to reinforce the requirement for the track warrant addressee to check and ensure the previous movement has cleared the “at” location.

Train Control must apply Crew Resource Management^[13] principles to provide train location information by use of Train Control radio call to the train if necessary and/or use of GPS position reporting.

- 3.18 The train controller issued track warrant 60 to the driver of hi-rail vehicle 36783 in an accurate manner, except for at first stating in clause 2, “after the departure of Train 924”. During the COVID-19 Alert Level 4 lockdown, KiwiRail ran a reduced freight schedule and the usual Train 924 was assigned a revised train number and operated as Train 932. The train controller recognised and corrected this error immediately, before moving to the next clause confirming the work-between locations as Henley and Benhar shown in clause 4.
- 3.19 When track warrant 60 was issued at 1501, conditional on the departure of northbound freight Train 932 from 429 km (the Limeworks Road public level crossing), the next train scheduled to pass over that location was southbound freight Train 937. Train 937 was expected to reach Limeworks Road public level crossing at about 1740, some 150 minutes later.
- 3.20 The workload for the train controller at that time was not excessive, with only two other active train movements for the area they were managing. It took the train controller three minutes to complete the issuing of track warrant 60. Therefore, when combined with a low level of rail activity in the area, there were minimal operational benefits from the train controller issuing a conditional track warrant to the hi-rail vehicle operator before the train had passed the 429 km mark. Once the track warrant was issued, the responsibility for the safe operation rested solely with the addressee to follow all the instructions in order to achieve a safe outcome. Placing that responsibility on an addressee, rather than a train controller who has more up-to-date information available regarding the locations of trains, can set up a situation for potential human error.
- 3.21 The track ganger stated during interview that he believed Train 932 had already passed the 429 km mark at the time the track warrant was read back correctly at 1501, but could offer no factual evidence as to why he thought that was the case. The requirement to verify that Train 932 had passed the 429 km mark before the track warrant became valid was overlooked entirely. The track ganger had not considered the broader issue as to why the train controller had issued a conditional track warrant when the train had passed their location already. The track ganger had a device

¹³ KiwiRail’s framework for non-technical skills including situational awareness, conscientiousness, communication, decision-making and action, co-operation and working with others, workload management and self-management.

available with a software program known as GeVis. This program enables the user to see the approximate locations of all trains on the network. Had the track ganger checked the device immediately after taking the track warrant, the train would have been shown as still on approach to 429 km.

- 3.22 In not providing train location information to the track ganger, the train controller did not apply Crew Resource Management principles effectively. Had the train controller stated Train 932 was near Milton, it would have been a further cue to the track ganger to wait trackside until the train had passed.
- 3.23 Issuing track warrants to infrastructure staff, hi-rail vehicles and trolley users that are conditional on the departure of trains from an “at location” presents a risk to these groups if they do not adhere to a warrant’s conditions. KiwiRail took immediate action in response to this incident by publishing a special bulletin to suspend the issue of clause 2 (i.e. conditional) track warrants to these groups. This has since been followed by a semi-permanent bulletin with this same restriction on clause 2 warrants (refer section 5). The Commission welcome this safety action and consider it to have addressed the issue identified.

Non-contributory factor: the emergency train brake

- 3.24 The train driver controlled the train on the approach to Limeworks Road public level crossing (429 km) in accordance with the Driver Advisory System’s¹⁴ recommended speed. It was not until the train was about 200 metres from the level crossing that the driver realised the hi-rail vehicle was in the train’s collision path. The train driver then applied the automatic train brake to full-service braking, and in doing so reduced the train speed from 57 to 44 kilometres-per-hour at impact.
- 3.25 The train driver expressed concern about using emergency braking due to the possibility of locking the wheels, which could damage the running surfaces of the wheels. However, by using emergency braking there is less chance of wheels locking up due to locomotives applying sand to the railhead automatically.
- 3.26 The use of the emergency brake does not increase train braking force when compared to a full-service brake application. However, by full venting of brake pipe air pressure – rather than its controlled reduction – emergency braking applies this braking force more rapidly than full-service braking. This reduced delay in braking force build-up time subsequently reduces the stopping distance.
- 3.27 During an emergency brake application sand is automatically applied to the railhead to improve wheel-rail adhesion, and the locomotive sends an emergency radio call to train control once the brake pipe pressure falls below 200 kilopascals. Usually this occurs after about 20 seconds but varies with the type(s) of wagons being hauled and increases with train length.
- 3.28 A post-accident train simulation was carried out at KiwiRail’s training centre using the same train profile, track alignment, and gradient profile to determine the operational benefits of making an emergency brake application. A train consist of 2 DX-class

¹⁴ A computer touch-screen mounted in the locomotive cab that is connected to the locomotive power supply, global positioning system and cellular antennae and provides a visual output of topographical and network data along with suggested speeds and operating modes.

locomotives and 32 wagons, with a total mass of 1865 tonnes and length of 559 metres, was loaded into the simulator.

- 3.29 In summary, the first simulation run was with a full-service brake application and independent brake applied at the same train speed and distance from Limeworks Road public level crossing. The output from this simulation run was consistent with the download data from the Train 932's event recorder, in that the impact speed showed a variation of 1 kilometre-per-hour and the stopping distance was within 1 metre of the actual (341 versus 340metres).
- 3.30 The second simulation run was carried out using the emergency brake. This output data showed the loaded train would have stopped 258 metres from where the emergency brake application was made. This was a reduction of 83 metres in stopping distance when compared with the full-service and independent braking simulation described above. Correspondingly, the train speed at impact was lowered 28 kilometres-per-hour when using the emergency brake.
- 3.31 While the application of the emergency brake would not have prevented the collision, the impact speed would have been lowered significantly, and as a result the impact damage to both the hi-rail vehicle and the locomotive would have been less severe.

4 Findings

- 4.1 The train driver had Train 932 under control on the approach to Limeworks Road public level crossing.
- 4.2 The train controller issued a track warrant to the track ganger conditional on the departure of Train 932 from Limeworks Road, in accordance with KiwiRail's operating rules and procedures.
- 4.3 When issuing the track warrant to the track ganger, the train controller did not apply Crew Resource Management principles by providing up-to-date information on the location of the next train approaching Limeworks Road.
- 4.4 The track ganger did not verify that Train 932 had passed Limeworks Road public level crossing before the hi-rail vehicle was placed on the track and in the path of the approaching train.
- 4.5 The train driver decided to make a full-service brake application rather than apply the emergency brakes, and as a result the train struck the hi-rail vehicle at a higher speed and took longer to stop than it would have had the emergency brake been applied.

5 Safety issues and remedial action

General

- 5.1 Safety issues are an output from the Transport Accident Investigation Commission's (Commission's) analysis. They typically describe a system problem that has the potential to adversely affect future operations on a wide scale.
- 5.2 Safety issues may be addressed by safety actions taken by a participant, otherwise the Commission may issue a recommendation to address the safety issue.

Track warrant rules

- 5.3 The track warrant control rules did not allow train controllers to issue train drivers with track warrants conditional on the departures of hi-rail vehicles. Train controllers were however permitted to issue track warrants to drivers of hi-rail vehicles conditional upon the departure of trains.
- 5.4 Three days after this accident KiwiRail issued Special Bulletin No. 308, which stated in part:

<p style="text-align: center;">Section 10.1 – Operating Procedures Train Control All Track Warrant Control Areas</p>
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Commencing 0600 Monday 27 April 2020 and continuing until further advised the following instruction will operate.

To be read in conjunction with Semi-Permanent Bulletin No.263 dated 2 April 2020 and TWC 402 clauses 3, 4 and 5.

15.0 Inquiries from Infrastructure Personnel, Hi Rail Vehicles and Trolley users

15.2 Summary of Procedures – Track Occupancy

The issue of all clause 2 track warrants is suspended for all infrastructure Personnel, Hi Rail Vehicle, and Trolley Users with the following exceptions;

15.2.4 Verification Procedure of last clearing rail vehicle(s):

- When the conflicting rail vehicles is a train, before granting any track occupancy authority Train Control must verify the last train's position to ensure that it has passed clear of the Intermediate Board (IB)/ section of the line clear of the tracking location.
- Verification must occur by:
 - Obtaining verbal advice and confirmation of a train's position from the locomotive engineer to confirm that the train has arrived at or is clear of the next station or Intermediate Board.

- 5.5 KiwiRail then, on 14 April 2021, issued Semi-Permanent Bulletin No. 281, which stated in part:

3. Conditional – All cases

Add after current instructions:

It is not permissible for Infrastructure Personnel, Hi-Rail Vehicles and Trolley Users to be issued with a track warrant conditional after the arrival / departure of any train, without Train Control having first verified that the train has passed clear of the next Intermediate Board (IB) / Section of line clear of the on-tracking location, or clear of station limits.

- 5.6 The Commission consider the above safety action taken by KiwiRail to have addressed the safety issue identified.

6 Key lessons

- 6.1 Issuing track warrants to infrastructure staff, hi-rail vehicles or trolley users that are conditional on the arrival or departure of trains is likely to endanger lives by causing accidents if the track warrant holders fail to confirm train locations.
- 6.2 Applying the train brake in its emergency position will achieve a shorter stopping distance than applying it to its full-service position.

7 Data summary

Vehicle particulars

Train type and number:	express freight Train 932
Operator:	KiwiRail Holdings Limited
Date and time	24 April 2020 at 1504
Location	428.92 km Main South line, Limeworks Road public level crossing
Operating crew	one train driver, one hi-rail vehicle operator
Injuries	nil
Damage	extensive to hi-rail vehicle minor to locomotive

8 Conduct of the inquiry

- 8.1 On 24 April 2020, Waka Kotahi, NZ Transport Agency notified the Commission of the occurrence. The Commission subsequently opened an inquiry under section 13(1) of the *Transport Accident Investigation Commission Act 1990* and appointed an investigator in charge.
- 8.2 The COVID-19 Alert Level 4 lockdown prevented Commission investigators examining the accident site. The train driver and the hi-rail vehicle operator were interviewed by Commission investigators using Microsoft Teams.
- 8.3 The Commission obtained the following records and documents for analysis:
- the train event recorder download data
 - the train control diagram
 - voice recordings of the radio communication between the train controllers and the train driver and the hi-rail vehicle operator
 - track warrants
 - training records
 - hi-rail vehicle Navman GPS download data
 - train simulator download data.
- 8.4 On 24 March 2021 the Commission approved a draft report for circulation to four interested persons for their comment.
- 8.5 The Commission received two submissions, and changes as a result of these have been included in the final report.
- 8.6 On 23 June 2021, the Commission approved the final report for publication.

9 Report information

Abbreviations

GPS	Global positioning system
km	kilometre(s)
m	metre(s)

Glossary

base call	a radio call where the caller's unique identifier is displayed on the train controller's radio screen. Activated by a pushbutton on the caller's radio unit
crew resource management	KiwiRail's framework for non-technical skills including situational awareness, conscientiousness, communication, decision-making and action, co-operation and working with others, workload management and self-management.
driver advisory system	a computer touch-screen mounted in a locomotive cab that is connected to the locomotive power supply, global positioning system and cellular antennae and provides a visual output of topographical and network data along with suggested speeds and operating modes
GeVis	web-based application that allows users to see the GPS-reported locations of trains and other select rail vehicles
hi-rail vehicle	a road vehicle fitted with retractable rail trolleys so that it can be driven along a rail track and can also be driven on or off track at level crossings
Main South line	a 601-kilometre-long train line that runs from Lyttelton, near Christchurch, to Invercargill. The 0.00 km peg is at Lyttelton
points	a mechanical installation that enables a train to be guided from one track to another

pull-apart	a situation that happens when two sections of rail separate at a rail joint
temporary speed boards	line-side signs that mark the start and finish of a temporary speed restriction
temporary speed restriction	a reduction of permissible speed, imposed to protect trains from substandard track conditions
track ganger	the person in charge of a track maintenance work group
track warrant	a written instruction issued by train control to authorise the occupation of a defined section of track
train controller	a person qualified to authorise train movements and track occupations

Appendix 1: Track warrant 51 as recorded by the driver of Train 932

Track Warrant MHS. 88

Track Warrant Number 51 FROM day 24 ARRU (Date)

To Driver / Locomotive Engineer / Operator / Rail Protection Officer* 932
(Designation, Name, Train, etc.)

At NES

1. ☐ Track Warrant Number _____ is cancelled

2. ☒ After ^{*departure} arrival of 931 ^{*from} at NES

3. ☒ Proceed from NES to MOSGIEL

4. ☐ Work between _____ and _____

5. ☐ Enter _____ at _____ ^{*to cross} _____

6. ☒ Main line reported clear 130 ^{(except for} 931 ⁾

7. ☐ No other warrants issued between these limits after _____

8. ☐ Verify _____ is clear of _____ before acting on this warrant

9. ☐ Not in use

10. ☒ Call Train Control at MAAURA - BALLOON, KMLON

11. ☐ Clear main line before _____ hours

12. ☐ Other instructions
TD Miller

Repeat correct at 1209 hours

Train Controller _____

Locomotive Engineer use only ☒ DAS Target Location set to ON
☐ DAS Not in Use


RPO use only All locked off in Safe Place and Work Site Clear at _____ hrs

Limits reported clear by
Driver / Locomotive Engineer / Operator / Rail Protection Officer* at _____ hours

(Mark "X" in box for each item instructed) ("Delete words not required) June 2015

Otari Rail Luminous Clipboard

Appendix 2: Track warrant 60 as recorded by the hi-rail vehicle operator

KiwiRail  Mis. 88

Track Warrant

Track Warrant Number 60 Fri day 24 April (Date)

To Driver / Locomotive Engineer / Operator / Rail Protection Officer* HRV
(Designation, Name, Train, etc.) 36783

At 429.00 km MSL

- ☐ Track Warrant Number is cancelled
- ☒ After ^{*departure} arrival of 932 ^{*from} at 429.00 km
- ☐ Proceed from _____ to _____
- ☒ Work between henley and behar
- ☐ Enter _____ at _____ ^{*to cross} _____
- ☐ Main line reported clear ^{*(except for} _____)
- ☒ No other warrants issued between these limits after 932
- ☒ Verify 932 is clear of 429.00 km before acting on this warrant
- ☐ Not in use
- ☐ Call Train Control at _____
- ☐ Clear main line before _____ hours
- ☒ Other instructions
the 429.00 km MSL
between bearton and henley
②

Train Controller

Repeat correct at 1501 hours

Locomotive Engineer use only	<input type="checkbox"/> DAS Target Location set to
	<input type="checkbox"/> DAS Not in Use

RPO use only	All locked off in Safe Place and Work Site Clear at _____ hrs
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Limits reported clear by
Driver / Locomotive Engineer / Operator / Rail Protection Officer* at _____ hours

(Mark "X" in box for each item instructed) (*Delete words not required)

June 2015

TAIC Kōwhaiwhai - Māori scroll designs

TAIC commissioned its kōwhaiwhai, Māori scroll designs, from artist Sandy Rodgers (Ngati Raukawa, Tuwharetoa, MacDougal). Sandy began from thinking of the Commission as a vehicle or vessel for seeking knowledge to understand transport accident tragedies and how to prevent them. A 'waka whai mārama (i te ara haumarū) is 'a vessel/vehicle in pursuit of understanding'. Waka is metaphor for the Commission. Mārama (from 'te ao mārama' – the world of light) is for the separation of Rangitāne (Sky Father) and Papatūānuku (Earth Mother) by their son Tāne Māhuta (god of man, forests and everything dwelling within), which brought light and thus awareness to the world. 'Te ara' is 'the path' and 'haumarū' is 'safe or risk free'.

Corporate: Te Ara Haumarū - The safe and risk free path



The eye motif looks to the future, watching the path for obstructions. The encased double koru is the mother and child, symbolising protection, safety and guidance. The triple koru represents the three kete of knowledge that Tāne Māhuta collected from the highest of the heavens to pass their wisdom to humanity. The continual wave is the perpetual line of influence. The succession of humps represent the individual inquiries.

Sandy acknowledges Tāne Māhuta in the creation of this Kōwhaiwhai.

Aviation: Ngā hau e whā - the four winds



To Sandy, 'Ngā hau e whā' (the four winds), commonly used in Te Reo Māori to refer to people coming together from across Aotearoa, was also redolent of the aviation environment. The design represents the sky, cloud, and wind. There is a manu (bird) form representing the aircraft that move through Aotearoa's 'long white cloud'. The letter 'A' is present, standing for aviation.

Sandy acknowledges Ranginui (Sky father) and Tāwhirimātea (God of wind) in the creation of this Kōwhaiwhai.

Marine: ara wai - waterways



The sections of waves flowing across the design represent the many different 'ara wai' (waterways) that ships sail across. The 'V' shape is a ship's prow and its wake. The letter 'M' is present, standing for 'Marine'.

Sandy acknowledges Tangaroa (God of the sea) in the creation of this Kōwhaiwhai.

Rail: rerewhenua - flowing across the land



The design represents the fluid movement of trains across Aotearoa. 'Rere' is to flow or fly. 'Whenua' is the land. The koru forms represent the earth, land and flora that trains pass over and through. The letter 'R' is present, standing for 'Rail'.

Sandy acknowledges Papatūānuku (Earth Mother) and Tāne Mahuta (God of man and forests and everything that dwells within) in the creation of this Kōwhaiwhai.



Transport Accident Investigation Commission

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Price \$11.00

ISSN 1178-4164 (Print)
ISSN 1179-9102 (Online)