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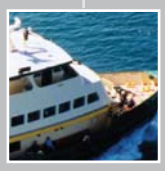


Rail Safety Investigation Report

UNANDERRA

20 June 2003

Signal Passed at Danger resulting in derailment of Pacific National Service B9162.

Investigation Report

Published by
The Office of Transport Safety Investigation (OTSI)
Issue Date: 28 July 2004
Reference Number: 00041

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CONTENTS

1.0 EXECUTIVE SUMMARY

Preliminary Facts

1. At approximately 10:35 on 28 June 2003, Pacific National Service B9162 (B9162) departed Dunmore on the South Coast Branch line for Cooks River. Prior to the train's departure, the train crew carried out a general mechanical inspection and brake test of the train. This test did not identify any mechanical or brake abnormalities. Prior to the train approaching Unanderra Platform the Driver (Driver 1[1]) applied the train's air brakes on two separate occasions. At each brake application the train was noted by the crew to brake in a satisfactory manner.
2. B9162 consisted of 2 x 81 Class Locomotives and 30 RHGF Mineral wagons with a train weight of 2760 tonnes and length of 481m.
3. The train crew noted the last three signal indications leading up to Unanderra Signal WG 1010. These three signal indications were Clear (green Signal WG 1030), Caution (yellow Signal WG 1024) and Proceed (yellow Signal WG 1016). The final signal indication at Signal WG 1010 was also noted at Stop (red).

The Accident

4. At 11:02 B9162 passed Signal WG 1010 at Stop and derailed all wheels of the lead locomotive 8127 and the leading bogie of the second locomotive 8148 at catch points 1106B. Signal WG 1010 was passed by approximately 55 metres. The train crew were tested for alcohol and drugs shortly after the incident producing negative results. No injuries resulted from the incident, however damage to the infrastructure and derailed locomotives was sustained.
5. A review of the second locomotive's Hasler tape revealed that B9162 maintained a braking pattern and corresponding speed consistent with a train expecting to pass Signal WG 1010 under a Caution Turnout indication, until 145m prior to this signal. At this point Driver 1 applied an emergency brake application on realising that Signal WG 1010 was displaying a Stop indication. This emergency brake application was not sufficient to stop B9162 prior to Signal WG 1010.

Causal Factors

6. The investigation determined that Driver 1 held the preconception that Signal WG 1010 would be set at a Caution Turnout indication, past the point where the train could have effectively braked to a stop prior to Signal WG1010. Those factors identified as being present at the time of the incident were determined to be:

[1] Pacific National refer to both train crew as drivers with either one of the drivers being assigned the driver duties at any one particular time. The driver assigned with driving duties during the course of this incident is referred to as Driver 1. The remaining driver observing operations of the train and Driver 1's performance is referred to as Driver 2.

(a) Driver 1 relying on situational indicators leading up to Signal WG 1010, such as the prior clearing of Signal WG 1030 from Caution to Clear and the stationary passenger train at Unanderra Platform No.1, to provide what was a false indication that Signal WG 1010 would be set at a Caution Turnout indication; and

(b) Driver 1 not making use of the available sighting distance of Signal WG 1010 before reacting to brake B9162 in a way that would have acknowledged Signal WG 1010 being at Stop.

Contributory Factors

7. The following factors, in addition to those described above, had the potential to contribute to the occurrence of this incident:

(c) Drivers may be less inclined to acknowledge the predictive information of a Caution signal indication that has a limited number of standard colour indications such as displayed on Signal WG 1024. Should drivers place little emphasis on the predictive information of this type of signal configuration they may be more inclined to look for other predictive measures to gauge the indication of Signal WG 1010;

(d) Driver 2 was not yet fully qualified with route knowledge of the Dunmore to Cooks River route. This lack of experience may have contributed to his failure in providing an earlier warning to Driver 1 concerning appropriate train braking leading up to Signal WG 1024 at Caution and Signal WG 1010 at Stop;

(e) Driver 2's only means of stopping B9162 effectively would have been to physically take control of Driver 1's brake controls in order to apply B9162's air brake. The inability of Driver 2 in not being able to apply an emergency brake application without physically invading Driver 1's working space may have been an inhibitor to Driver 2 in carrying out this type of action; and

(f) Both drivers did not communicate with each other, with regard to the indication of signals, in a manner consistent with Pacific National's communication protocol. Whilst signal indications were called by Driver 2 they were not acknowledged and confirmed by Driver 1.

Recommendations

8. A complete listing of the safety recommendations of this investigation are contained within Section 7.0 of this report. It is recommended that the following remedial safety actions be undertaken by the specified responsible entity:

a. Pacific National:

(1) Take action to ensure drivers maintain an appropriate level of signal aspect vigilance;

(2) Determine whether RHGF vehicle's operating on the Unanderra

Branch line have acceptable emergency braking performance. Any deficiencies identified should then be corrected;

(3) Determine if conditions exist where the use of dynamic and full service train braking is preferred over emergency air braking. Where such conditions exist Pacific National should appropriately train their drivers on when and how to take advantage of any such braking improvements under emergency conditions;

(4) Take action to ensure the certification and operational verification of Hasler speed recorders is undertaken by drivers prior to a train's departure;

(5) Ensure the Driver 2 competency re-certification process covers an assessment of the driver's competency to apply emergency brake applications when required;

b. RailCorp:

(6) Conduct a Human Factors review of the risks associated with a driver's response to single head signal configurations that have a limited number of coloured light indications;

(7) Determine the suitability of Signal WG 1024's signalling configuration considering the current signalling design principles and other signals within the Unanderra Junction configuration that have been modified in line to facilitate a medium (pulsating yellow light) indication. Following from this review, correct the configuration of Signal WG 1024 where deemed necessary;

(8) Signal WG 1016 be cleared of any vegetation sighting obstructions. Ongoing maintenance of vegetation sighting obstructions should also occur at Signal WG 1016; and

c. Independent Transport Safety & Reliability Regulator:

(9) Determine whether freight locomotives should be mandated to have a second emergency brake cock fitted to each driver's cab for the use of the second driver in the event this person is required to apply an emergency brake application.

2.0 TERMS OF REFERENCE

Date of incident:	28 June 2003
Location:	Unanderra Signal WG 1010 & Catch Points 1106B
Details of Incident:	Pacific National Service B9162 passed signal WG 1010 at Stop and derailed all wheels on leading locomotive and leading bogie of the second locomotive at catchpoints 1106B.
Type of Inquiry:	Railway Investigation Section 67
Investigator:	Transport Safety & Rail Safety Regulation, Ministry of Transport
Assisting:	Pacific National Rail Infrastructure Corporation State Rail Authority
Owning Railway:	Rail Infrastructure Corporation
Operator:	Pacific National
Infrastructure Maintainer:	Rail Infrastructure Corporation

The Executive Director of the Transport Safety & Rail Safety Regulation authorised the investigation and publication of this report pursuant to the provisions of Sections 67 and 70 of the Rail Safety Act 2002 NSW. The Office of Transport Safety Investigation (OTSI) has finalised this investigation pursuant to Schedule 5 Section 17 of the Rail Safety Act 2002 NSW.

The investigation was commissioned to:

1. Identify all factors which contributed to the occurrence of the incident.
2. Identify whether the incident type should have been anticipated and assess the effectiveness of the risk management strategies adopted.
3. Assess the adequacy of the emergency response to the incident as it affected the safety of all persons involved.
4. Advise on any matters arising from the investigation which would enhance the safety of rail operations.

3.0 INVESTIGATION METHODOLOGY

The investigation has been conducted in accordance with the principles of Australian Standard AS 5022:2001, Guidelines for railway safety investigation.

The objective of the investigation was to determine the circumstances surrounding the incident and provide information to prevent the recurrence of similar events.

The investigation is in no case intended to imply blame or liability. However sufficient factual information is included to support the analysis and conclusions. Some information may reflect on the performance of individuals and organisations, and how their actions have contributed to the outcomes of the matter under investigation.

System safety accident investigation (SSAI) techniques have been applied to structure the investigation and analyse the evidence.

The SSAI approach includes;

- Applying the Reason model to analyse accident causation in terms of latent conditions and active errors,
- Identifying and analysing human factors issues,
- Identifying and analysing the risk management strategies that should have prevented the accident, and
- Using events and conditions charting to illustrate the incident.

Information and data has been gathered as evidence for the investigation. This includes:

- Records of interviews with infrastructure workers, signallers, drivers and relevant management,
- Metronet voice recordings,
- CCTV footage taken at Unanderra Platform,
- Hasler tape taken from Pacific National Locomotive 8148,
- RIC signalling standards,
- RIC Network Rules and Procedures,
- SRA driver's maps,
- Pacific National train consist & brake certificate records,
- Rolling stock maintenance records, and
- Unanderra signal logs.

4.0 FACTUAL INFORMATION

4.1 Incident Overview

On 28 June 2003 at 11:02, B9162 passed Unanderra Signal WG 1010 at Stop and derailed all wheels of the lead Locomotive 8127 and the leading bogie of the second Locomotive 8148 at catch points 1106B. Signal WG 1010 was passed at Stop by approximately 55 metres.

A review of the second locomotive's Hasler tape revealed that B9162 maintained a braking pattern and corresponding speed consistent with a train expecting to pass Signal WG 1010 under a Caution Turnout indication, until 145m prior to this signal. On realising that Signal WG 1010 was displaying a Stop indication the Driver of B9162 applied an emergency brake application 145m prior to Signal WG 1010. This emergency brake application was not sufficient to stop B9162 prior to Signal WG 1010.

Both the train crew were tested for alcohol and drugs producing all negative results. No injuries resulted from the incident, however damage to the locomotives and infrastructure was sustained. A large amount of fuel was also spilt at the incident site as the fuel tank of Locomotive 8127 was ruptured during the incident.

4.2 Incident Summary

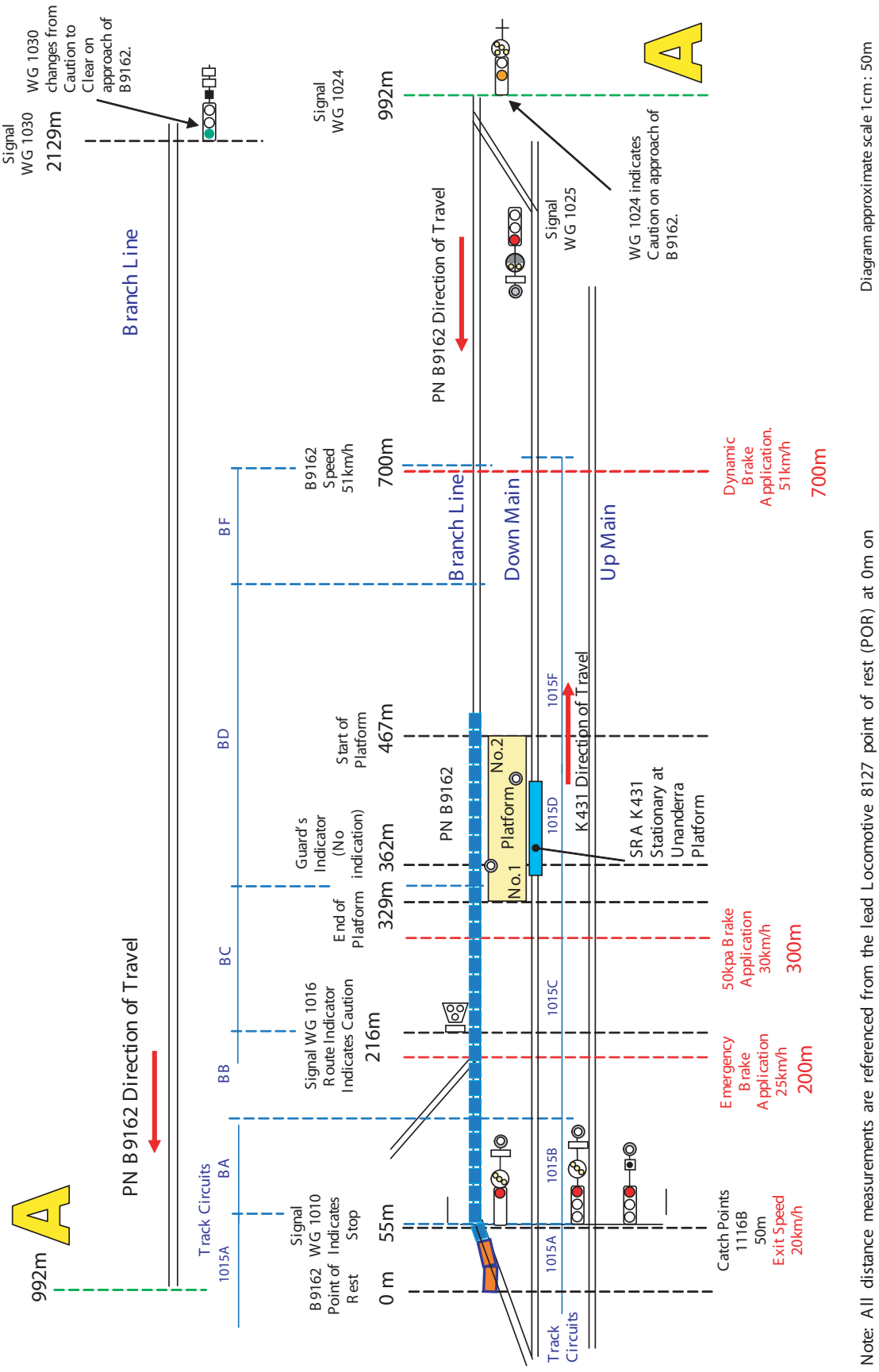
Pacific National Service B9162 departed Dunmore at approximately 10:35 for Cooks River on 28 June 2003. The journey leading into Unanderra was without incident. During this stage of the journey Driver 1 made two brake applications and noted that the train braked in a manner consistent with the brake application pressure, train speed and train weight.

As B9162 approached Unanderra Platform No. 2 the train passed Signal WG 1030 (2129m from where locomotive 8127 came to rest (POR) at ~ 10:59:30[2]) with a Clear indication and Signal WG 1024[3] with a Caution indication (992 m from POR at ~ 11:00:38). Refer to Figure 4.1 depicting the location of signals WG 1030 and WG 1024. Signal WG 1030 was noted by the train crew to change indication from Caution to Clear as B9162 approached this signal. Refer to Appendix 8.7 and 8.8 defining the position of infrastructure components (signals etc.) from the POR.

One and a half minutes prior to the incident a CityRail passenger train K431 (K431) made a scheduled stop at Unanderra Platform No. 1 (11:00:50). In order for this scheduled stop to occur, and in order to minimise delays to K431, the original route of B9162 through Unanderra was changed from: (1) a Branch Line to Up Main crossover movement using Signal WG 1024 to (2) a Branch Line to

[2] Event times have been provided by the Signal Log and are accurate to within +- 1 ½ seconds due to the limitations of transmission and recording of the signal log data.

[3] Signal WG1024 is a limited aspect signal that can only display a Caution (yellow) or Stop (red) indication in comparison to a standard single head three colour signal which may display Clear (green), Caution (yellow) or Stop (red) indications or a modified single head three colour signal which may also display a Medium (pulsating yellow) indication.



Note: All distance measurements are referenced from the lead Locomotive 8127 point of rest (POR) at 0m on B9162. Refer to Appendix 8.7 for calculation of these distances.

Figure 4.1 PN Service B9162 Braking and Speed Diagram

Up Main crossover movement using Signal WG 1010. A pictorial representation of this change in route can be referenced in Figure 4.2.

The change in set up of these operational movements occurred approximately 4 minutes prior to the incident by the signaller controlling the South and Coast panels (Signaller 1)[4]. In resetting the crossover movement of B9162, Signal WG 1024 was initially set to Stop and then cleared. This signal manipulation resulted in Signal WG 1024 displaying a Caution indication. Signal WG 1010 was subsequently left at Stop and Signal WG 1030 would have then automatically displayed a Clear indication as Signal WG 1024 displayed the Caution indication. The event of Signal WG 1030 changing from a Caution indication to a Clear indication was witnessed by the train crew of B9162 as previously described.

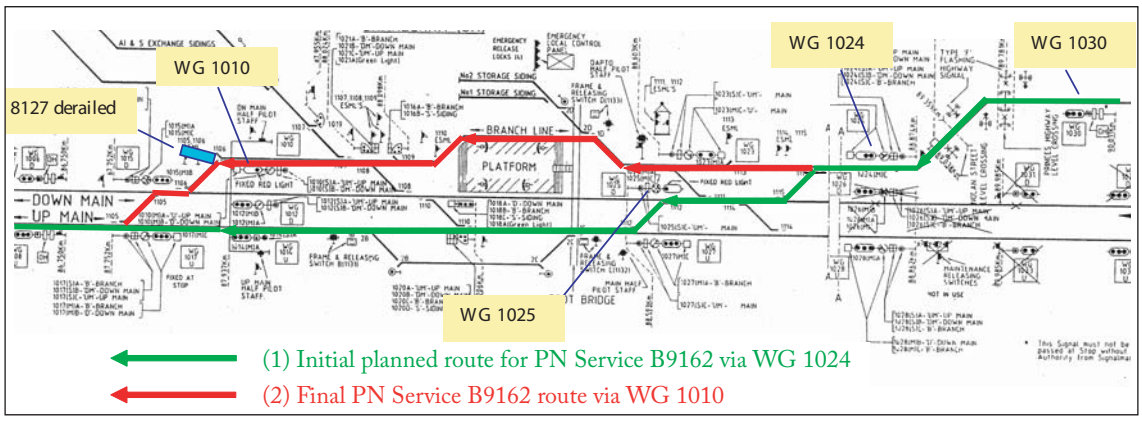


Figure 4.2 Change in Route Selection for B9162 through Unanderra Platform

As K431 cleared the Down Main track circuit 1015A (11:00:37) leading into Unanderra Platform No. 1 the potential would then have existed for Signal WG 1010 to be cleared, thus enabling B9162 to be routed onto the Up Main.[5] This route however was not called at this point due to the uncertainty of the route required for B9162 to progress from Unanderra to Wollongong as there was track work being undertaken on the Down Main at Wollongong during this period. Consequently Signaller 1 held Signal WG 1010 at stop until the signaller controlling the Wollongong Panel (Signaller 3) determined B9162's route from Unanderra to Wollongong. In planning this route Signaller 3 had to consider Down Main diversions onto the Up Main together with the progress of B9162 onto the Up Main as a result of the track work being undertaken at Wollongong. Effectively Signaller 3 was not in a position to determine the route of B9162 onto his area of control until just prior to 11:02:06.

At 11:01:20 track circuit BF was occupied which approximately coincided with the time at which Driver 1 applied the dynamic brake. Shortly after this point

[4] Signaller 1 was relieving the signaller who originally controlled the Coast Panel (Signaller 2). Signaller 2 at the time of the incident was taking a scheduled lunch break. Signaller 1 was therefore controlling two signal panels during the course of the incident. The relieving of signallers in this manner is common practice on a weekend where traffic movements are less frequent in comparison to weekdays. On weekdays there is a signaller assigned specifically to fill in for a Signaller taking a scheduled break.

[5] Refer to Figure 4.1 and Appendix 8.6 depicting the location of track circuit 1015A and other track circuit locations particular to the description of events.

the crew of B9162 would have been aware of K431 stationary at Unanderra Platform No.1. The speed of B9162 at the time of dynamic brake application was approximately 51km/h. B9182 then decelerated to 30km/h where Driver 1 applied a minimum brake application some 245m from Signal WG1010. The approximate time of this application was at 11:01:46.

K431 then departed Unanderra Platform No. 1 at approximately 11:01:52 as track circuit 1015F became occupied. Shortly after this event, at 11:01:58, Driver 1 applied the emergency brake. At this point B9162 was 145m from Signal WG1010.

Some 8 seconds later (~ 11:02:06) Signaller 1 set the Main line route for B9162 to pass WG1010 under a Caution Turnout indication. The catch points protecting Signal WG 1010 were then registered to have started driving after a further 2 seconds (~ 11:02:08). Track circuit 1015A was registered as occupied after another 2 seconds (~ 11:02:10) indicating that B9162 had passed Signal WG 1010 at this point. Shortly after this event the lead bogie of locomotive 8127 would have then derailed through the catchpoints 1106B. The speed of B9162 on derailment was estimated at 20km/h.

At approximately 11:02:11 the Down Main to Branch Line route for K431 via Signal WG 1025 was called by Signaller 1.

The Branch Line catch points 1106B were then detected in the reverse (closed) position at 11:02:17. Under normal operations 1106B points take approximately 7 to 8 seconds to move from the open to reverse position after a route change on Signal WG 1010 has been activated by the signaller. The extended time frame of 3 seconds (11 seconds in total) can be explained in this instance if a flange or more than one flange on the lead bogie of Locomotive 8127 restrained the catch point closing movement as the bogie moved past the catch points.

After the wheelset on the leading bogie of Locomotive 8127 had passed through the open catchpoint 1106B, the trailing bogie of Locomotive 8127 and the leading bogie of Locomotive 8148 were also subsequently derailed.

The trailing bogie of Locomotive 8148 and the lead bogie of the first trailing RHGF minerals vehicle remained in the railed position between points 1106B and 1106A, as per the changed route.

B9162 eventually came to a stand some 50m past the catchpoints 1106B. At this point the train crew verbally checked each other for injuries. Driver 1 then contacted the Wollongong Signal Complex and advised Signaller 3 of the incident. Signaller 3 then advised Signaller 1 of the incident resulting in blocks being placed on Signal WG 1010 and the other Main Line signals adjacent to WG 1010.

Signaller 1 then initiated the appropriate incident response notifications resulting in emergency services and infrastructure services attending the incident.

As the fuel tank on Locomotive 8127 was ruptured and leaking, the NSW fire brigade was called to attend the incident and decant the remaining fuel on this locomotive. Fuel decanting operations were finished at 13:00 on 28 June 2003.

Port Kembla emergency unit arrived on site at 12:10 with rerailing of Locomotive 8148 commencing at 15:10 and finishing at 17:40. Locomotive 8127 was rerailed at approximately 17:00 on 29 June 2003 with the civil restoration works commencing shortly after. The track was certified fit for service again at approximately 18:00 on 30 June 2003. Reference can be made to Appendix 8.2 for a more detailed account of the incident sequence of events.

4.3 Incident Location

Signal WG 1010 is located on the South Coast Branch Line at 87.937km. Unanderra Station consists of two platforms and is located between the Branch Line and the Down Main at 88.349km. Refer to Figures 4.2 & Appendix 8.6 depicting the Unanderra track layout and relevant infrastructure details.

4.4 Injuries

No injuries were sustained to the train crew.

4.5 Loss or Damage

4.5.1 Civil Infrastructure

Damage to the civil infrastructure was assessed as 20 concrete sleepers, 12 timber sleepers, 40 metres of rail, 1 crossing and 7 x 4.6 metre points timbers.

4.5.2 Signals Infrastructure

Damage to points 1106B, signalling cable and block joint.

4.5.3 Rolling Stock

Damage to the rolling stock was assessed as:

Locomotive 8127 - extensive damage to the rear bogie and all running gear and ruptured fuel tank, and

Locomotive 8148 - minor damage to no. 1 end.

4.6 Train Control

The system of safeworking on the Unanderra Branch Line is Rail Vehicle Detection with remotely controlled signals.

4.7 Train Information

B9162 consisted of 2 x 81 Class Locomotives and 30 RHGF Mineral wagons with a train weight of 2760 tonnes and length of 481m. B9162 departed Dunmore at 10:35 and was tabled to arrive at its destination of Cooks River at 17:36. B9162 presented to Illawarra Control ahead of schedule which allowed the service to take up a departure time of 10:35. It is more common for this mineral service to depart Dunmore at 11:30 where the arrival time at Cooks River would not change irrespective of the departure time.

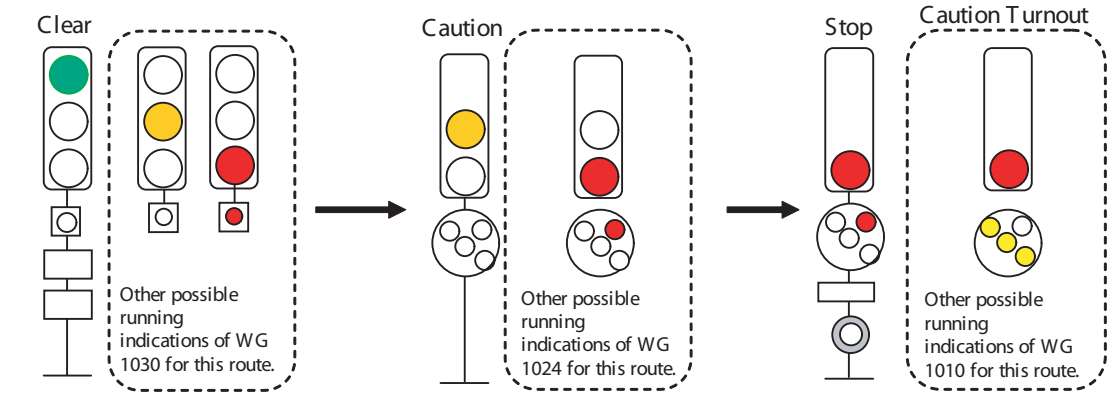
No issues were raised as to any mechanical failure of the train; however Driver 1 did indicate that the braking performance of RHGF wagons often varied between trips and that a Driver would need to be cognisant of this factor when managing the train's braking. Driver 1 did also note that the braking rate of B9162 varied between the initial applications made prior to Unanderra platform and when the emergency brake was applied just prior to Signal WG 1010.

4.8 Infrastructure Details

4.8.1 Unanderra Branch Line Signal Configuration

The main route signals leading up to and including Signal WG1010 are of the single head 3 light type. The signal indications that would have been displayed to the train crew of B9162 prior to the derailment are shown in Figure 4.3 A. In addition to these indications, Figure 4.3 A also depicts the remaining possible running indications of these signals.

4.3 A - Branch line to Up Main route via WG 1010 signal indications



4.3 B - Branch line to Up Main route via WG 1010 signal indications - Modified Medium (pulsating yellow) Signal WG1024 & Caution Turnout route passed WG 1010

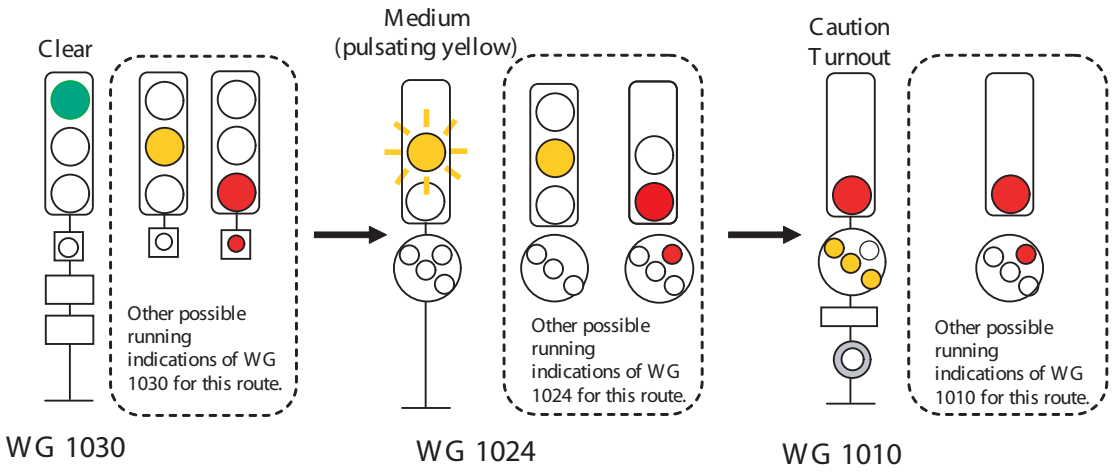


Figure 4.3 – Unanderra Branch Line Signals – Route Indications on 28 June 03 and other possible route indications leading to Signal WG 1010.

Since the introduction of single head signals in the early 80's there have been further improvements in signalling indication control technology for these types of signals. The improvements have allowed the yellow signal to pulsate thereby representing a Medium indication as defined by the RIC Network Rules at NSG 606 (refer to Appendix 8.12). This Medium signal indication provides drivers with a definitive indication that the next main route signal will be set as a minimum at Caution. At least two signals controlled by the Wollongong Signal Complex have been modified to allow the yellow or yellow turnout signals to pulsate in this manner. If the current signalling design principles contained in RIC's standard SC 00 13 01 01 SP were applied to Signal WG 1024 as a new installation, the signal would be configured with a Medium aspect as shown in Figure 4.3B.

If Signal WG 1024 was configured with a pulsating yellow (Medium) signal the signal indications depicted in Figure 4.3B would be possible when Signal WG 1010 is set at either Stop or Caution Turnout.

4.8.2 Signal Sighting

There exists a number of intermittent signal sighting obstructions that obscure the aspect of Signal WG 1010 on approach of trains to this signal. At 88.244km there exists an unobstructed view of Signal WG 1010's red light indication as a train proceeds to the base of this signal. Overhead wiring structures do however intermittently obstruct one or more of the yellow turnout indicators of this signal. Any obstruction of this nature would place further emphasis on the Driver to closely monitor the turnout signal aspect. Refer to Figure 4.4 depicting the signal sighting view of Signal WG 1010.

Figure 4.4 Signal Sighting of Signal WG 1010 at 88.244km.

Vegetation in close proximity to Signal WG 1016 was also noted to cause an intermittent signal sighting obstruction of this signal.

4.8.3 Curve and Gradient

The falling grade leading up to Signal WG 1010 is approximately 1:120.

4.8.4 Track Structure Design

The track speed leading into Unanderra on the Branch Line is 80km/h with a 25km/h turnout speed in place at Signal WG 1010.

4.9 Workers Involved

The workers involved in this incident included:

Pacific National Train Crew:	2 Train Drivers, Driver 1 driving duties, Driver 2 observer duties.
State Rail Authority Signallers:	3 Signallers

Relevant qualifications and medical records for all rail safety workers involved in the incident were current at 28 June 2003.

4.10 Train Crew Management Details

4.10.1 Train Crew Competency Re-certification

Both train crew were current in their competency re-certification as drivers. Pacific National have an extensive driver competency checklist that forms part of the assessment process for when a driver is initially certified to drive locomotives. This competency checklist requires the competency assessor to check for competency in performing normal and emergency braking procedures. This checklist can be referenced in Appendix 8.11.

When a driver undergoes re-certification a number of the driver certification checklist sections are assessed. These sections are highlighted for the competency assessor on the competency re-certification assessment form as depicted in Appendix 8.11. When drivers are assessed for re-certification it is common practice for the competency assessor to also review compliance of the driver against relevant safety notices. This additional assessment requirement is not however formalised within the re-certification process documentation. An assessment of a driver's competence with regard to Section 6 Perform train braking Clauses 2.3 is also not a formal requirement of the re-certification process as referenced in Appendix 8.11.

4.10.2 Train Crew Route Knowledge

Both train crew were qualified drivers as at 28 June 2003. Driver 1 was qualified with route knowledge for the journey between Dunmore and Cooks River having a number of years experience in driving mineral trains for FreightCorp along this route.

Driver 2 was not qualified with route knowledge between Dunmore and Cooks River and therefore could not be assigned a driver's duties for B9162's route on 28 June 2003. Driver 2 recently transferred from his base country location of Temora and was in the process of gaining his route knowledge competency for the applicable Wollongong routes.

According to Driver 1's previous experience in operating trains on the Unanderra Branch Line, the route for a train to pass from the Branch Line to the Up Main via Platform No.2, would almost always be set if there was a train stationary on Platform No.1.

4.10.3 Signal Recognition

Driver 2 stated to the investigation that he verbally called the indications of Signal WG 1024 and Signal WG 1016 to Driver 1 as "one". This term translates to a signal indication of Caution. Driver 2 also stated that he called Signal WG 1010 to Driver 1 as "red", where this term translates to a signal indication of Stop. Directly following the provision of this advice Driver 2 stated to Driver 1 that he "didn't think the train was going to pull up". It was at this point in time that Driver 2 noted Driver 1 apply the emergency brake. Driver 1 did not repeat back the signal indications to Driver 2 to confirm the accuracy of the verbal signal indications provided by Driver 2.

Driver 1 had no recollection of Driver 2 calling the signals leading up to Signal WG 1010 although he did recall that it was common practice for Driver 2 to "call the signals" on the previous occasions the crew had worked together.

4.10.4 Hasler Equipment and Recorded Information

The following Hasler analysis of B9162's journey passed Signal WG 1024 was provided by Pacific National from the Hasler tape on Locomotive 8148. The full Hasler tape review can be referenced in Appendix 8.5.

> *At 22.6 km's the speed of the train starts decreasing from 51km/h to 30km/h, there is no reduction of the brake pipe pressure. This is consistent with controlling a locomotive by the use of dynamic brake.*
>
> *At 23 km's a minimum reduction[6] is made, the speed of the locomotive decreases to 25km/h.*
>
> *At approximately 23.1 km's the brake pipe pressure rapidly reduces to zero and the speed of the locomotive decreases. This is consistent with an emergency application.*
>
> *At approximately 23.3 km's the speed of the locomotive drops suddenly from 20km/h to zero. The rate of deceleration would indicate that there was an outside influence brought to bear on the locomotive[7].*

[6] A minimum reduction refers to a 50kPa brake application.

[7] This point in time corresponds to B9162 derailing at the catch point 1106B and coming to a sudden stop as the train derailed into the track ballast and substructure.

The analysis information provided above has been transcribed onto the braking and speed diagram in Figure 4.1 and can also be referenced within Figure 4.5.

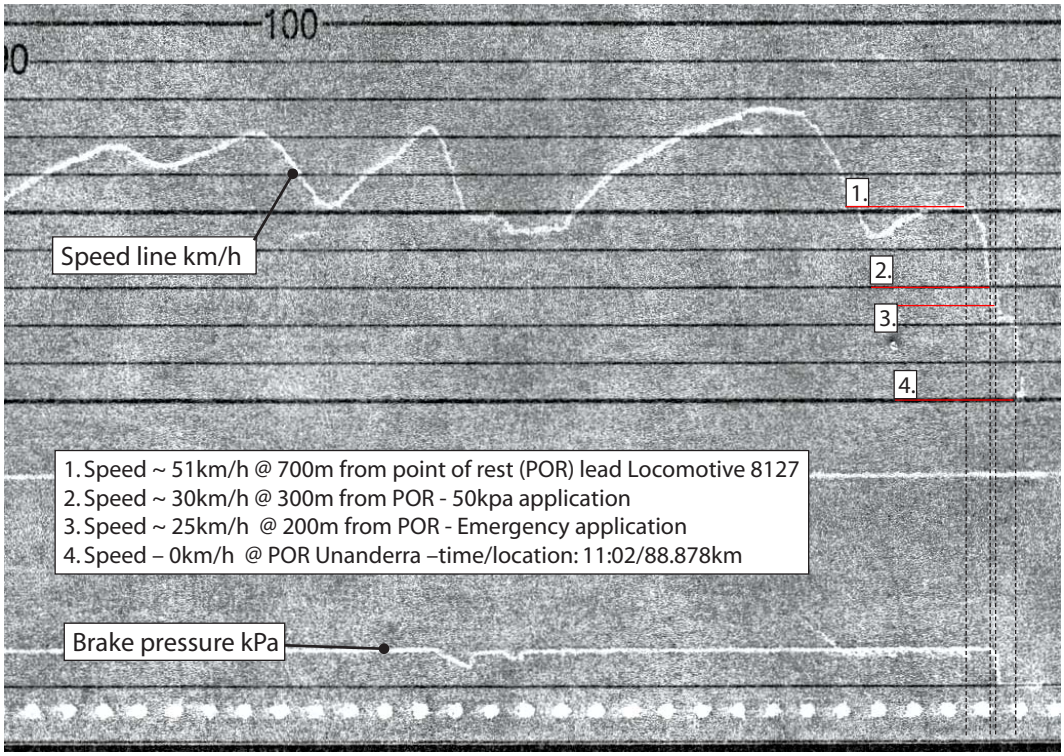


Figure 4.5 81 Class 8148 Hasler tape

The Hasler tape retrieved from the lead locomotive 8127 was ripped and had not been recording for approximately 2 weeks prior to the incident date. Pacific National's Driver Locomotive preparation procedures requires a driver to check the Hasler operation and sign the Hasler tape in order to confirm that the Hasler has been inspected and found to be operational. An inspection of the Hasler tape revealed that there were no driver's initials marked at the signing location where the tape had stopped some two weeks prior to the incident.

Pacific National also reported that there had not been any notice or mechanical defect log from drivers reporting that the Hasler tape on 8127 was defective.

4.10.5 Train Braking

A comparison of the train braking deceleration rates between the combined use of dynamic[8] and minimum air brake[9] application against the emergency brake[10] application of B9162 can be referenced in Table 4.1. This comparison indicates

[8] "Dynamic brake" denotes a train brake system where the locomotive's traction motors are used to provide a braking force to the locomotives wheel's via the traction motor system.

[9] A trains air brake uses compressed air to apply the brakes to the train's wheels and to control the operation of the brake along the train. The compressed air is supplied by a motor driven compressor on the locomotive or train. The brake control is actuated from a "driver's brake valve". This valve is used to feed air to the brake pipe or to allow air to escape from the brake pipe.

[10] "Emergency brake" denotes a selection on the driver's brake valve that allows the air brakes to be applied with their maximum air pressure and provides the most instantaneous application of this pressure selection.

that the deceleration rate of B9162 using a combination of dynamic and minimum air brake application was greater than the deceleration rate of B9162 using the emergency brake. It should be noted however that these deceleration rates for emergency braking are well below simulated results for a train of B9162's configuration. Simulated deceleration rates for a train of B9162's configuration are more likely to be in the order of 0.5m/s^2. The difference between the simulated results and calculated results from B9162's hasler analysis should be qualified by in-service testing carried out at the incident location.

No.	Description	Initial Speed (u) m/s	Final Speed (v) m/s	Distance (d) m	Deceleration (a) m/s^2
1	Deceleration rate between when dynamic brake with minimum air-brake application was made to the point where the emergency brake application was made.	8.3	6.9	100	~ 0.11
2	Deceleration rate between the Emergency Brake application and when the locomotive passed through the catchpoints 1106B.	6.9	5.6	145	~ 0.06

Table 4.1 Comparison of B9162 braking deceleration rates between Dynamic/Air Brake and Emergency Air Brake operation

If Driver 1 had left the train braking in dynamic and air brake mode, under the same settings, the derailment speed at 1106B catchpoints would have been approximately 4km/h. Following this incident Pacific National conducted indicative tests at Otford confirming that greater braking deceleration rates could be achieved using a combination of dynamic and air brake operation in comparison with emergency only air brake operation.

4.10.6 Closed Circuit Television (CCTV) Recorded Information

Closed Circuit Television (CCTV) footage from Unanderra Platform cameras 2, 3, 5 and 6 were reviewed in relation to the incident and provided the following information.

CityRail Service K431 remained stationary at Unanderra Platform for 37 seconds prior to its departure.

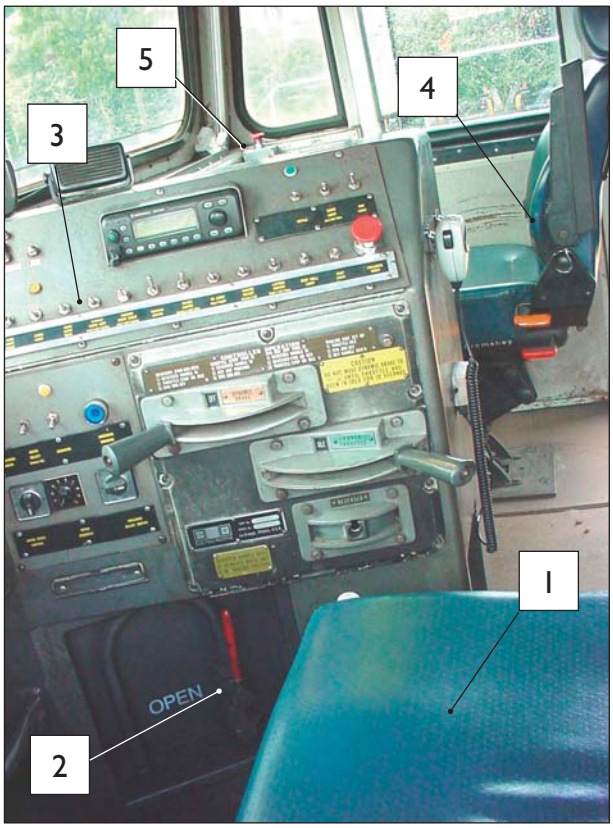
The speed of B9162 as is moved past the start of Unanderra Platform No. 2 (467m from POR) was calculated from CCTV images at approximately 41km/h. Refer to Appendix 8.3 for calculations of the CCTV at this point. The CCTV calculated speed corresponds with the Hasler tape recorded speed at the start of Unanderra Platform No. 1, this point being approximately 467m from the POR.

The two locomotives of B9162 were noted to pass the end of Unanderra Platform No.2 just prior to K431 departing Unanderra Platform No.1. Refer to Appendix 8.4 depicting this CCTV time reference.

4.10.7 81 Class Emergency Brake - Secondary Application System

81 class locomotives have a single brake emergency cock positioned in the Driver 1's control stand. The relative position of this brake cock to Driver 1 in the seated

position is adjacent to the driver's right foot. Should Driver 2 be required to apply the emergency brake cock he/she would have to leave their seated position and reach down between the control stand and the Driver 1's right leg. Refer to Figures 4.6 and 4.7 depicting the views of the emergency brake cock from both the Driver 1 and Driver 2 seats.



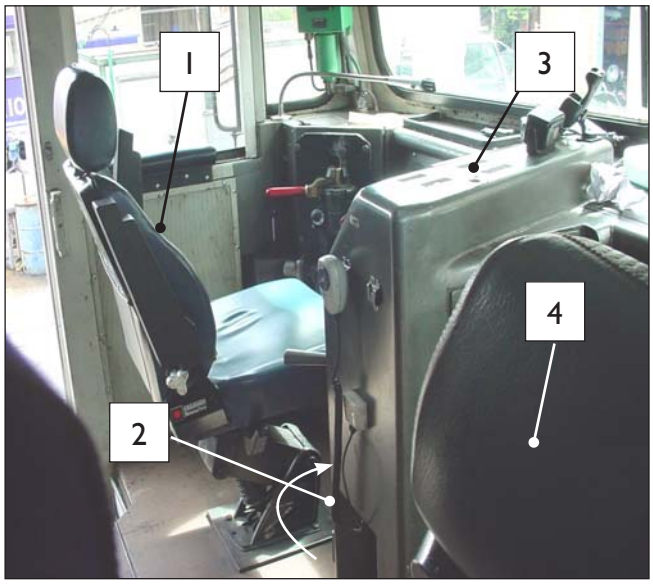
81 Class Cab (ex National Rail 81 Class) – View from Driver 1's seat facing control stand and Driver 2's seat.

1. Driver 1's seat
2. Driver 1's Emergency cock (normal closed position)
3. Driver1's control stand
4. Driver 2's seat
5. Driver 2's vigilance control (Removed on ex FreightCorp 81 Class Locomotives in 2002 and retained on ex National Rail 81 Class Locomotives)

Figure 4.6 81 Class Cab (ex National Rail)– View from Driver 1's seat facing control stand and Driver 2's seat

When 81 class locomotives were first manufactured they were configured with a vigilance control for the Driver 2. This vigilance control would enable Driver 2 to activate the emergency brake on depressing the vigilance button continuosly. On a continuous application of the vigilance control the emergency brake would activate within a maximum period of 42 seconds. The vigilance controls within ex FreightCorp 81 class locomotives were disconnected in 2002 in response to actions undertaken to address the Beresfield collision recommendations[11]. At that time FreightCorp linked the brake and throttle applications to reset the vigilance system. This modification was designed to compensate for the change in vigilance control configuration.

[11] FreightCorp commissioned a human factors and ergonomic review of the locomotive vigilance control system where this study recommended an alternative method be instituted to improve train crew vigilance. Subsequently the Driver 2 vigilance control button was removed from all FreightCorp locomotives.



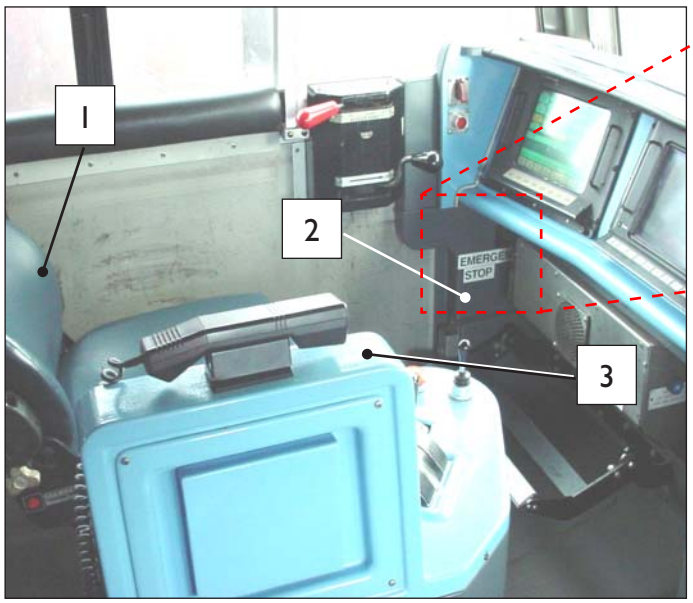
81 Class Cab – View from Driver 2's seat facing back of control stand and Driver 1's seat.

1. Driver 1's seat
2. Driver 1's Emergency cock (behind control stand)
3. Driver 1's control stand
4. Driver 2's seat

Figure 4.7 81 Class Cab – View from Driver 2's seat facing back of control stand and Driver 1's seat.

4.10.1 NR Class Emergency Brake - Secondary Application System

NR class locomotives have two emergency brake cocks located within the driver's cab. A number of other NSW locomotives also have two emergency brake cocks located within the driver's cab. The locations of the emergency brake cocks within an NR class locomotive are depicted in Figure 4.8 and 4.9.



NR Class Cab – View from Driver 2's seat facing Driver 1's seat.

1. Driver 1's seat
2. Driver 1' Emergency cock (closed position)
3. Driver 1's control stand

Figure 4.8 NR Class Cab – Driver 1's Emergency Brake Cock - View from Driver 2's seat facing control stand

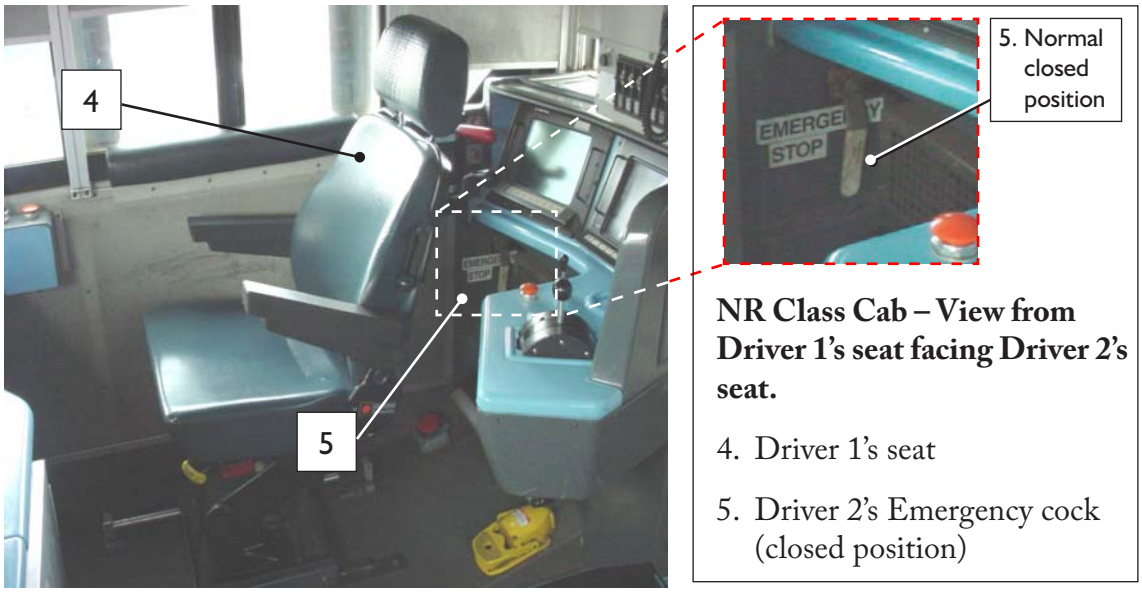


Figure 4.9 NR Class Cab – Driver 2's Emergency Brake Cock - View from Driver 1's seat facing Driver 2's seat

NR Class emergency brake cocks are placed primarily to cater for drivers operating the locomotive in either direction. The emergency brake cock located at the rear of Driver 2's seat is positioned for when a driver is operating the locomotive in the No. 2 end leading direction.

4.11 Driver Safety Procedures

Those driver procedures relating to the incident are covered under Pacific National's Train Management Manual and relevant Safety Notices together with RIC's Network Rules.

4.11.1 Responsibilities of 2nd Crew Members in Locomotive Cabs

On 22 November 2002 Pacific National issued a System Safety Notice (SSN) No: 07/02 relating to the responsibilities of the 2nd crew member in a locomotive cab. This SSN was issued "*as a result of two recent major safety incidents involving two person crewed trains and a misunderstanding by the second crew member on each occasion as to their continuing safety responsibility when not performing the actual driving function.*"

SSN also stated: *"On trains operated by a two person crew, the safeworking responsibility for the continued safe operation of the train is equally shared by both persons, regardless of which person is actually undertaking the driving duties at that time."…*

….."In relation to a crew member observing that the driver performing the driving duties is undertaking (or is about to undertake) an unsafe act, it is the responsibility and duty of the second crew member to take immediate action as is necessary to prevent the unsafe act."

"This action may, in some extreme circumstances, require the second member to take

direct action to cause the train to come to an emergency stop. In addition to making an emergency brake application with the brake valve, this direct action may be initiated by opening an emergency isolating cock, continuously depressing a vigilance control button, or tripping the vigilance control circuit breaker etc".

"Both crew members are responsible for the safety of the train and reporting all safety incidents."

This safety notice highlights the responsibilities of Driver 2 in taking appropriate action to control a train should Driver 1 not be managing the train in a safe manner as required by the signalling system. SSN No: 07/02 can be referenced in Appendix 8.10.

4.12 Signaller Safeworking Rules and Procedures

RIC's Network Rules at NGE 234 cover the responsibilities of Signallers in relation to this incident.

4.13 Pre & Post Incident Communication

The following pre and post incident communication occurred between B9162 and Wollongong Signal Complex. This information was sourced from the communications voice recording equipment located at the Wollongong Signal Complex where all incoming and outgoing land line calls are recorded and incoming train radio calls are recorded.

4.13.1 Pre Incident Communication

There was only one voice communication call logged and recorded between B9162 and the Wollongong Signal Complex prior to the derailment. This communication consisted of Driver 1 confirming the operational status of B9162 prior to the train's departure of Dunmore.

4.13.2 Post Incident Communication

The Driver of B9162 advised Wollongong Signal Complex of the SPAD derailment immediately after the incident took place. The Driver also advised Wollongong Signal Complex that there were no injuries to the train crew, that the Down Main was fouled and that fuel was leaking from Locomotive 8127.

4.14 Environmental Factors

The weather at the time of incident was fine, providing clear visibility of signals within the Unanderra area.

4.15 Toxicology Information

A breath test of the train crew was conducted at 12:55 following the incident producing all negative results.

The train crew were also Drug tested following the incident. These tests produced negative results.

The Signallers at Wollongong Signal Complex were not breath tested following the incident.

4.16 History of Similar Occurrences

A search of the RIC Safety Incident Database (SAD) revealed one previous signal passed at danger at Signal WG 1010 which occurred on 22nd July 1991. This incident involved a freight train.

The remarks recorded for this incident include:

> *"At 0223 hours A.I.S. Loco. D36 passed WG 1010 signal at stop and derailed 1106b catchpoints."*

4.17 Relevant Safety Regulations

The NSW Rail Safety Act 2002 applies to the matters under investigation.

4.18 Emergency Response to the Occurrence

As the fuel tank on Locomotive 8127 was ruptured and leaking, the NSW fire brigade was called to attend the incident and decant the remaining fuel on this locomotive. Fuel decanting operations were finished at 13:00.

The first Major Incident Management (MIM) meeting was held at 13:10 and a forecast of 16:00 on Sunday 29 June 2003 for restoration of the down line was provided.

Power was removed from the overhead wire section K171/1 on authority of permit number E43/03.

Two 82 class light engines arrived on site at 14:00 to attach to the rear of B9162 to assist in rerailing and subsequent removal of the train to Port Kembla (excluding the two locomotives).

Port Kembla emergency unit arrived on site at 12:10 with rerailing of Locomotive 8148 commencing at 15:10 and finishing at 17:40.

At 21:50 a Track Occupancy Authority was taken out by RIC Civil to carry out preparatory civil restoration works. Removal of Locomotive 8127 clear of the down main line commenced at 18:00. At 22:30 all work ceased due to fatigue experienced by the emergency crew staff. Work recommenced on the rerailing of Locomotive 8127 at 09:00 29 June 2003 with civil restoration works commencing at 17:00. The track was certified fit for service again at approximately 18:00 on 30 June 2003.

4.19 Train Crew's Shift Roster – Two Weeks prior to Incident

The train crew's fatigue scores were analysed according to the Fatigue Audit InterDyne (FAID) guide providing fatigue scores on the 28 June 03 below 80, being well within acceptable limits.

Refer to Appendix 8.1 for fatigue plots of all rail safety workers involved in this incident.

FAID calculates a fatigue rating using four factors that have emerged from research into shiftwork and fatigue over the last few decades. The specific formulae for this program has been developed and validated by the Centre for Sleep Research at the University of South Australia. The specific determinants of work-related fatigue as used in the FAID model are:

1. The time of day of works and breaks
2. The duration of work and breaks
3. Work history in the preceding seven days
4. The biological limits on recovery sleep.

Fatigue scores below 80 are considered satisfactory, 80 to 100 suggest a risk assessment of the working should be conducted and scores in excess of 100 are considered problematic.

4.20 Signaller Shift Rosters – Two Weeks prior to Incident.

Fatigue scores for all signalling staff were also checked against the Fatigue Audit InterDyne guide providing fatigue scores on the 28 June 2003 for two of the three signalling staff outside the recommended FAID risk limit of 80. These FAID results can be referenced within Appendix 8.1. It is worth noting that the overtime worked by these individuals was often the factor in the FAID risk scores exceeding 80.

5.0 ANALYSIS

The following investigation analysis has been derived from the evidence documented in Section 4.0 and corresponding appendices.

5.1 Train Management

The investigation considers that Driver 1 may have held the preconception that Signal WG 1010 was set at a Caution Turnout indication based on situational factors that were present up to the point in time when Driver 1 noticed Signal WG 1010 indicating Stop. Those situational indicators that support the scenario of Driver 1 assuming that Signal WG 1010 was set at a Caution Turnout indication are:

- B9162 passed Signal WG 1030 at Clear, where this signal was sighted by both crew members to have changed indication from Caution to Clear as B9162 approached the signal. This change in signal aspect may have been the first situational indicator to Driver 1 of the possibility that a clear route was being set for the passage of B9162 from the Branch Line onto the Up Main.
- Signal WG 1024 was sighted and passed by B9162 at Caution, where Signal WG 1024 can only display a Caution, Caution Turnout, or Stop indication by design. The significance of these limited number of indications is that Signal WG 1024 would never provide an advanced indication as to whether Signal WG 1010 would be set at either a Caution Turnout or Stop indication. Because Signal WG 1024 does not provide a definitive indication as to whether Signal WG 1010 is not set at a caution turnout indication, Signal WG 1024's signal indication could become passive to a driver should he/she consider other indicators, than the immediate signal, to gauge the indication of the next signal.
- Driver 1 noted an Intercity train (K431) stopped at Unanderra Platform No.1 as B9162 approached Platform No.2. According to Driver 1's previous experience in operating trains on the Unanderra Branch Line, the route for a train to pass from the Branch Line to the Up Main would almost always be set when there is a train stationary at Platform No.1.
- Signal WG 1016 was sighted by the Driver at Proceed, whilst B9162 passed through Unanderra Platform No.2, where Shunting signal WG 1016 will only ever display a Proceed or Stop indication by design. The significance of these limited indications is identical to that of Signal WG 1024 where Signal WG 1016 would never provide an advanced indication as to whether Signal WG 1010 is set at a Caution Turnout or Stop indication.

The fact that the Driver initially applied a minimum brake application instead of a heavier brake application leading up to Signal WG 1016 would indicate at that point in time that the Driver was not anticipating to stop the train.

Approximately 305 metres of clear sighting distance leading up to Signal WG 1010 was available. Driver 1 subsequently applied an emergency brake application 145m from Signal WG 1010. Driver 1 had therefore approximately 160m of clear sighting of Signal WG 1010 at stop prior to him applying a brake application that would eventually stop the train. Over this distance, at an average approximate

speed of 30km/h, 19 seconds would have elapsed between the first available opportunity for a clear sighting of Signal WG 1010 at Stop and when the emergency brake was actually applied.

Based on advice from Pacific National Driver specialists, Driver 1 maintained B9162's speed close to its maximum permissible value into Unanderra Platform No. 1 up to the point where he would have had clear sighting of Signal WG 1010. Any delayed reaction to acknowledge a Stop indication of Signal WG 1010 at this point would have increased the risk of B9162 not being able to stop in time prior to Signal WG 1010.

5.2 Local Signalling Configurations of Signal WG 1024 and Signal WG 1010

The Network Rules are explicit in their definition of a Driver's response to a Caution signal and the predictive information conveyed by such an indication on a single head signal[12]. Drivers however may be less inclined to acknowledge the predictive information of this type of signal where it does not display the full complement of standard[13] or modified[14] 3 colour indications. One of the main purposes of a signal, apart from providing information on how the driver should respond to the actual signal, is the predictive information a signal conveys regarding the next signal in advance.

When a Caution indication is displayed in a single head 3 position signal configuration the next signal is expected as a minimum to be set at Stop, with only a possibility of the signal being displayed at Caution.

The configuration of Signal WG 1024, being limited in its signal aspects, only allows for the display of Caution and Stop indications. In this case there exists no definitive indication within Signal WG 1024 that Signal WG 1010 will ever display a Caution Turnout indication. Signal WG 1024 would need either a green light or a pulsating yellow light to provide a predictive indication of Signal WG 1010 being set at a Caution Turnout indication.

When trains are routed from the Unanderra Branch line to the Up Main via Signal WG 1010 this signal is more likely to be set at a Caution Turnout indication than at Stop. The Up Main route may be set in this manner in order to facilitate freight trains and interurban passenger trains moving through the junction more efficiently due to the signal's Up Main line crossover function. Considering these conditions, drivers may well start to disregard the predictive information of Signal WG 1024 in relation to the indication of Signal WG 1010 being at Stop. If drivers were less inclined to consider the predictive information of Signal WG 1024 they may then start to look for other predictive environmental/situational indicators that may give some guidance on the indication of Signal WG 1010.

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[12] Refer to Appendix 8.12 Network Rules NSG606 – Responding to Signals and Signs for the applicable definition.

[13] Standard indications on a single head 3 position signal include Clear (green), Caution (yellow) or Stop (red).

[14] An additional Medium (pulsating yellow) indication may exist on a modified single head 3 position signal.

5.3 Crew Resource Management

Just prior to the derailment, Driver 2 communicated to Driver 1 on four separate occasions. The first three instances of verbal communication relayed the signal indications of Signal WG 1024("one" ➔Caution), Signal WG 1016 ("one" ➔Caution) and Signal WG 1010 ("red" ➔ Stop). The last communication with Driver 1 included a comment concerning doubt as to whether the train would stop before Signal WG 1010 after the emergency brake was applied. Driver 2's comments to Driver 1 leading up to Signal WG 1010 were reactive to the type of train management being undertaken by Driver 1 and not pro-active in terms of advising Driver 1 how the train should have been handled on approach to Signal WG 1010 before the emergency brake was applied.

For approximately twenty years, the global aviation industry has attempted to reduce accidents and incidents by providing an additional defence known as Crew Resource Management (CRM) training. CRM has provided a structure for operational crews (similar to train drivers and train guards) to utilise all available resources including information, people and equipment in the prevention of accidents through improvements to crew coordination and communication. CRM has also focussed on the development of cognitive and interpersonal skills.

In 1999 the Royal Aeronautical Society described CRM thus:

"CRM encompasses a wide range of knowledge, skills and attitudes including communications, situational awareness, problem solving, decision making, and teamwork…"

CRM is about recognising the limits of human performance and taking steps to minimise the potential for error. The outcome is enhanced performance, reduced likelihood of error, and increased safety. The steps taken to minimise the error and compensate for the limitations of human performance represent the process, and this process is free to vary, to reflect local conditions and local constraints.[15]

CRM training generally incorporates the following elements:

- Decision making
- Communication skills
- Behavioural factors
- Attitude
- Leadership
- Teamwork
- Culture and norms

CRM principles applied to the incident scenario may have assisted Driver 2 in successfully identifying that Driver 1 was not suitably responding to signals WG 1024 and WG 1010 and communicating this concern to Driver 1 in time for B9162 to be stopped prior to Signal WG 1010.

[15] Applied Aviation Psychology Achievement, Change and Challenge, Edited by Brent J. Hayward and Andrew R. Lowe

5.4 81 Class (ex FreightCorp) Emergency Train Braking

In 2002 ex FreightCorp 81 class locomotives had the Driver 2 vigilance control button removed from the locomotive cab. There is also only one emergency brake cock located in the locomotive cabin. The location of this brake cock does not provide Driver 2 with a convenient means of operation, should Driver 1 restrict its access to Driver 2 for any number of reasons.

In the event that Driver 2 had expressed any concern over the point at which Driver 1 should have brought B9162 under control he would have had little or no method of stopping B9162 under his own physical actions.

Other Pacific National locomotives have an additional emergency brake cock positioned within reach of Driver 2. This brake cock facilitates the application of an emergency brake application by Driver 2 independent of Driver 1's control.

5.5 Train Signalling Operations Management

Those planned operational route changes made to the passage of B9162 through Unanderra Platform No. 2, to allow for the expedient passage of a K431 through Unanderra Platform No. 1, were consistent with the priority allocated to passenger services over freight services. In effect, K431 experienced little to no delay as it approached, stopped and departed from Unanderra Platform. Just prior to Unanderra, CityRail Service K431 was running approximately 1 – 2 minutes late as referenced against the published CityRail timetable.

Any further delays experienced by K431 would have resulted in this train running late where CityRail trains are considered to be on time to within 5 minutes of their timetabled stopping pattern.

The change in route movements to B9162 would have resulted in this freight service being delayed by approximately 3-4 minutes. Considering that B9162 was running effectively 1 hour ahead of the scheduled journey time, a delay of approximately 3-4 minutes at Unanderra would not be considered abnormal in terms of freight train timetabled operations.

The responsibility and planning of a train's journey throughout the rail network resides with Train Controllers and Signallers. The exact train route, in terms of sections of tracks traversed by a train, can in some instances vary depending on the route options available and traffic priorities at the time. Consequently a freight train such as B9162 would not necessarily know the exact track route in which the service may take. There is no specific safeworking requirement for a train's route to be communicated to a driver. The Driver is essentially required to obey the approaching signals that effectively route the train with regard to the train's timetable and overall route.

Considering also that there was track work taking place at Wollongong on the Down Main, and that train diversions were in place just prior to the incident, the planned delay to B9162 was appropriate considering:

- The priority given to trains clearing out of the diversion area, in this case CityRail Service K431, and

- The route of B9162 from Signal WG 1010 would have required additional time to consider based on the planning required to divert services from the Up Main onto the Down Main in order to circumvent track work at Wollongong.

Apart from those factors determined to have influenced Signal WG 1010 being set at Stop for B9162, there could have been a number of other factors that may have had the potential to result in Signal WG 1010 being maintained at Stop. Such factors include:

- A train occupying the section Unanderra North to Unanderra (Up or Down)
- Points failure at 1106B,
- Signal failure at Signal WG 1010,
- Fallen overhead wiring or other fallen structure,
- A failed Up Main service on the next track circuit, or
- Track structure vandalism, trespassers etc.

6.0 CONCLUSIONS

6.1 Findings

Those factors that were determined to have directly contributed to the occurrence of the incident included:

- The Driver 1 relying on situational indicators leading up to Signal WG 1010, such as the prior clearing of Signal WG 1030 and the stationary passenger train at Unanderra Platform No.1, to provide an indication that Signal WG 1010 would be set at a Caution Turnout indication.
- The Driver 1 not appropriately braking B9162 in response to the Caution signal displayed at Signal WG 1024 in preparation for Signal WG 1010 being at Stop.

6.2 Contributing factors

The following factors, in addition to those direct factors described above, had the potential to have contributed to the occurrence of this incident:

- Drivers may be less inclined to acknowledge the predictive information of a Caution signal indication on a limited aspect single head signal such as Signal WG 1024, where a Caution indication would normally translate to a Stop indication on Signal WG 1010. Should drivers place little emphasis on the predictive information of this type of signal configuration they may be more inclined to look for other predictive measures to gauge the indication of Signal WG 1010.
- Driver 1 maintained B9162's speed close to its maximum permissible value into Unanderra Platform No. 1 up to the point where he would have had clear sighting of Signal WG 1010. Any delayed reaction to acknowledge a Stop indication of Signal WG 1010 at this point would have increased the risk of B9162 not being able to stop in time prior to the signal.
- Driver 1's immediate reaction to apply an emergency brake application on sighting Signal WG 1010 at Stop resulted in the dynamic brake cutting out and inturn reducing the deceleration of B9162 leading up to Signal WG 1010. Had Driver 1 applied a maximum service application at that point in time the dynamic brake would have remained engaged and provided the maximum braking effort leading up to Signal WG 1010. This combination of braking would have reduced the speed at which B9162 passed through 1106B catchpoints and may have even stopped B9162 prior to the catchpoints.
- Driver 2 was not yet fully qualified with route knowledge of the Dunmore to Cooks River route. This lack of experience may have contributed to his failure in not providing an earlier warning to Driver 1 concerning the appropriate level of train braking required on the approach to Signal WG 1024 at Caution and Signal WG 1010 at Stop.
- Driver 2's only means of stopping B9162 effectively would have been to physically take control of Driver 1's brake controls or emergency brake cock in order to apply B9162's air brake. The inability of Driver 2 in not being able

to apply an emergency brake application independently of Driver 1's working space and controls may have been an inhibitor to Driver 2 in carrying out this type of action.

- Both Drivers did not communicate with each other, with regard to the indication of signals, in a manner consistent with Pacific National's communication protocol. Whilst signal indications were called by Driver 2 they were not acknowledged and confirmed by Driver 1.

All latent conditions and active errors thought to have contributed to the incident are provided below.

6.2.1 Latent conditions

Those latent conditions[16] that may have contributed to the occurrence of this incident include:

- The lack of formal re-certification training and supporting documentation in the assessment of emergency train braking for drivers carrying out observer duties.
- Pacific National 81 Class ex FreightCorp locomotives do not have either a Driver 2 emergency brake cock or vigilance control button to activate should Driver 2 need to stop the locomotive in an emergency.
- Drivers may be less inclined to take full account of the predictive information of a Caution signal indication on a limited aspect single head signal such as Signal WG 1024, where a Caution indication would theoretically translate to a Stop indication on Signal WG 1010.

6.2.2 Active errors

Those active errors[17] that have been determined to have contributed to the occurrence of this incident are:

- The lack of Driver 1's response in not braking his train in a manner consistent with the caution indication provided by Signal WG 1024, in preparation for stopping at Signal WG 1010.
- The lack of response by Driver 1 in not sighting Signal WG 1010 at stop where Driver 1 would have had approximately 160m/19seconds of clear signal sighting distance before he applied the emergency brake in response to the signal's indication.
- The lack of lead time provided to Driver 1 by Driver 2 to advise that B9162 would require an appropriate air brake application to stop the train.
- Driver 1 did not follow standard safeworking communication protocols in terms of confirming verbal signal indication communications from Driver 2.

[16] Latent conditions are those conditions that result in the delayed consequences of technical and organisational actions and decisions (conditions or failures).

[17] Active errors are the unsafe acts committed by people who are in direct contact with the safety system.

6.3 General Safety Related Findings

The investigation found that the following matters did not contribute to the incident, but had the potential to affect rail safety.

- The Hasler tape on locomotive 8127 was found ripped on examination after the incident. This Hasler tape had not been signed by drivers for at least two weeks prior to the incident indicating a lack of compliance by Driver 1 and other drivers in not certifying the Hasler tape prior to the train's departure.
- The sighting of Signal WG 1016 was obstructed intermittently by vegetation growing in the Up cess side.

7.0 SAFETY RECOMMENDATIONS

7.1 Post Incident Safety Actions

Immediately following the incident Pacific National assessed the competency of both drivers.

7.2 Direct Safety Recommendations

As of the 1 July 2004 RailCorp was vested with safety management responsibility for Rail Infrastructure Corporation and State Rail Authority. The safety recommendations of this investigation have therefore been amended to reflect this change. The following direct safety recommendations are made to Pacific National and RailCorp in order to avert the occurrence of similar incidents.

7.2.1 Improvements required in Pacific National driver signal aspect vigilance

It is recommended that Pacific National take action to ensure drivers maintain an appropriate level of signal aspect vigilance. Pacific National is recommended to review their driver training and re-certification methods in order to facilitate and ensure greater communication and interaction between train crews. This communication and interaction is recommended to be designed to maximise the vigilance and experience of both drivers with the intent of achieving the highest level of driver safety and signal vigilance reliability.

Pacific National may consider reviewing and adopting CRM techniques that could be of benefit in achieving this outcome.

7.2.2 Review required of a Driver's response to limited aspect single head signal configurations including a review of Signal WG 1024

It is recommended that RailCorp conduct a human factors review of the potential risks associated with a driver's response to single head signal configurations that have a limited number of coloured light indications. Such a review is recommended to determine if the existing pulsating yellow Medium signal enhancement is considered an appropriate modification to address the human factor concerns of removing the predictive information associated with standard single head signals. The review is also recommended to assess the suitability of those locations on the NSW network in which the pulsating medium indication is currently implemented.

It is also recommended that RailCorp determine the suitability of Signal WG 1024's signalling configuration considering current medium signalling design principles and those other signals within the Unanderra junction configuration that have been modified to include a medium (pulsating yellow light) indication. Following from this review, RailCorp is recommended to correct the configuration of Signal WG 1024 where deemed necessary.

7.2.3 Improvements required in 81 Class Driver 2 's emergency brake system

The Independent Transport Safety and Reliability Regulator is recommended to determine whether freight locomotives should be mandated to have a second

emergency brake cock fitted to each driver's cab, so that the second driver can independently apply an emergency brake application in an emergency.

7.2.4 Review of RHGF vehicle's acceptable braking performance using emergency braking or a combination of air and dynamic braking.

It is recommended that Pacific National determine whether RHGF vehicle's operating on the Unanderra Branch line have acceptable emergency braking performance. Pacific national is recommended to correct any deficiencies identified.

It is recommended that Pacific National determine if conditions exist where the use of dynamic and full service train braking is preferred over emergency air braking. Where such conditions exist Pacific National is recommended to appropriately train their drivers on when and how to take advantage of any such braking improvements under emergency conditions.

7.3 General Safety Actions

The following safety actions are recommended to Pacific National and RailCorp management in order to improve upon rail safety management as identified within this investigation.

7.3.1 Review of the Driver 2's competency re-certification in making emergency brake applications

It is recommended that Pacific National ensure the Driver 2 competency re-certification process covers an assessment of the driver's competency to apply emergency brake applications when required.

7.3.2 Certification and operational verification of Hasler Speed Recorders prior to a train's departure.

It is recommended that Pacific National take action to ensure the certification and operational verification of Hasler speed recorders is undertaken by drivers prior to a train's departure. It is also recommended that Pacific National ensure adequate training and ongoing emphasis is provided to drivers in relation to the certification and verification of Hasler recording devices.

7.3.3 Signal WG1016 sighting obstruction and ongoing maintenance of vegetation sighting obstructions.

It is recommended that RailCorp clear all vegetation sighting obstructions at Signal WG 1016. An ongoing vegetation maintenance program at Signal WG 1016 is also recommended.