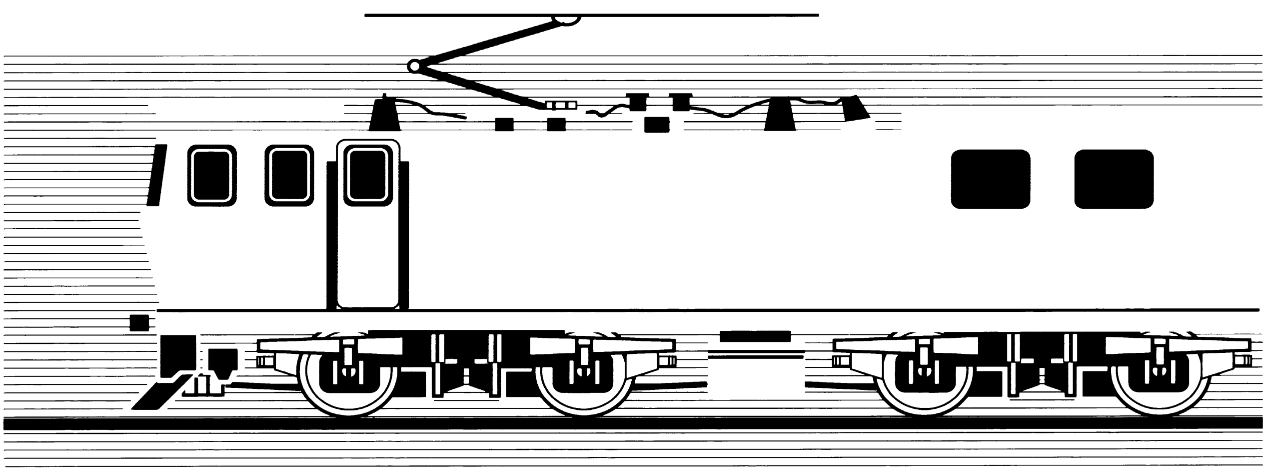
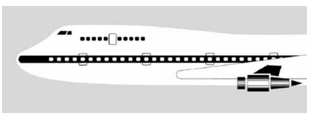
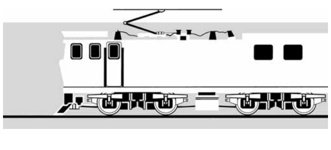


RAILWAY OCCURRENCE REPORT

04-109 **passenger express Train 804, *Tranz Alpine*, stalled and slid back, Otira Tunnel** **28 March 2004**





TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

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Report 04-109

passenger express Train 804 *Tranz Alpine*

stalled and slid back

Otira Tunnel

28 March 2004

Abstract

On Sunday 28 March 2004, at about 1541 shortly after entering the Otira Tunnel Train 804, the Greymouth to Christchurch *Tranz Alpine* passenger express, with 268 passengers and 6 crew on board, stalled and slid backwards. The locomotive engineer eventually brought the train under control but when he attempted to move forward again the locomotives could not develop traction and the train stopped.

After a second unsuccessful attempt to move the train forward, the locomotive engineer was authorised by train control to set back to Otira where extra locomotive power was attached for the trip through the Otira Tunnel to Arthurs Pass.

Contributing factors and safety issues identified included:

- the loss of traction experienced by the locomotives
- the failure of the locomotive sanding equipment to operate correctly
- a residue of coal dust and moisture on the railhead within the tunnel
- the inability to establish radio communication between the locomotive engineer and train controller
- the imbalance of axle weight distribution on locomotive DCP4801
- the lack of filtering of locomotive sand
- the loss of situational awareness by the locomotive engineer.

Two safety recommendations were made to the Chief Executive of Toll NZ Consolidated Limited.

Contents

Figures

Abbreviations

km/h	kilometres per hour
kPa	kilopascals
kg/m	kilograms per metre
m	metre(s)
Selcall	selective radio calling
t	tonnes
Toll Rail	Toll NZ Consolidated Limited[1]
Tranz Rail	Tranz Rail Ltd
Tranz Scenic	Tranz Scenic 2001 Limited
VDU	visual display unit
VHF	very high frequency

[1] New owner of Tranz Rail, effective 5 May 2004 and Tranz Scenic 2001 Limited, effective 20 May 2004.

Data Summary

Train type and number:	passenger express Train 804	
Date and time:	28 March 2004 at about 1541[2]	
Location:	Otira Tunnel	
Persons on board:	crew:	6
	passengers:	268
Injuries:	crew:	nil
	passengers:	nil
Damage:	nil	
Operator:	Tranz Scenic 2001 Limited (Tranz Scenic)	
Investigator-in-charge:	D L Bevin	

[2] Times in this report are New Zealand Daylight Standard Times (UTC+12) and are expressed in the 24 hour mode.

1 Factual Information

1.1 Narrative

1.1.1 On Sunday 28 March 2004, Train 804 was the Greymouth to Christchurch *Tranz Alpine* passenger express. It consisted of DCP class locomotives 4559 (leading) and 4801 (trailing) in multiple, 10 passenger carriages, a viewing platform carriage and a luggage van for a gross weight of 384 t.

1.1.2 Train 804 was crewed by a locomotive engineer, 2 train managers and 3 train attendants and was carrying 268 passengers.

1.1.3 At 1533, Train 804 passed through Otira and climbed the incline to the western portal of the Otira Tunnel. As the train entered the tunnel, the locomotive engineer activated the distance monitor[3] located in the locomotive cab.

1.1.4 Shortly after entering the tunnel the locomotive engineer became aware that the driving wheels of the locomotives were slipping, and the train was slowing down. He reduced power, used the independent brake[4] and activated the locomotive sanding equipment in an attempt to reduce the wheelslip and maintain speed. The sanding was unsuccessful so he further reduced power and made a slight brake application using the independent brake to stop the wheels slipping, but this also had no effect.

1.1.5 About 2 km into the tunnel, the train encountered a fog bank (see 1.2.8), which lasted for a distance of about 2 km. While travelling through the fog, the locomotive engineer could not see either ahead of the locomotive or the sides of the tunnel to monitor his progress. He said he thought the train had been travelling at between 20 and 25 km/h when it entered the fog but once in it the movement of the train had not felt right.

1.1.6 The locomotive engineer saw that the speedometer was still registering a speed. However, when he looked at the distance monitor he realised that the train was travelling backward, so he made an automatic brake[5] application and gradually brought the train to a stop.

1.1.7 The locomotive engineer made 2 unsuccessful attempts to restart the train. He tried to contact the train controller via radio channel 4 but did not receive a response, so he sent an emergency radio signal (see 1.9.28).

1.1.8 The train controller unsuccessfully tried for about 5 minutes to contact the locomotive engineer after receiving the emergency radio call and eventually contacted the train manager. The train manager confirmed that the train was stationary and the passengers were safe.

1.1.9 When the train controller eventually made contact with the locomotive engineer, he was told that the locomotives were experiencing traction problems, and the locomotive engineer requested permission for the train to set back to Otira. The train controller authorised the movement after ascertaining that the tunnel doors were open.

1.1.10 Train 804 arrived back at Otira at about 1624.

1.2 Site information

1.2.1 The Otira Tunnel was situated on the Midland Line between Otira, at the western end, and Arthurs Pass at the eastern end (see Figure 1).

[3] A monitor in the locomotive cab used to display the distance travelled from a fixed point.
[4] The independent brake worked only on the locomotive.
[5] The automatic brake operated throughout the train.

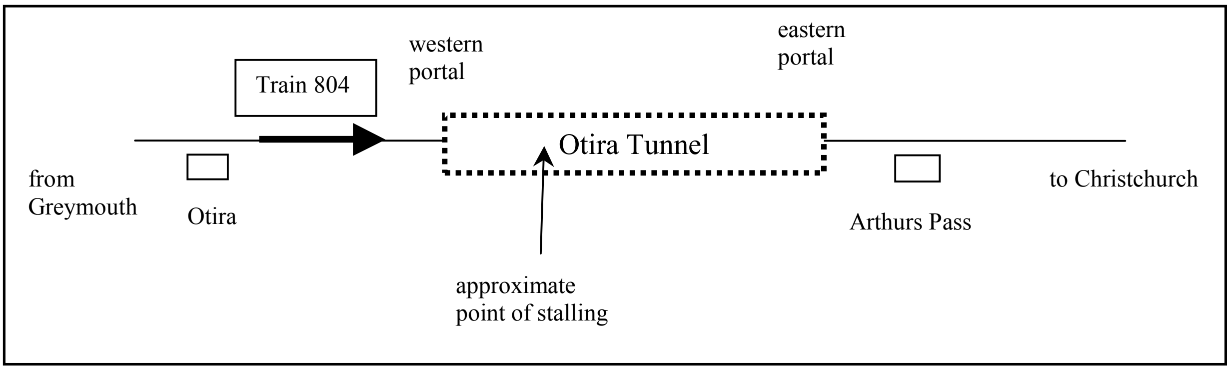

Figure 1
Location of the Otira Tunnel (not to scale)

1.2.2 Eastbound trains climbed a 1 in 35 gradient from Otira towards the tunnel, but the gradient increased to 1 in 33 about 1 km before the western tunnel portal. The 8.5 km long tunnel was on a uniform 1 in 33 gradient from the western portal to Arthurs Pass (see Figure 2).

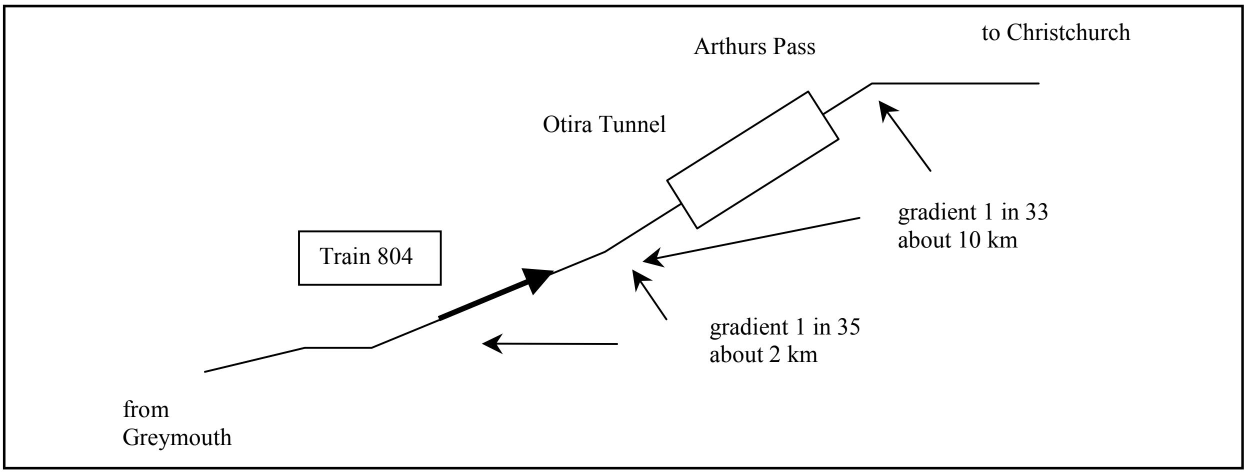

Figure 2
Gradient diagram Otira to Arthurs Pass (not to scale)

1.2.3 In 1981, the rail in the tunnel had been replaced with 50 kg/m rail, and all joints were welded at that time.

1.2.4 Until 1997 all eastbound freight trains and most passenger trains had been hauled through the tunnel by 4 electric locomotives operating in multiple, using a 1500 volt overhead direct current electric system. In 1997, following the installation of 2 extraction fans and a sliding door at the western portal of the tunnel, electric operations had been replaced by full diesel operations. The fans worked in conjunction with the sliding door to provide cool air for the diesel locomotives hauling trains up the gradient from Otira to Arthurs Pass, as well as purging the tunnel of fumes (see Figures 3 and 4).

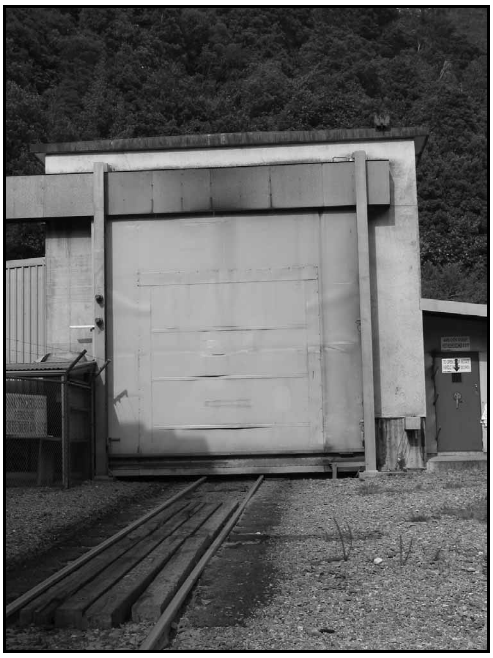

Figure 3
The sliding door in the closed position at the western portal of Otira Tunnel

1.2.5 Once an eastbound train was inside the tunnel, the sliding door closed and the first fan started, which provided airflow through the tunnel for cooling the locomotives. When the train arrived at Arthurs Pass, the second fan started and both fans ran for 20 minutes to purge the tunnel of exhaust fumes before the door reopened.

1.2.6 After a westbound train cleared the tunnel, the door closed and both extractor fans started and ran for 11 minutes to purge the tunnel of exhaust fumes. When the fans stopped, the door reopened. Figure 4 shows the extractor fan outlets.

Figure 4
The extractor fan exhaust outlets at the western portal of Otira Tunnel

1.2.7 There was extensive water seepage throughout the tunnel. The water was channelled into a covered concrete box side drain. However, the coal dust contamination of the ballast inhibited the efficiency of the drain in some areas.

1.2.8 The passage of an eastbound train through the tunnel created air pressure ahead of the train. When the fan started and drew the moist air through the tunnel, the temperature and air pressure change created a fog around the lead locomotive. This was a localised condition that affected all eastbound trains and occurred once the train was about 2 km inside the tunnel, and lasted for about 2 km.

1.2.9 Train 832, a loaded eastbound coal train, had travelled through the tunnel and arrived at Arthurs Pass about 35 minutes before Train 804 arrived at Otira. The coal train consisted of open CW class hopper wagons, which were a known source of escaping coal dust because of the low sides of the wagons. As Train 832 travelled through the tunnel, the coal dust blowing from the wagons settled on the railhead and when mixed with the moisture in the tunnel, formed a slippery film on the railhead. The locomotives on Train 804 had to overcome the moist rail to maintain traction.

1.2.10 A banker consist[6] of 3 DX class locomotives was attached to Train 832 at Otira to assist the train through the tunnel to Arthurs Pass. The banker consist was detached at Arthurs Pass but there was not enough time for it to return to Otira without delaying Train 804, so it was left at Arthurs Pass.

1.2.11 Train 847, a westbound empty express freight coal train, arrived at Arthurs Pass at 1437 but, because of the opposing Train 832 in the tunnel, it could not be advanced to Otira, so remained at Arthurs Pass to cross Train 804.

1.3 The locomotive engineer

1.3.1 The locomotive engineer held current certification for Grade 1 locomotive engineer's duties. He had 27 years' experience in locomotive running duties, most of which had been based in Christchurch. He was experienced in driving on the Midland Line and had operated express freight, coal and passenger trains on the route before transferring to Tranz Scenic in 2002 to drive passenger trains full time.

1.3.2 On 28 March, the locomotive engineer was rostered to operate Train 803, Christchurch to Greymouth *Tranz Alpine* passenger express, returning on Train 804, Greymouth to Christchurch *Tranz Alpine* passenger express. He commenced his shift at 0735 at the Tranz Scenic locomotive depot in Christchurch where he completed his book-on duties and attended to the paperwork relating to the running of his train. After completing these tasks, he uplifted breathing apparatus for use, if required, in the Otira Tunnel, and travelled by motor vehicle to Christchurch station where he took up the running of Train 803.

1.3.3 The trip to Greymouth had been uneventful. The locomotive engineer said it had been a good run and Train 803 had arrived at Greymouth a few minutes ahead of schedule. He had his rostered meal break at Greymouth while the passenger carriages were cleaned and the locomotives prepared for the return to Christchurch as Train 804.

1.3.4 Train 804 passed through Otira on schedule. The locomotive engineer said that the gradient from Otira to the western portal of the tunnel was a good indication as to how the train would perform through the tunnel, because both gradients were similar. If the train was not exceeding 30 km/h before reaching the tunnel portal, it indicated that there may be a problem and the train could be stopped before entering the tunnel and return to Otira for assistance.

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[6] Additional locomotive power added to heavy eastbound trains at Otira to assist them up the gradient to Arthurs Pass.

1.3.5 The locomotive engineer said that as the train climbed towards the tunnel it was travelling at about 50 km/h, which was not unusual given the dry conditions at the time, and had entered the western portal at about 38 km/h. However, shortly after entering the tunnel he experienced wheelslip. In an attempt to minimise the wheelslip while still maintaining momentum he reduced the throttle setting from notch 8 to notch 7 to decrease the amperage to the traction motors. He also manually operated the sanding equipment to lay sand on the railhead, but the wheelslip continued. He further reduced the throttle setting to notch 6, and partially applied the independent brake. These actions stopped the wheelslip and allowed the locomotive to regain and maintain a speed of 25 km/h. However, when he released the independent brake, the wheelslip started again and the speed decreased. He again applied the independent brake and further reduced the throttle setting back to notch 5 to stop the wheelslip, but the speed continued to drop.

1.3.6 The locomotive engineer said that he had run into the fog bank about 2 km into the tunnel, a phenomenon he encountered every time he drove an eastbound train through the tunnel. He described it as “instant fog” and said visibility was so bad that there may as well be no windows in the locomotive cab as he could only see about a metre in front of him and couldn’t see the sides of the tunnel. From experience he thought the fog bank usually lasted for about 2 km.

1.3.7 The locomotive engineer realised the train was losing speed. At some point he saw a speed registered on the speedometer but on looking at the distance monitor he realised the train was going backwards and responded by making a three-quarter application of the train brake. He was mindful that a full brake application could cause the wheels on the carriages to lock and slide, which would reduce the braking capability. He was not able to estimate how far his train had slid back after stalling because of the foggy conditions within the tunnel as he had been concentrating on the braking and control of the train and had not looked back to the distance monitor. He later recalled that the train may have slid back for a period of between 30 and 40 seconds but he was not sure.

1.3.8 The locomotive engineer attempted to restart the train by selecting throttle setting notch 4 and releasing the brakes, but as soon as the speed reached 15 km/h the locomotives again experienced wheelslip and the train stalled. He made one further attempt to start the train but this was also unsuccessful.

1.3.9 Following the second attempt to restart Train 804, the locomotive engineer tried to contact the train manager (train manager 1) on channel 1[7] to advise him of the situation but was unsuccessful. He was aware of the range limitations of channel 1 radio within the tunnel, about 100 m, and thought that train manager 1 was possibly further away than that. After trying several more times to make contact, he decided to try the train control radio channel 4[8].

1.3.10 The locomotive engineer knew that he required permission from the train controller to use channel 4 under these circumstances, so he said he pressed the Selcall button (see 1.9.27) to establish contact. From his experience it was not unusual for a delay before the train controller responded to Selcall because the train controller was often busy performing other tasks and would respond when he was able. However, the locomotive engineer became concerned at the time he waited and eventually sent an emergency alarm[9] (see 1.9.28) over the train control radio system “as a last resort”. He estimated his emergency alarm was responded to by the train controller between one and 2 minutes later, by which time he had also been able to establish contact with train manager 1 and advise him of the situation.

[7] Channel 1 was a very high frequency point-to-point radio communication channel that did not use repeaters.
[8] Channel 4 was the train to train control radio channel which operated within Otira Tunnel.
[9] This sent an emergency radio signal to the train controller when activated.

1.3.11 The locomotive engineer said that he had not initially used the emergency call to train control because it was only used as a last resort for emergencies. He had used the Selcall button on the train control radio channel rather than verbally call the train controller, in case the train controller was in the process of talking to, or issuing operating instructions to another train, and by voice calling him the locomotive engineer was concerned he might interrupt.

1.3.12 The locomotive engineer was aware that he could either obtain assistance in the form of the banker locomotive consist at Arthurs Pass, or set back out of the tunnel and return to Otira (see 1.7). He decided against utilising the banker locomotive consist for assistance and arranged instead to set back based on the limited visibility as a result of the fog, the gradient and greasy track conditions, together with passenger comfort and the fact that Train 804 was closer to the western portal, and therefore Otira.

1.3.13 Once contact was established with the train controller, the locomotive engineer was able to arrange permission for Train 804 to reverse back to Otira, with train manager 1 arranging a pilot in the rear carriage to guide the train back. No further problems were experienced as the train set back to Otira.

1.3.14 The banker locomotive consist was not due to arrive at Otira from Arthurs Pass for about 30 minutes after Train 804 arrived back in Otira, so the locomotive engineer took the opportunity to check the electrical circuits in the locomotive. He did not find anything that suggested a problem, so he checked the locomotive sand boxes. He found small pebbles had blocked the outlets from at least 2 of the sand boxes, preventing the sand from being deposited on the railhead.

1.3.15 The locomotive engineer said that when he had manually operated the locomotive sanding equipment prior to the stall he heard the sound of compressed air being released. However, this did not indicate that the sanding equipment was operating correctly as it made the same sound whether sand was being deposited or not.

1.4 The train crew

General

1.4.1 The 10 passenger carriages on Train 804 were separated into sets of 5 carriages by the viewing platform carriage, which effectively made 2 separate trains.

1.4.2 The leading 5 carriages were crewed by train manager 1, train attendant 1 and train attendant 3. The rear 5 carriages were crewed by train manager 2 and train attendant 2. Train manager 1 was responsible for the overall running of the train.

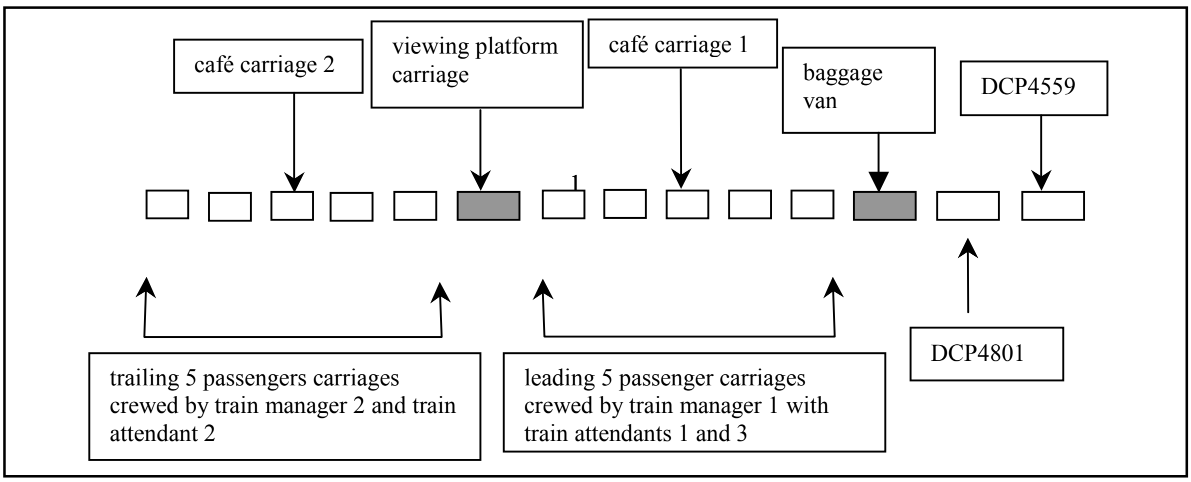

Figure 5
The make-up of Train 804 eastbound *Tranz Alpine* passenger express (not to scale)

1.4.3 Each member of the on-board train crew was a certified train manager with current qualifications, which included Otira Tunnel emergency response procedures.

Train manager 1

1.4.4 Train manager 1 had been in the role for nearly 9 years and was experienced on the *Tranz Alpine* route.

1.4.5 When Train 804 entered the tunnel, train manager 1 was riding in café carriage 1, the third passenger carriage from the front of the train, with train attendant 1 and train attendant 3 (see Figure 5). He felt the train was not travelling as fast as normal when it climbed the grade towards the western portal.

1.4.6 He had previously experienced a stalled eastbound passenger express train setting back out of the tunnel and he said the circumstances on this day were similar. He had not expected Train 804 to get very far into the tunnel before stalling, so he put his radio on to channel 4, anticipating a message from the locomotive engineer.

1.4.7 The train slowed progressively after it entered the tunnel and train manager 1 saw the light of a telephone booth[10] go past his carriage at about walking pace before the train came to a stop about 3 or 4 minutes later. He tried to contact the locomotive engineer on channel 4 but there was no response so he tried channel 1[11]. He was aware of the 100 m range limitation of channel 1 within the tunnel, but felt that he was roughly within that distance. However, there was still no response from the locomotive engineer, so he made an announcement over the public address system and advised passengers of the stalling and that the train would be away again shortly.

1.4.8 Train manager 1 suddenly became aware that the train had started to move backwards. Initially the movement did not concern him, but he soon realised that the train was gathering speed. This was confirmed when the telephone booth he had seen earlier "flashed" past. He knew the end of the tunnel was not far away, and he and train attendant 1 were just about to apply the emergency brake in the café carriage when he felt the brakes go on and the train gradually came to a halt. Despite continued attempts, he had not been able to make contact with the locomotive engineer as the train ran backwards.

1.4.9 After a short time, the train started to move forward again and train manager 1 again saw the telephone booth as the train passed it at walking pace. The train stopped and he estimated it to be about at the same location as the original stall. At this time he was able to contact the train controller on channel 4 and advised him of the situation, after which the locomotive engineer came on channel 4 and preparations were made for Train 804 to set back to Otira. Train manager 1 then handed over responsibility for piloting the train backwards to train manager 2 as she was at the rear of the train and had an unrestricted view of the track ahead.

1.4.10 Train manager 1 said that during the previously experienced train stalling in the tunnel he had been able to maintain radio contact with the locomotive engineer at all times. This occasion was the only time he had experienced a train reversing without the locomotive engineer communicating with him first. His radio had been tuned to channel 4 but he had not heard any prior communication between the locomotive engineer and train control, so he considered the movement was a roll back rather than a controlled set back.

1.4.11 Train manager 1 had later enquired as to the speed of the train as it entered the tunnel and was surprised to find it was "above regulation".

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[10] Refuges within the tunnel where telephone facilities were provided to contact train control.

[11] Radio channel 1 was normally used for local communications and not routed through a repeater. If channel 4 was required for communication between 2 people in the tunnel, the train controller's permission was required because the transmissions would be heard over the entire Rolleston to Otira (Midland) train control radio line.

Train attendant 1

1.4.12 Train attendant 1 had been in the role for about 8 years and was experienced on the *Tranz Alpine* route.

1.4.13 He was riding in café carriage 1 with train manager 1 and train attendant 3. When Train 804 entered the tunnel he commented to train manager 1 that he didn't feel the train had enough speed on, but he wasn't unduly concerned about it. The train slowed and they commented that it looked like they would stop, which is what eventually happened. However, they were still not concerned as they expected it was probably a locomotive problem. Train attendant 1 said he was unsure just how far they travelled into the tunnel because of the difficulty in assessing distance while in the dark.

1.4.14 They did not hear from the locomotive engineer, so after a short time train manager 1 tried to contact him by radio but there was no response. The train then started to move backwards quite slowly. Train attendant 1 had initially been unsure as to whether they were moving backwards or forwards, so shone a torch through the window on to the tunnel wall to confirm their direction of travel. Both he and train manager 1 commented that it was unusual to set back without the locomotive engineer first making contact with them, but again he was not unduly concerned. However, the train seemed to pick up speed quite quickly as it ran backwards before the brakes came on hard and the train slowed and stopped.

1.4.15 After a short time Train 804 started to move forward again. Train attendant 1 surmised that the locomotive engineer was making a second attempt to get through the tunnel and that the backward movement may have been so he could lay sand for another attempt. After moving forward for a short distance the train stopped again.

1.4.16 Train attendant 1 heard train manager 1 establish radio contact with the train controller, who expressed concern that he had received an emergency alarm from Train 804 but could not contact the locomotive engineer. At that time he heard train manager 1 inform the train controller of the situation following which the locomotive engineer joined the radio conversation and arrangements were made for the train to set back to Otira.

1.4.17 Train attendant 1 said that his biggest concern was that neither he nor train manager 1 knew what was going on as they had not received any communication from the locomotive engineer. He thought that the first reverse movement had initially felt controlled but then the train accelerated and the brakes came on hard, as if it was picking up too much speed. He said that at that stage both he and train manager 1 were within seconds of applying the emergency brake.

Train attendant 3

1.4.18 Train attendant 3 had been in the role for about 4 years and was experienced on the *Tranz Alpine* route.

1.4.19 She was riding in café carriage 1 with train manager 1 and train attendant 1 and thought that Train 804 was travelling rather slowly as it approached the tunnel.

1.4.20 After entering the tunnel, Train 804 continued on for some distance, she wasn't sure how far, before coming to a stop. She became concerned, as she always did, when trains stopped in the tunnel.

1.4.21 Train attendant 3 thought the train remained stopped for a couple of minutes before it started to go backwards, gathering speed as it did so. She could not remember for how long it ran backwards before coming to a stop, but it then started to move forward again, which surprised her. She wondered why they were making a second attempt when the first attempt had been unsuccessful.

1.4.22 The train stopped again and train attendant 3 heard, on train manager 1's radio, the train controller say he had received an emergency alarm from Train 804 but could not contact the locomotive engineer. The discussion about the emergency call had concerned her as she had not anticipated a problem up until that time.

Train manager 2

1.4.23 Train manager 2 had been in the role for nearly 5 years and was experienced on the *Tranz Alpine* route.

1.4.24 She was riding with train attendant 2 in café carriage 2, the eighth passenger carriage from the front of the train, when it entered the tunnel (see Figure 5).

1.4.25 Train manager 2 said it was standard practice to close the viewing platform carriage and the cafés and ask the passengers to remain in the carriages while the train travelled through the tunnel. This had been done and she was standing in the café carriage when the train, which she thought was about a quarter of the way through the tunnel at the time, began to slow noticeably and finally stopped.

1.4.26 She switched her portable radio to channel 4 expecting to hear what had happened, but although she heard train manager 1 trying to contact the locomotive engineer, there had been no response. She also heard the train controller say that he had received an emergency alarm from Train 804 but had not been able to contact the locomotive engineer.

1.4.27 The train started moving again, however, because of the darkness in the tunnel, train manager 2 said she was unsure if it moved backwards or forwards, although she thought it was forward. The train came to a stop again but still there was no contact with the locomotive engineer.

1.4.28 Then the train started to move backwards and gain speed. She became concerned, firstly because she thought the locomotive engineer may have become incapacitated, and secondly, because she should have been at the rear of the train to pilot any reversing movement. The train finally stopped and shortly afterwards she heard on her radio that communication had been established between train manager 1, the train controller and the locomotive engineer.

1.4.29 Arrangements were made for the train to set back to Otira and train manager 1 asked her to go to the rear of the train to guide the driver, which she did, accompanied by train attendant 2.

1.4.30 Train manager 2 was aware of the existence of the emergency brake and had been trained in its use but had not considered using it because she was having difficulty in determining if the train was going backwards or forwards.

Train attendant 2

1.4.31 Train attendant 2 had been in the role for nearly 10 years and was experienced on the *Tranz Alpine* route.

1.4.32 He was riding in café carriage 2 with train manager 2 and thought that Train 804 was travelling slower than usual when it entered the tunnel. Over the next 7 or 8 minutes it went slower and slower until it became difficult for him to tell if the train was actually moving or had stopped. He estimated that the train eventually stopped about 2 to 2.5 km inside the tunnel.

1.4.33 He was standing beside train manager 2, who had her radio set to scan mode[12] and said he heard over her radio the electronic "blip" signals as the locomotive engineer sent Selcall transmissions to train control on channel 4. He thought about 4 such signals were sent but there was no response from train control.

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[12] Some radios can be put into scan mode; this allows calls to be received from a number of different channels.

1.4.34 At about this time he thought the train had started to move backwards but he had the impression it had not moved far and had not been moving very fast. However, from later discussions with other members of the train crew he understood that the train had moved backwards quite a distance.

1.4.35 The darkness within the tunnel made it difficult for him to tell if the train was moving or not. At one point train manager 2 had said the train was moving but train attendant 2 thought it wasn't, so he went over to the carriage window and saw that in fact the train was moving, but it was very hard to tell.

1.4.36 About this time communication was established with train control on channel 4. However, shortly after the locomotive engineer was heard, on what train attendant 2 thought was channel 2 (Midland radio line), he heard the train controller query the locomotive engineer regarding the channel on which they were talking.

1.4.37 Train attendant 2 accompanied train manager 2 back to the rear of the train and, at her request, undertook the piloting duties, including confirming that the tunnel door was open and calling identification points and signal indications to assist the locomotive engineer.

1.5 The train controller

1.5.1 The train controller had 29 years' experience in the role, and had been certified as competent to operate the West Train Control Desk[13] for more than 3 years. He was experienced in the operation of the radio systems, the tunnel doors and the Otira Tunnel emergency procedures. He was on his first shift back after a short period of leave.

1.5.2 The train controller had not communicated with the locomotive engineer of Train 804 regarding the performance of the train during the journey from Greymouth to Otira, nor had he received a request for the banker locomotive consist to be available at Otira to assist Train 804 to Arthurs Pass. He saw from the visual display unit (VDU)[14] in front of him that Train 804 had entered the tunnel, the tunnel door had closed and the extractor fans had started.

1.5.3 At 1545 the train controller received an emergency radio call from Train 804 via what he thought was the "Otira and Tunnel" repeater. He said he had expected communication to be through this repeater while Train 804 was in the tunnel, as that repeater was set up to cover only "Otira and Tunnel" radio communications, with separate repeaters being utilised for radio communications west and east of the tunnel. He was unaware that the "Otira and Tunnel" selection was not an independent repeater but was instead permanently connected to the Midland radio line.

1.5.4 The train controller verbally responded several times to the emergency call before sending a base call (see 1.9.26) to Train 804. He was adamant that the base call had "locked on" to the locomotive because of the audio acknowledgement he received. He continued to transmit verbal messages and repeat the base call procedure to ensure it was "locking on". However, despite his efforts there was no response.

1.5.5 The train controller was aware of instances where locomotive engineers had inadvertently activated the emergency call button while operating the sanding lever because of the close proximity of the switches on the control console, but he was not prepared to dismiss the emergency call on those grounds.

[13] Controlled train movements from Rolleston to Greymouth and Westport.
[14] Track circuits were illuminated in red on the VDU when the track section to which they applied was occupied by a train.

1.5.6 After 3 or 4 minutes the train controller was getting very concerned because he had not made contact with anyone in the tunnel, but shortly afterwards train manager 1 responded. The train controller had also heard train manager 1 trying to make contact with the locomotive engineer on channel 4, so he realised the train was intact and was relieved to find there was no major emergency. Train manager 1 then told him that the locomotive engineer advised they had an adhesion problem with the locomotives, and that there had been concern when the train had started to slip back.

1.5.7 A short time later the train controller made contact with the locomotive engineer who confirmed the traction difficulties with the locomotives and requested permission for the train to set back to Otira. The train controller manually shut down the tunnel ventilation systems and opened the tunnel door before authorising the movement to set back.

1.5.8 The train controller later expressed surprise that the radio transmission from the locomotive engineer of Train 804, while in the Otira Tunnel, had come via the Midland radio line. He had always believed that radio communications with trains within the Otira Tunnel were via a specific repeater designated "Otira and Tunnel".

1.5.9 The train controller had just returned from leave and was not aware of any changes to the radio system.

1.6 The locomotives

The control stand and speedometer

1.6.1 The locomotive control panel, containing the brake and throttle handles as well as various gauges, was situated immediately to the left of the locomotive engineer, while the speedometer was situated a little higher than the control stand and midway between it and the locomotive engineer's front view window.

Locomotive wheel arrangements

1.6.2 The DCP class locomotives had a 3-axle bogie at each end. Each bogie had 2 driving axles and an idler axle between them. Positioned to assist with distributing the weight of the locomotive for axle load limiting purposes, the idler axle rotated freely as the locomotive moved in either direction. The locomotive speedometer operated from an alternator box located on the idler axle.

1.6.3 The idler wheels on DCP4801, the trailing locomotive, had an incorrect diameter relationship with the driving wheels, which resulted in an imbalance of tractive weight on the driving wheels and consequently reduced tractive effort and braking capability. If the idler wheels were incorrectly set up they could take too much or too little of the locomotive weight.

1.6.4 According to Design Manual M6000, the static (or holding) brake characteristics of DCP locomotives was 12% adhesion[15] and was based on a formula which assumed the correct weight distribution of 16 tonnes per axle. This was correct on DCP4559 but, because of wheel turns (maintenance) and wheel change-outs (replacements) on DCP4801, the weight distribution on the driving axles of DCP4801 was reduced by about 1.75 tonnes per axle, to 14.25 tonnes axle load. This was compensated for by an equivalent increase in the load on the idler axle.

1.6.5 Following the incident DCP4801 underwent a bogie change because one of the driving wheels had been reduced to less than the minimum diameter permissible as a result of the damage sustained when the locomotive slid backwards.

[15] The percentage of locomotive adhesive weight on the track that is available for power or braking the locomotive.

The locomotive event recorders

1.6.6 The data from the locomotive event recorders for DCP4559 and DCP4801 was provided for analysis.

1.6.7 The locomotive event recorder of DCP4801 registered speeds of 6 km/h less than those recorded on the locomotive event recorder of DCP4559. This was because of the difference in idler wheel diameters between the 2 locomotives. DCP4559 was correctly set up and its event recorder was used for the analysis.

1.6.8 Locomotive event recorders did not register speeds below 5 km/h. As soon as the train speed reduced below that threshold they registered at 0 km/h, even if the train was still moving.

Locomotive load schedules

1.6.9 Tranz Scenic operated under Tranz Rail's Working Timetable. Section L8, Clause 6.11.3, Passenger Train Tonnages, stated that when 2 locomotives were attached to passenger trains from Otira to Arthurs Pass, the maximum train size was 12 carriages with a total weight of 384 t.

1.6.10 The Tranz Rail/Tranz Scenic Engineering Manager advised that although this restriction was not documented, it related to the static brake capabilities of the 2 DCP locomotives and was based on the size of a train that could be held on the tunnel gradient by the locomotives independent brakes only.

1.6.11 At the time of the incident, because of the imbalanced weight distribution on DCP4801, an excessive amount of the locomotive weight rested on the idler axles. If the axle weight distribution had been correct on both locomotives, the train would have been at the maximum weight limit for 2 locomotives to hold on the 1 in 33 gradient, using the locomotive's independent brakes only.

1.6.12 Following the incident this weight limit was reviewed. As a result the number of carriages that could be held with the independent brake applied on 2 DCP class locomotives was reduced to 11.

1.6.13 Toll Rail (formerly Tranz Rail) advised that there was no specific requirement for DC or DCP class locomotive wheelset axle loadings to be checked once the locomotives were running in general service. However, maintenance staff were expected to monitor the differences in wheel diameters between the idler and driving wheelsets whenever locomotives were returned from wheel lathe attention, and when the wheel Z (tyre thickness) readings were taken on service checks. Where there was a large difference in wheel readings, the expectation was that it would be either actioned by depot staff or referred higher for guidance as to what action to take.

1.6.14 The last service check on DCP4801 prior to this incident was on 29 November 2003 in Te Rapa, but the locomotive had been out of service for about 6 weeks between that check and the incident, waiting for a replacement traction motor. Toll Rail advised that although no wheel diameter defect had been detected during that check, it was likely that the wheels on the locomotive were already in an out-of-balance situation at that time.

Locomotive sanding equipment

1.6.15 Sand was carried on DCP locomotives in boxes located in front of the leading wheels in the direction of travel. The sand was used to assist with adhesion and could be applied automatically by the locomotive's adhesion control systems, or manually by the locomotive engineer.

1.6.16 When wheelslip was detected by the locomotive control system, sand was applied to the leading wheels only where wheelslip was detected. When the locomotive engineer worked the system manually, sand was applied in front of the leading wheels of all locomotives in the consist.

1.6.17 When the sanding equipment was activated, the sand dropped from the sand box into a chamber where it mixed with compressed air (see Figure 6) and was blown through a 25.4 mm pipe and deposited on the railhead immediately in front of the leading wheels (see Figure 7).

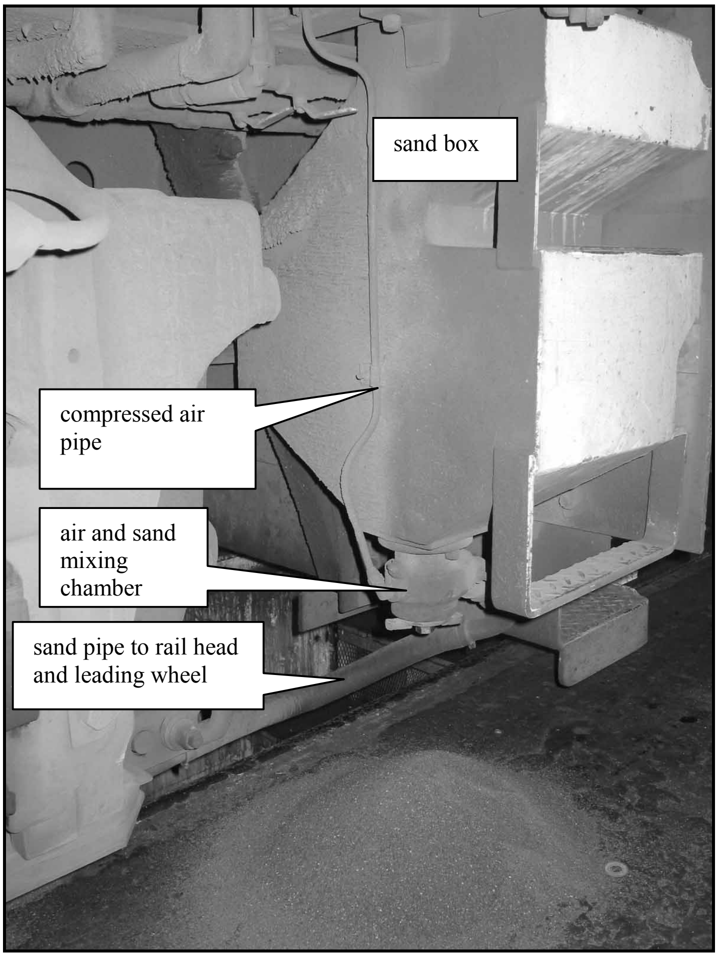

Figure 6
The sand box on a DCP locomotive

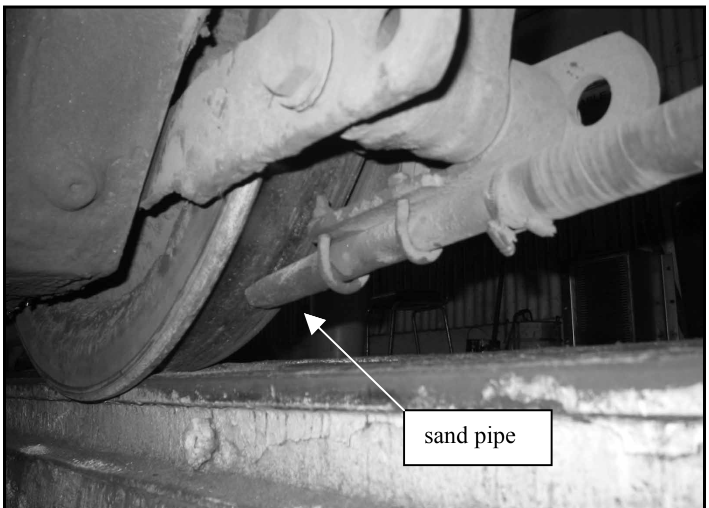

Figure 7
The sand pipe from the sand box

1.6.18 There was no filter on the top of the sand box to prevent pebbles mixed with the sand entering the sand boxes during refilling. Originally there had been a filter screen on the top of the sand boxes to take out any larger objects such as pebbles. When these filters corroded they were not replaced.

1.6.19 After the incident, the outlets of both sand boxes on the front end of the leading locomotive and one on the front end of the trailing locomotive were found to be blocked by pebbles.

1.7 Locomotive stalling recovery procedures

1.7.1 Tranz Rail's Working Timetable, Section L8, provided 2 alternatives for a train to clear the tunnel after a stall situation. The first and preferred option, if locomotive assistance was available at Arthurs Pass, was to initiate procedures to send a relief locomotive. The second option was to reverse the train back to Otira, once train control had authorised the movement.

1.7.2 Tranz Rail's Working Timetable, Section L8, clause 6.10.4 (b) stated that in an impending stall situation, the locomotive engineer should stop the train with a minimum reduction (50 kPa) on the train brake and at the point of stopping apply the independent brake on the locomotive. This instruction also applied to locomotive engineers on passenger trains.

1.7.3 When the train manager was required to pilot the train during setting back, permission was required from train control to use channel 4 for communications between the locomotive engineer and the train manager (see 1.9.11).

1.8 Supply of sand

1.8.1 Toll Rail advised that no formal written specifications existed for the supply of locomotive sand, although the company expected the sand to be screened and dried by the supplier prior to delivery. There were several suppliers nationwide and deliveries were made direct to the locomotive depots.

1.8.2 Quality checks of the product were not undertaken and no records were kept as to the suitability of the variously supplied products. About 3 months earlier a study of the sand had been conducted by Alstom[16], who purchased the sand on Toll Rail's behalf, and there appeared to be no variation of in-use performance between the sand from different suppliers.

1.8.3 Sand was delivered to the Tranz Scenic locomotive depot in Christchurch in 20 kg bags and was emptied directly into the locomotive sand boxes.

1.8.4 Toll Rail advised of 3 other locomotive stallings on the rail network in March 2004 that had been attributed to lack of sand. However, it could not be determined if these were caused by blocked or defective sanding equipment on the locomotive or by empty sand boxes.

1.9 Train control radio system

1.9.1 Train movements on the Rolleston to Westport and Greymouth route were normally controlled from the South Island Coal Route Desk (Desk 9) in the Wellington train control centre.

1.9.2 Radio communications between train control and trains on the route were directed through one of 2 radio lines. The Midland radio line covered the route from Rolleston up to, and including, the Otira Tunnel. The West Coast radio line covered the route from the Otira Tunnel to the West Coast. Radio signals were channelled through various repeaters along the route. As a train progressed along the route, so the locomotive engineer selected the appropriate channels for the radio lines.

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[16] The service provider contracted to Toll Rail and responsible for the maintenance of the diesel electric locomotive fleet.

1.9.3 When locomotive engineers called train control, the train identifier and the repeater through which the signal was sent and the portion of the route covered by the repeater, appeared on the train controller's VDU. To answer that call, the train controller clicked on the item on the screen and the return call was routed automatically through the appropriate repeater and radio line.

1.9.4 To initiate a radio call, a train controller had to first select a repeater and radio line from their knowledge of the train's approximate position. To answer that call, the locomotive engineer's transmission would automatically be routed through the radio line and repeater closest to the train, given that the correct selection of channel had been made.

1.9.5 Because of the unique nature of the Otira Tunnel, train controllers needed to know that a radio call had originated from within it. The tunnel was treated as a separate area and radio calls from within the tunnel were identified on the train controller's VDU as coming from "Otira and Tunnel", although the signal was not directed through a separate repeater. Such calls were all routed through the Midland radio line.

1.9.6 When workload demanded, train control desks could be either amalgamated or split as required by simply transferring the radio line from the original desk to the appropriate next desk.

1.9.7 In early 2004, a new desk (Desk 10) was established to allow the coal route to be split between 2 desks when traffic demanded. Because of the amount of traffic involving banker locomotives through the Otira Tunnel, the ideal split was deemed to be from Rolleston to, but not including, the tunnel, and then the tunnel to the West Coast. To make this split possible, because the tunnel was previously linked with the Midland radio line, a communications technician had to transfer the radio operation within the tunnel to the West Coast radio line.

1.9.8 Within train control, all incoming radio calls from the entire network were directed through a message switching processor (MSP), which then directed those calls to the train control desk monitoring that particular line. As part of the system change the MSP also had to be re-programmed to accommodate the change.

1.9.9 The technician carried out preparatory work for the intended change. This work included establishing Selcall codes which would allow the "Otira and Tunnel" identifier to be connected to the West Coast radio line, before being disconnected from the Midland radio line. This operation would need to be carried out once only and thereafter the identifier would remain on the West Coast radio line whichever desk was monitoring that portion of the route. The technician intended to make the change on Thursday 25 March.

1.9.10 The technician had given the Selcall codes to the network control manager, but had not distributed them to the train controllers, and asked the network control manager not to do so. He had done this so that the network control manager could use the codes in the event of a Transfield Infrastructure Services Limited work outage in the tunnel, but he did not want the train controllers making changes to the radio line set-up.

1.9.11 Because the anticipated opening of Desk 10 was on an initial "as required" basis to cope with the workload on the West Coast coal route, the network control manager entered the codes into a computer file and advised the train controllers where to find them if needed.

1.9.12 On Wednesday 24 March 2004 at 0724, the West Coast radio line was shifted from Desk 9 to Desk 10 because of the workload expected on the 0700 to 1500 shift that day. This was the first time Desk 10 had been used for its intended purpose. The train controller who opened Desk 10 said, that on doing so, he had transferred the monitoring of the West Coast radio line from Desk 9 to Desk 10 as part of the desk splitting procedure.

1.9.13 The train controller obtained the Selcall codes from the network control manager and, after transferring the monitoring of the West Coast radio line to Desk 10, he disconnected the "Otira and Tunnel" identification selection from the Midland radio line and reconnected it to the West Coast radio line using the Selcall sequence. However, he said he lost the "Otira and Tunnel" identification selection. The train control radio log confirmed that the shift of the "Otira and Tunnel" identification selection to the West Coast radio line, using the Selcall codes, had been done at 0726.

1.9.14 The train controller was not aware of the requirement to update the MSP as part of the process. Without the MSP being updated, incoming radio calls from the tunnel to train control would be routed to the desk via the Midland radio line, whereas the train controller had set up outgoing calls to be routed to the tunnel via the West Coast radio line. This discrepancy was not noticed because no communication from within the tunnel had been necessary during the shift.

1.9.15 On completion of the shift at about 1500, the train controller shut down Desk 10 and transferred the monitoring of the West Coast radio line, including the "Otira and Tunnel" identification selection, back to Desk 9. He could not recall shifting the "Otira and Tunnel" identification selection back to the Midland radio line by using the Selcall codes when he closed Desk 10 down. The train control radio log had no record of it having been done at that time, or indeed at any other time, before the technicians planned changeover the following day. However, with both radio lines being monitored from a single desk, all calls to and from the tunnel were monitored from Desk 9.

1.9.16 On Thursday 25 March, the technician commenced the system changeover. He first used the appropriate Selcall codes to disconnect the "Otira and Tunnel" identification selection from both the West Coast and Midland radio lines. He did not know at that time that the identification selection had been left connected to the West Coast radio system the previous day.

1.9.17 The technician next supervised the train controller then on duty at Desk 9 as he issued the Selcall codes from the desk to establish the "Otira and Tunnel" identification to the West Coast radio line. The radio log showed this to have been completed at 1425. The technician then updated the MSP to accommodate the change.

1.9.18 Having made the changeover, there was no subsequent need for train controllers to make any other changes when splitting desks, because the "Otira and Tunnel" identifier would remain connected to the West Coast radio line and automatically move with it to any desk, and the MSP would direct any incoming calls to the desk monitoring that line. However, no specific instructions regarding the change of operation of the Otira radio system had been issued to the train controllers.

1.9.19 With the changeover complete, the technician tested the system. He found it to be working correctly except that the automatic response to the polling system of the tunnel was not being received. The polling system automatically sent a signal at 0600 and 1900 each day to each radio repeater that caused it to respond with a return message, thus confirming that the link to the repeater and the repeater itself were working. The technician planned to investigate and repair the fault on Monday 29 March.

1.9.20 The radio log showed that the system remained as set by the technician until Sunday 28 March 2004 at 0004, when the "Otira and Tunnel" was disconnected from the West Coast radio line and reconnected to the Midland radio line using Selcall codes from the train controllers desk. The MSP was not updated to reflect the change at the same time. As a result the MSP continued to make all outgoing calls for the "Otira and Tunnel" identification selection to the West Coast radio line, while any inward calls from that identification selection would show as coming via the Midland radio line.

1.9.21 The train controller on duty at 0004 on Sunday 28 March was the one who had opened Desk 10 on the preceding Wednesday and so was aware of the Selcall codes for disconnecting and reconnecting the "Otira and Tunnel" identification selection, although he was not aware of the need to reconfigure the MSP to reflect the change. However, he had no recollection of initiating the changeover at 0004 on Sunday and could think of no reason why he would have done so, unless a train had called him via what he thought was an incorrect radio line indication and he had made the change to rectify that.

1.9.22 Following the incident involving Train 804, the ability to transfer the "Otira and Tunnel" identification selection between radio lines was removed, and the "Otira and Tunnel" identification was secured to the Midland radio line pending modifications and the development of new procedures.

1.10 Train control voice tape and radio log

1.10.1 A copy of the train control radio communication voice tapes and a printout of the radio log were provided for analysis.

2 Analysis

2.1 General

2.1.1 Train stalling can and does occur for a number of reasons, and Toll Rail's and Tranz Scenic's rules and procedures allowed for this. The significance of this incident was that appropriate braking procedures were not followed because the locomotive engineer, having lost situational awareness, had not realised his train had stalled and was sliding backwards.

2.1.2 The rules and procedures for recovering from a stall in the Otira Tunnel were adequate and the available recovery options were safe and effective.

2.2 The locomotive engineer

2.2.1 The locomotive engineer was appropriately qualified and was experienced in driving all types of trains on the route and was aware of the "fog bank" phenomenon within the Otira Tunnel. However, on this occasion he appeared to have lost his situational awareness once his locomotive entered the fog, and he did not detect that Train 804 had stalled, or that it had started to slide backwards, until it reached a significant speed in reverse.

2.2.2 The locomotive engineer's decision to continue into the tunnel based on the speed of the train as it approached the western portal was correct. Speed data from the locomotive event recorder confirmed his speed was appropriate and his decision in this regard did not contribute to the incident. However, given the imbalanced weight distribution and its effect on the tractive effort of DCP4801, together with the impending non-operation of the sanding equipment on the locomotives, neither of which he could have known about, Train 804 was destined not to complete the journey through the tunnel without stalling.

2.2.3 The locomotives had been experiencing wheelslip since Train 804 entered the tunnel and the locomotive engineer had concentrated on stopping the wheelslip while keeping the train moving forward. He tried to keep his train moving using a combination of throttle and brake applications. Once the train entered the fog bank he was reliant on his instruments but had not seen the speedometer reduce to zero as the train stalled, and then rise again as it slid backwards.

2.2.4 When the train stalled, the locomotive cab was surrounded by fog which, together with the darkness in the tunnel, would have made it difficult for him to see that the train was going backwards as he could not see any fixed points by which to judge his progress. The welded rail through the tunnel meant that as the train slid backwards there would have been no noise from the wheels sliding, or running in the case of the "idler" wheels, over joints in the rail. It was only when he referred to the distance monitor that he was able to determine that the train was moving backwards.

2.2.5 When the locomotive engineer realised the train was moving backwards his response in not attempting to bring the train to an immediate stop by applying maximum train braking was appropriate, and showed that he was by then fully aware of the situation. However, his application of the brakes was some time after the train had started to slide back and only seconds before members of the train crew riding in café carriage 1 were going to apply the emergency brakes.

2.2.6 The braking technique defined in the operator's procedures required that in an impending stall situation the train be brought to a stop by use of both the train brake and the independent brake. This inferred that a stop under managed conditions within the tunnel was preferable to a stall. If the locomotive engineer had realised the train was stalling and had stopped it in accordance with this procedure, the application of both brakes would probably have held the train on the gradient and prevented it sliding back. Likewise, had the train brake been applied in conjunction with the independent brake after the stalling, there would have been sufficient effective braking to prevent the train sliding back. Following the incident, all Tranz Scenic locomotive engineers in Christchurch received refresher training in the operating procedures for the Otira Tunnel, including braking techniques, and no safety recommendation covering this issue has been made.

2.2.7 The locomotive engineer said he had made a Selcall to the train controller before sending an emergency call but the radio log showed that the emergency call had been made first, about 60 seconds after the train stopped, followed about 30 seconds later by the first Selcall and a second about 90 seconds later. These calls were all received and acknowledged by the train controller but the locomotive engineer of Train 804 did not receive his responses. Although the locomotive engineer did not recall doing so, his action in sending an emergency call to train control was proper as it alerted the train controller to the emergency situation within the tunnel, even though verbal radio communication could not at that time be established.

2.2.8 The decision by the locomotive engineer to set back to Otira was appropriate and was carried out in a safe and effective manner with the approval of train control.

2.3 The train crew

2.3.1 The train crew were all experienced on the route, and several expressed surprise at what they thought was the slow speed at which Train 804 had approached and entered the western portal of the Otira Tunnel. The locomotive event recorder showed the train approached the tunnel at an acceptable speed, so why the train crew had an impression of slow speed could not be determined.

2.3.2 Train manager 1 had experienced 2 previous stalls in the tunnel, and the circumstances on this occasion reminded him of those. He switched his radio to channel 4, expecting a message from the locomotive engineer but he did not receive any messages, and was consequently unaware of what was going on in the locomotive.

2.3.3 The train crew had been concerned when Train 804 began going backwards without prior radio warning from the locomotive engineer. Setting back procedures required that radio communications were established with the locomotive engineer on channel 4 and the train manager was to pilot the train back, but this had not been done. Although they first thought it was a controlled backwards move, the speed increased to an extent that they became concerned and were about to apply the emergency brake but then felt the train brakes go on and the speed start to decrease. Had the emergency brake been applied, the stopping of the train would probably have been more severe and less controlled than that managed by the locomotive engineer.

2.3.4 When Train 804 started to move forward again, the train crew assumed that the locomotive engineer was making a second attempt to get the train through the tunnel, but again there had been no communication from the locomotive engineer and the train subsequently stalled again.

2.4 Train control

2.4.1 The train controller was unaware that the "Otira and Tunnel" identification selection was not in fact a repeater, but was simply a code to identify trains making radio contact from within the tunnel. As a result he did not know that when he selected the "Otira and Tunnel" identification selection his radio calls had been traditionally transmitted through the Midland radio line and not through an independent repeater. Several train controllers spoken to in the course of the investigation were also unaware of this.

2.4.2 The value of this identification code, despite not being attached to a specific "Otira and Tunnel" repeater, was proven when the train controller was able to see immediately that the emergency call he had received showed on his radio VDU as from Train 804 in the Otira Tunnel.

2.4.3 There was a belief amongst the train controllers that the "Otira and Tunnel" identification selection required to be individually transferred to either the Midland radio line or the West Coast radio line each time the train control operation was shifted between desks. This was fostered by the belief that the identification selection was a separate repeater. After the switch had been done by the communications technician it was not expected that it would need to be done again.

2.4.4 When Desk 10 had been opened on Wednesday 24 March the "Otira and Tunnel" identification selection had been transferred by the train controller from the Midland radio line to the West Coast radio line using the Selcall code. This was so the radio calls from the tunnel could be monitored on the West Coast radio line at that desk. However, when the desk was closed down and the work transferred back to Desk 9, the "Otira and Tunnel" identification selection had not been transferred back to the Midland radio line but had remained connected to the West Coast radio line, the monitoring of which had transferred to Desk 9. The MSP at this time was still configured to take "Otira and Tunnel" identification selections from the Midland radio line but, because the identification selection was connected to the West Coast radio line, all outgoing messages would go via that radio line.

2.4.5 There had not been a requirement for radio communication between train control and any trains within the "Otira and Tunnel" identification selection from Wednesday 24 March until the changeover by the communications technician on Thursday 25 March, so the discrepancy was not identified. Following the changeover the situation was inadvertently corrected when both the identification selection and the MSP were changed to the West Coast radio line.

2.4.6 When the Selcall codes were used early on the morning of Sunday 28 March to transfer the "Otira and Tunnel" identification selection to the Midland radio line, it created the same situation that existed on Wednesday in that the identification selection was now connected to one line while the MSP was connected to the other. Again this would not be identified until an attempt was made to establish radio contact between train control and a train in the Otira Tunnel, which is exactly what happened later in the day when Train 804 sent an emergency radio signal and the train controller could not establish contact with the locomotive engineer.

2.5 Loss of traction

2.5.1 If the operation of the sanding equipment on the locomotives had been checked prior to departure from Greymouth, the pebbles blocking the sand pipe might have been found and removed, but there was no requirement for this to be done. Following the incident Tranz Scenic issued an instruction that sand boxes on DCP locomotives were to be checked before Train 804 departed from Greymouth.

2.5.2 Although such a check would ensure that the sand boxes were working at Greymouth, it was not a guarantee they would still be working once Train 804 entered the Otira Tunnel. If the sanding equipment had operated between Greymouth and Otira there would be an opportunity for any pebbles present in the sand box to move down with the sand and, if of sufficient size, block the entrance to the pipe and prevent the sand from falling into the chamber to mix with the compressed air. Alternately, smaller pebbles could be blown into the sand pipe and become lodged there, again blocking the flow of sand. The single operating sander on the leading wheels of the rear locomotive would not have assisted traction on the leading locomotive. However, the check of the sand boxes prior to departure from Greymouth was an additional defence against blockages and no safety recommendation covering this issue has been made.

2.5.3 The imbalanced weight distribution on the driving wheels of DCP4801 affected the adhesion of the locomotive for both tractive effort and its ability to assist DCP4559 with holding the train on the grade while under independent braking. Had the weight distribution on the driving wheels of DCP4801 been as designed, the traction gained may have averted the stalling, despite the absence of sand.

2.5.4 In the 12 weeks between its last service check and the incident, DCP4801 had been out of service for 6 weeks which would have limited the amount of running of the locomotive between those events. As a result, it was unlikely that the wheel diameter could have gone from within code to out of code in such a short time and Toll Rail's conclusion that the wheels were already in an out of balance state at the time of the service check was probably correct. A safety recommendation relating to this issue was made to the Chief Executive of Toll Rail.

2.5.5 Had the banker locomotive consist or Train 847 travelled through the tunnel from Arthurs Pass to Otira prior to Train 804 departing from Otira, its wheels may have removed or significantly reduced the effect of the coal dust and moisture mixture on the railhead. However, there had not been sufficient time after the arrival of Train 832 in Arthurs Pass to complete the air purging of the tunnel and for a trip to Otira to occur without delaying Train 804. As no request had been made for assistance from the banker locomotives, there was no immediate need to reposition them.

2.6 Sand

2.6.1 There were no documented specifications held by Tranz Rail for the supply of locomotive sand so foreign material, including pebbles of varying sizes, could be mixed with it. The absence of such a specification, together with the wide range of suppliers, meant that variations in the quality of the delivered product to the various locomotive depots could be expected. Checks of the sand quality were not required and neither was there a process for sifting it prior to loading into the locomotive sand boxes, so there was no physical defence in place to prevent foreign material from entering the sanding equipment with the sand.

2.6.2 The sand boxes on both DCP locomotives were probably filled at the same time and from the same batch of sand while being serviced at Christchurch locomotive depot. The absence of filters in the locomotive sand boxes meant that there was no defence in place to prevent foreign bodies from entering with the sand.

2.6.3 The geographical nature of the route, together with the adverse weather conditions often experienced, should have been sufficient reason to ensure that the sand quality did not affect the operation of the sanding equipment on the locomotives. A safety recommendation regarding a quality assurance process for the supplying of sand has been made to the Chief Executive of Toll NZ Consolidated Ltd.

2.7 Locomotive event recorder data prior to stalling

2.7.1 Because of the inaccuracy of the data from the locomotive event recorder on DCP4801 created by the incorrect dimension of the idler wheel, only data from the event reorder on DCP4559 was analysed.

2.7.2 Analysis of this data showed that:

- at about 1530 Train 804 reduced speed from 50 km/h to 25 km/h as it approached Otira
- after Train 804 had passed through Otira at about 1531 the train gradually increased speed until it was travelling at 39 km/h as it climbed the gradient towards the western portal of the tunnel
- Train 804 was travelling at about 37 km/h when it entered the tunnel at 1534:50. The speed continued to reduce until by 1535:35 Train 804 was travelling at 34 km/h
- this speed was maintained until about 1536:35 when it further reduced to 15 km/h by about 1539:20
- by about 1539:30 the speed had increased to 17 km/h, which was maintained until about 1539:45 when it again reduced until the speed of Train 804 reduced below 5 km/h at about 1541:38; by 1543 the speed was again recorded at 5 km/h.

2.7.3 The recorded speed of Train 804 as it climbed the gradient towards the tunnel confirmed the locomotive engineer's belief that the train was travelling at sufficient speed to enable it to travel safely through the tunnel and this, together with the fact that the locomotives appeared to be functioning as expected, confirmed his decision to continue was appropriate. However, during the first 55 seconds inside the tunnel, the train speed gradually decreased from 37 km/h to 34 km/h, where it stabilised for about 65 seconds.

2.7.4 This initial reduction in speed corresponded with when the locomotive engineer had first noticed the locomotive wheelslip. The stabilising of the speed at 34 km/h probably resulted from his response to the wheelslip when he made a minimum brake application of the independent brake and reduced power. These combined actions had probably temporarily reduced the wheelslip and allowed the locomotive to maintain speed.

2.7.5 After maintaining 34 km/h for about 65 seconds the speed again reduced until 165 seconds later it stabilised at 15 km/h for about 10 seconds before increasing to 17 km/h. These fluctuations in speed corresponded with the locomotive engineer's actions in first releasing the locomotive independent brake, which allowed the wheelslip to reoccur, and then reapplying the locomotive independent brake about 10 seconds before the speed reduced to 15 km/h, a move which stopped the locomotive wheelslip and allowed the train to increase in speed to 17 km/h.

2.7.6 After maintaining 17 km/h for about 15 seconds Train 804 started to reduce speed again and continued to do so until it eventually fell below 5 km/h 113 seconds later.

2.7.7 The locomotive event recorder was not designed to record speeds of less than 5 km/h. It was therefore estimated that, although the last speed registered was 5 km/h at 1541:15, the train probably continued on below 5 km/h for another 20 seconds before finally stopping at about 1541:35. The train probably remained stationary for a few seconds before sliding back and getting up to 5 km/h at 1543.

2.8 Locomotive event recorder data during backward slide

2.8.1 Analysis showed that after the train had stopped it probably remained stationary for a maximum of 5 seconds before it started to slide back. When the locomotive engineer made a train brake application the train was travelling backwards at 35 km/h. The speed continued to increase over the next 10 seconds until it reached a maximum of 40 km/h before the brakes took effect and the train began to slow. The train finally stopped at about 1543:10 after having slid backwards for about 90 seconds, during which time it covered a distance of about 520 m.

2.9 Train control voice tapes and radio log data

2.9.1 Although the times from the train control voice recording were about 105 seconds behind those from the train control radio log, this was not critical as events recorded by both systems relating to radio transmissions corresponded. The train control radio log times closely reflected those of the locomotive event recorder so for the purpose of analysis the train control voice times were adjusted to match the train control radio log times.

2.9.2 Analysis of the train control voice tapes and radio log data showed:

- at 15.45:15 train manager 1 attempted to contact the locomotive engineer of Train 804 by radio on channel 4 (via Midland radio line) but there was no response. This call registered on the radio log as originating from radio handset 34305, the Tranz Scenic radio allocated to train manager 1 on that day

- at 15.45:48 an emergency call from DC4559, the leading locomotive on Train 804, was received in train control from the Midland radio line.

- at 15.46:05 and 15.46:15 the train controller verbally responded to the emergency call from DC4559 but his response was routed via the West Coast radio line

- at 15.46:26 the train controller initiated an attempt to contact DC4559 by Selcall via the West Coast radio line

- at 15.46.27 an incoming call from the radio handset of DC4559 was received in train control from the Midland radio line

- at 15.46:36 the train controller verbally responded to this call but his response was routed via the West Coast radio line

- at 15.46:53 and again at 15.47:01 the train controller initiated attempts to Selcall DC4559, both of which were routed via the West Coast radio line

- at 15.47:06 the train controller again tried to contact DC4559 verbally through the West Coast radio line

- at 15.47:14 and again at 15.47:30 the train controller verbally tried to contact train manager 1 with calls to Tranz Scenic radio 34305 via the West Coast radio line

- at 15.47:42 the train controller again tried to contact DC4559 verbally through the West Coast radio line

- between 15.47:56 and 15.48:17 the train controller made 4 further attempts, 3 Selcall and one verbal, to contact DC4559, all of which were routed via the West Coast radio line

- at 15.48:27 the train controller verbally tried to contact train manager 1 with a call to Tranz Scenic radio 34305 via the West Coast radio line

- between 15.48:45 and 15.50:36 the train controller made several attempts, both Selcall and verbal, to make contact with DC4559, all via the West Coast radio line, but without success. During this time he also attempted unsuccessfully to make contact with the banker locomotive consist and the locomotive of Train 847, both of which were at Arthurs Pass, again via the West Coast radio line

- at 15.51:02 the radio log registered another attempt by train Manager 1 to contact the locomotive engineer of Train 804 by radio on channel 4 via the Midland radio line but again there was no response

- the train controller immediately made 2 attempts to contact train manager 1, at 15.51:05 and 15.51:17, via the West Coast radio line but these were unsuccessful

- at 15.51:26 the train controller again attempted to contact either the banker locomotive consist or the locomotive of Train 847 at Arthurs Pass, this time via the Midland radio line, and received a response from the locomotive engineer of Train 847, in locomotive DX5327.

2.9.3 The locomotive engineer of Train 847 told the train controller that he had heard the train manager of Train 804 (train manager 1) trying to establish radio contact with the locomotive engineer by radio on channel 4 but there had been no response. At the train controller's request the locomotive engineer of Train 847 then attempted to contact the locomotive engineer of Train 804 on channel 4.

2.9.4 There was no response from the locomotive engineer but train manager 1 responded and said that he had also been trying unsuccessfully to contact the locomotive engineer and advised that the train had just come to another standstill in the tunnel.

2.9.5 Further analysis of the train control voice tapes and radio log data showed:

- at 15.52:23 the train controller established contact with train manager 1 via the Midland radio line L2 and maintained communication with him for about 90 seconds. During this time train manager 1 confirmed that Train 804 had come to an initial stop, and had then moved backwards. The backwards movement had stopped and the train had moved forward again only to come to another stop

- at 15.53.57 the locomotive engineer of Train 804 made verbal contact with the train controller via the Midland radio line and confirmed the train had stalled in the tunnel and was stationary. The train controller expressed surprise at the radio line through which they had made contact. The locomotive engineer said he was going to try to get the train moving again

- at 15.56:56 the locomotive engineer of Train 804 advised the train controller that he could not get the train started and requested permission to set back out of the tunnel.

2.9.6 There had been a delay of about 8 minutes from when the train controller had received the emergency alarm from the locomotive engineer of Train 804 until he eventually established verbal contact with him. This was caused by incoming radio calls to train control from the "Otira and Tunnel" identification selection being routed via the Midland radio line but the outgoing calls from the train controller being routed via the West Coast radio line.

2.10 Train control to train radio system

2.10.1 The reason for not developing and distributing procedures to the train controllers for connecting the "Otira and Tunnel" identification selection to the West Coast radio line was valid. The technician believed that once the connection had been made there would be no requirement to change it to the Midland radio line because whichever desk was controlling the Otira Tunnel environ would automatically monitor the West Coast radio line. As a result there would have been no need for the train controllers to either use the Selcall codes or reconfigure the MSP when transferring the monitoring of the West Coast radio line to another desk.

2.10.2 The desk split on 24 March had pre-empted the technician's proposed changeover and was done without his knowledge. The train controller who managed the split on that day obtained the Selcall codes from the network control manager and used them to connect the identification selection to the West Coast radio line, but he had not known about the MSP requirements. As a result the MSP remained configured for receiving inward messages from the "Otira and Tunnel" identification selection from the Midland radio line while the Selcall code change meant that outward calls went via the West Coast radio line. However, this variance would not be noticed unless the train controller tried to contact a train in the Otira Tunnel or if the locomotive engineer of a train in the tunnel tried to contact train control, at which time the differing radio lines would register on the train control radio VDU.

2.10.3 The technician believed that the changeover on Thursday 25 March was to be a "one-off" and from then on the "Otira and Tunnel" identification selection would remain permanently connected to the West Coast radio line. However, as a result of the radio issues raised following the incident, the "Otira and Tunnel" identification selection was transferred back to the Midland radio line until the process is modified and documented. In view of this action no safety recommendation has been made.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 Train 804 was travelling at an appropriate speed as it entered the Otira Tunnel and should have been able to transit the tunnel.

3.2 Train 804 was at the limit of allowable weight for 2 DCP locomotives.

3.3 The idler and driving wheelsets of DCP4801 were probably in an out-of-balance state at the time of the most recent service check.

3.4 Train 804 lost traction and experienced wheelslip for the following reasons:

- build-up of coal dust on the wet rail surface
- reduction of traction created by the incorrect weight distribution on the trailing locomotive
- the inability to lay sand, either automatically or manually, because 3 of the 4 leading sand boxes were blocked.

3.5 The locomotive engineer lost situational awareness and did not realise that his train had stalled and was sliding backwards.

3.6 Had the locomotive engineer recognised an impending stall and brought the train to a controlled stop, the combination of the independent locomotive brake and the train brake would have held the train stationary.

3.7 The rules and procedures for a train recovering from a stall in the Otira Tunnel were appropriate.

3.8 The locomotive engineer's decision to set back Train 804 to Otira to obtain assistance was appropriate.

3.9 The radio system was undergoing process and procedural changes that were not communicated to train controllers so was not working as the train controller expected and did not provide an effective back-up, resulting in no communication between train control and the train.

3.10 There were no specifications for the supply of locomotive sand or quality assurance checks in place to monitor the quality of the sand, nor were there any sieving facilities in place to remove foreign bodies when pouring the sand into the locomotive sand boxes.

4 Safety Actions

4.1 On 29 March 2004 Tranz Scenic issued an instruction restricting the weight of eastbound passenger trains with 2 DCP class locomotives passengers to 11 carriages.

4.2 Tranz Scenic advised that it had also issued South Island Staff Memorandum 26 on 29 March 2004. This instruction required that the sand boxes on the locomotives of Train 804 be tested prior to departure from Greymouth. If they were found to be not operating correctly, additional locomotive power in the form of the Tranz Rail banker locomotive consist was to be arranged to meet the train at Otira.

5 Safety Recommendations

Safety recommendations are listed in order of development and not in order of priority.

5.1 On 16 December 2004 it was recommended to the Chief Executive of Toll NZ Consolidated Limited that he:

develop and introduce appropriate specifications for the supply of locomotive sand that include quality assurance procedures to ensure the sand is fit for purpose. (081/04)

and

develop a regime to ensure that locomotive driving and idling wheelset axle weights are maintained within tolerance. (082/04)

5.2 On 11 January 2005 Toll NZ Consolidated Limited advised that they accepted the recommendations.

Approved on 17 December 2004 for publication

Hon W P Jeffries
Chief Commissioner

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