Australian Government

Australian Transport Safety Bureau

Derailment of freight train WG713

Denman, New South Wales | 19 January 2016

Investigation

ATSB Transport Safety Report

Rail Occurrence Investigation

RO-2016-001

Final – 22 March 2019

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Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

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Addendum

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Safety summary

What happened

On 19 January 2016, at approximately 0400 Australian Eastern Daylight Time (AEDT), an empty Pacific National coal train derailed in a section between the Ogilvie and Rosemount Road level crossings at Denman, New South Wales. The lead bogie of the 64th wagon behind the locomotives operated in a derailed state for a period of time before re-railing at the Rosemount Road level crossing.

The train crew were unaware of the incident until they were notified by the Australian Rail Track Corporation's (ARTC) network controller, after a signal electrician advised of track damage at that location. The train stopped at Bylong Loop approximately 71 km away from the derailment site.

What the ATSB found

The derailment occurred near a long twist track defect in an area with other known track geometry defects that had been identified a week before. The defective area was managed with Temporary Speed Restrictions (TSRs) until it could be repaired. It was found that the area deteriorated at a faster rate than anticipated, leading to the derailment. The known long twist defect was measured after the derailment and found to be out of ARTC's acceptable tolerance limits within its Civil Code of Practice (COP).

The ATSB found the track was damaged between the point of derailment up to the Rosemount Rd level crossing. The track damage and marks exhibited on the steel road plate of the level crossing were consistent with that of a train derailing and re-railing.

What has been done as a result

Since the incident, ARTC has:

- Instigated a recurring weekly "Unscheduled Asset Examination" to inspect the track formation at the incident location until permanent repairs could be completed
- Repaired and reconditioned the formation in the area in July 2017
- Reviewed its track/civil engineering standards and guidance documentation.

Safety message

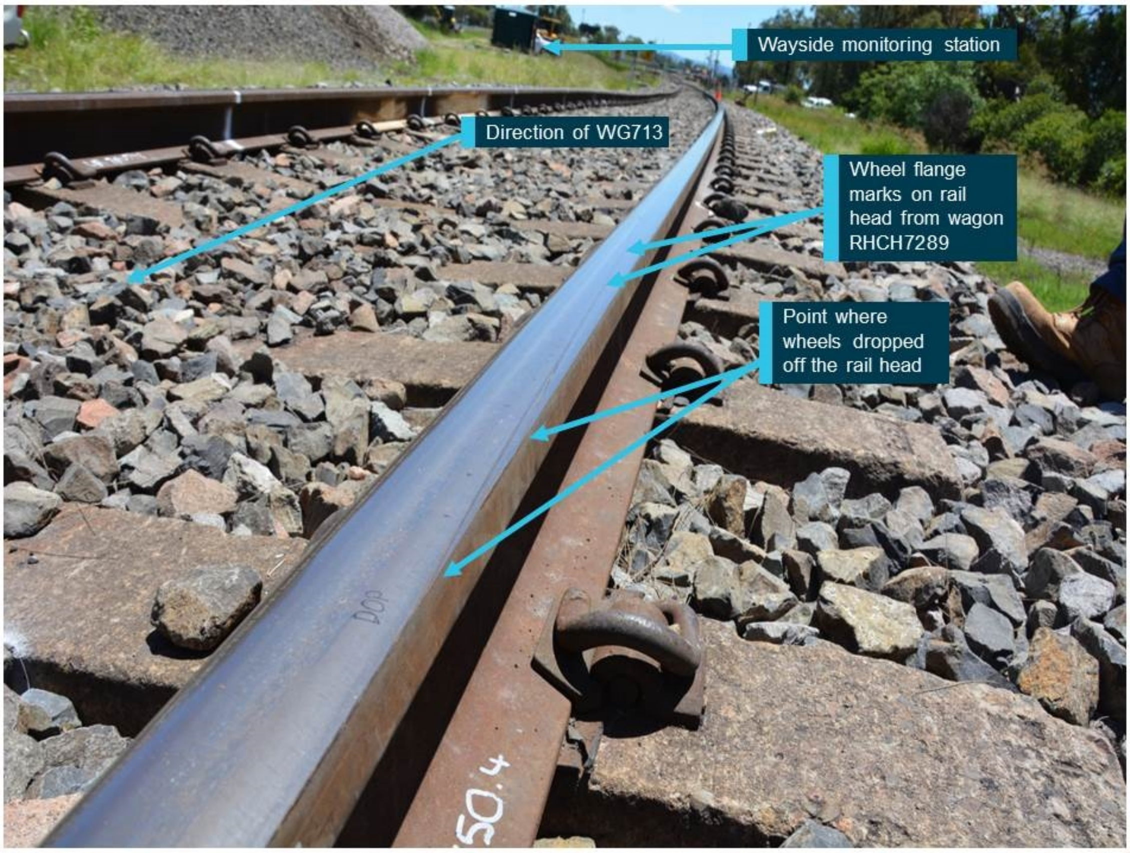
Maintenance inspection and categorisation of defects must take into account that defects may deteriorate faster than expected. Factors that can contribute to rapid deterioration should be considered when developing maintenance responses.

Contents

The occurrence

Train WG713 with a crew of two was travelling within New South Wales (NSW) from Kooragang Coal Terminal, Newcastle to Wilpinjong Colliery, near Mudgee. As WG713 approached Denman, the train was slowed to comply with a 20 km/h Temporary Speed Restriction (TSR) in force across an area (314.450 km to 314.600 km) with known track geometry defects.

Figure 1: Incident location, Denman, NSW



Source: ATSB

At 314.540 km, the left-hand wheels (in the direction of travel) of the lead bogie of the 64th wagon behind the locomotives mounted the rail. The right-hand wheels likely followed the profile of a long twist[1] defect approximately 30 m before the Point of Mount (POM) which resulted in the left-hand wheels losing vertical load (unloading). This wheel unloading allowed the left-hand wheel flanges to rise onto the Down rail[2] (outside rail) head. The left-hand wheels then tracked across the railhead of the Down rail for 10 m before dropping off the rail at 314.550 km (see Figure 1).

As a consequence of this, the right-hand wheels in the direction of travel also dropped off the Up rail (inside rail), into the four foot (area between the two rails). All wheels of the lead bogie then ran in a derailed state for approximately 690 m towards the Rosemount Road level crossing (see Figure 6). The wheels then struck the steel road plate of the level crossing (see Figure 2). This lifted the wheels up above railhead height and all four wheels re-railed. This was likely assisted by the longitudinal tensile draft forces in the train as the locomotives applied power to pull the train up the grade.

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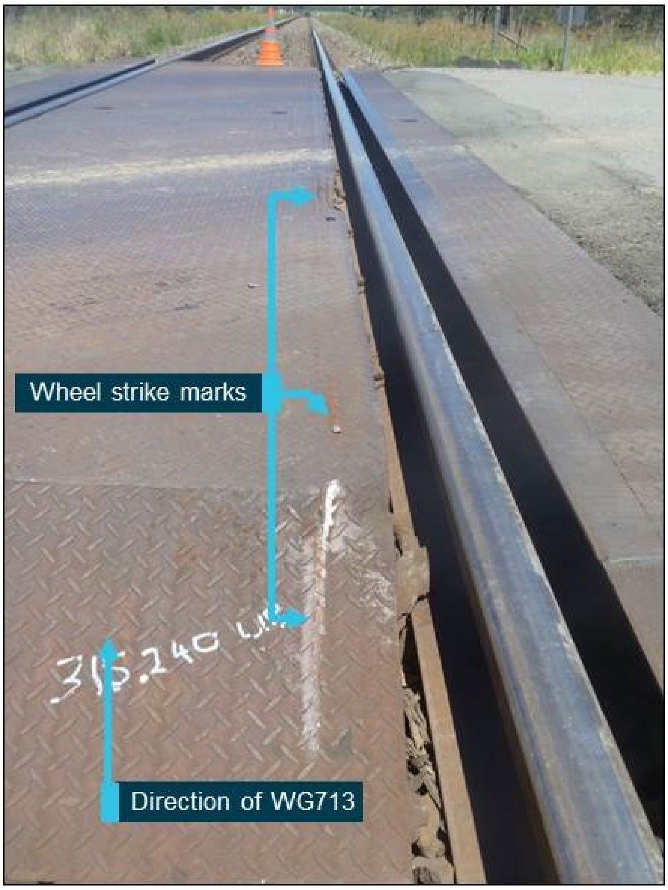
1 Long Twist: Variation in cross level (height difference between two rails) measured over 14 metres.

2 The Up rail in NSW is the left-hand rail when facing Sydney; similarly, the Down rail is the right-hand rail when facing Sydney.

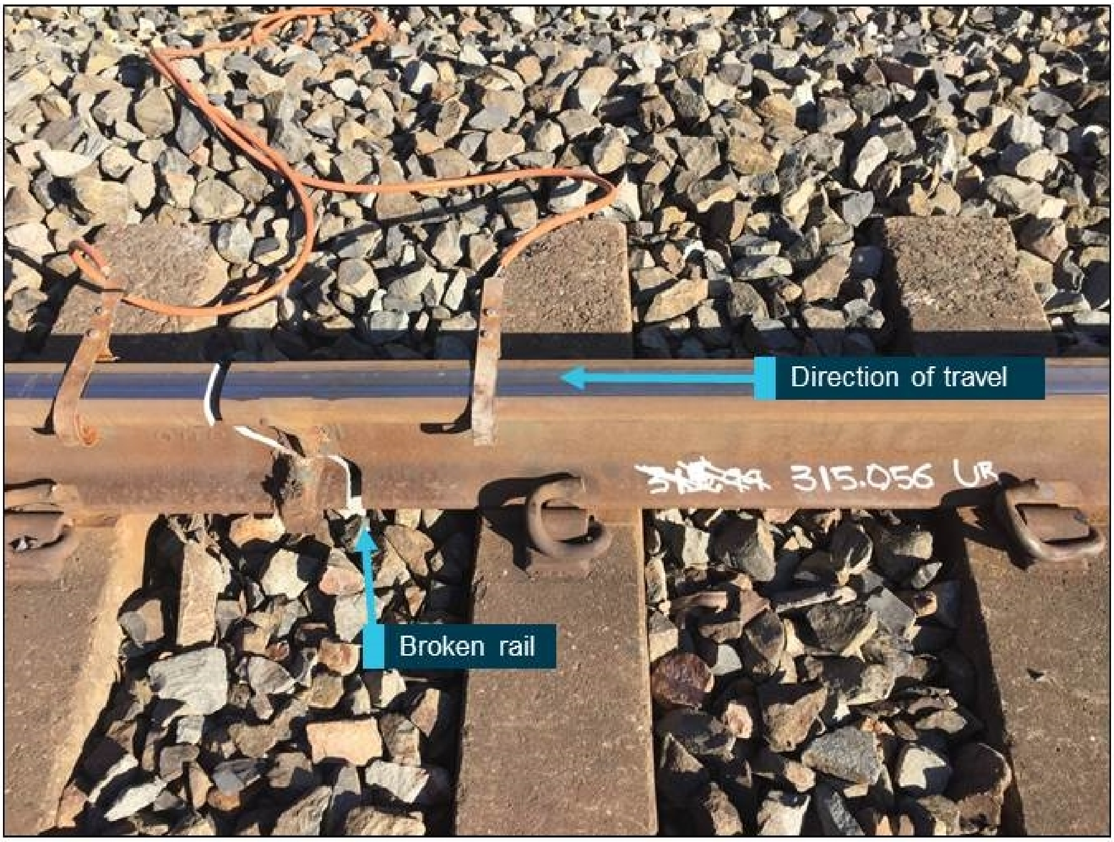
As the wheels ran in a derailed state, they impacted the track fastenings and the foot of the rail. A number of rail welded joints, sleepers and fasteners were damaged by the derailed wheels on both rails. The Up rail at 315.056 km suffered a full cross-section break at an alumninothermic weld joint (see Figure 3). The rail break subsequently broke the track circuit which triggered a signal failure to occur. At 0400 the Network Control Officer (NCO) located at the Australian Rail Track Corporation's (ARTC) Network Control Centre North (NCCN) was alerted to the problem after the train had cleared the section. The train crew were unaware that the train had derailed and continued onto their destination.

Figure 2: Wheel strike marks on Rosemount Road level crossing road plate



Source: ATSB

Figure 3: Broken Up rail at 315.056 due to weld being struck by WG713's derailed wheel



Source: ATSB

Post-occurrence

The NCO responded to the signal failure by calling the crew of WG713 at 0403. The crew reported they had cleared the section and they were not aware of any problems. The NCO then called a signal electrician to investigate the problem at 0406.The signal electrician arrived at the location and called the NCO at 0501 to obtain a Controlled Signal Block[3] (CSB) to inspect the area.

A crew member of WG713 called the NCO at 0503 requesting they be routed into Bylong Loop to restart a locomotive that had shut down in Cox's Gap No.1 Tunnel. This tunnel was located at 367.000 km, which was 53 km away from Denman and 18 km away from Bylong.

The signal electrician called the NCO at 0510 and reported track damage at the location. The signal electrician advised that track repairs were going to be necessary and that WG713 should be stopped due to potentially dragging equipment on the train. The NCO then contacted WG713 and informed the train crew there was track damage at Denman. The NCO requested the crew to inspect their train when they stopped at Bylong Loop.

The signal electrician called the NCO at 0519 and reported a broken rail at the location which had most likely caused the failed track circuit. At this time, train WG713 was still travelling towards Bylong Loop. A crew member of WG713 called the NCO at 0527 and advised they had arrived at Bylong Loop and one crew member was preparing to inspect the train.

At 0532, the crew of WG713 contacted the NCO and advised that they had inspected WG713 and identified no issues with the train.

[3] A Controlled Signal Block (CSB) is a form of track worksite protection where the Network Control Officer (NCO) sets controlled signals on either side of a section to stop. This excludes rail traffic from both directions from entering a section of track.

At 0550, the NCO contacted train UL264 which was travelling in the Up direction and had passed WG713. At this time, UL264 was approaching Yarrawa Loop located just before Denman. The NCO warned the train driver there was track damage ahead at Denman and requested that UL264 proceed into Yarrawa loop with caution and stop. At this time, the NCO was of the opinion that WG713 may have derailed at Denman and asked the train driver of UL264 to report any damage they observed.

At 0555, the NCO contacted train AT712, another train which was travelling in the Up direction and was approaching Murumbo (see Figure 5). The NCO requested that the train driver proceed into Murumbo loop and stop due to track damage at Denman.

The derailed wagon was taken to Pacific National's One Spot facility in Kooragang and inspected and tested. A twist test[4] was conducted by Pacific National staff in accordance with its standards.

[4] A twist test is to assess a unit of rolling stock's capability to negotiate a specific curve radius and superelevation.

Context

Incident location

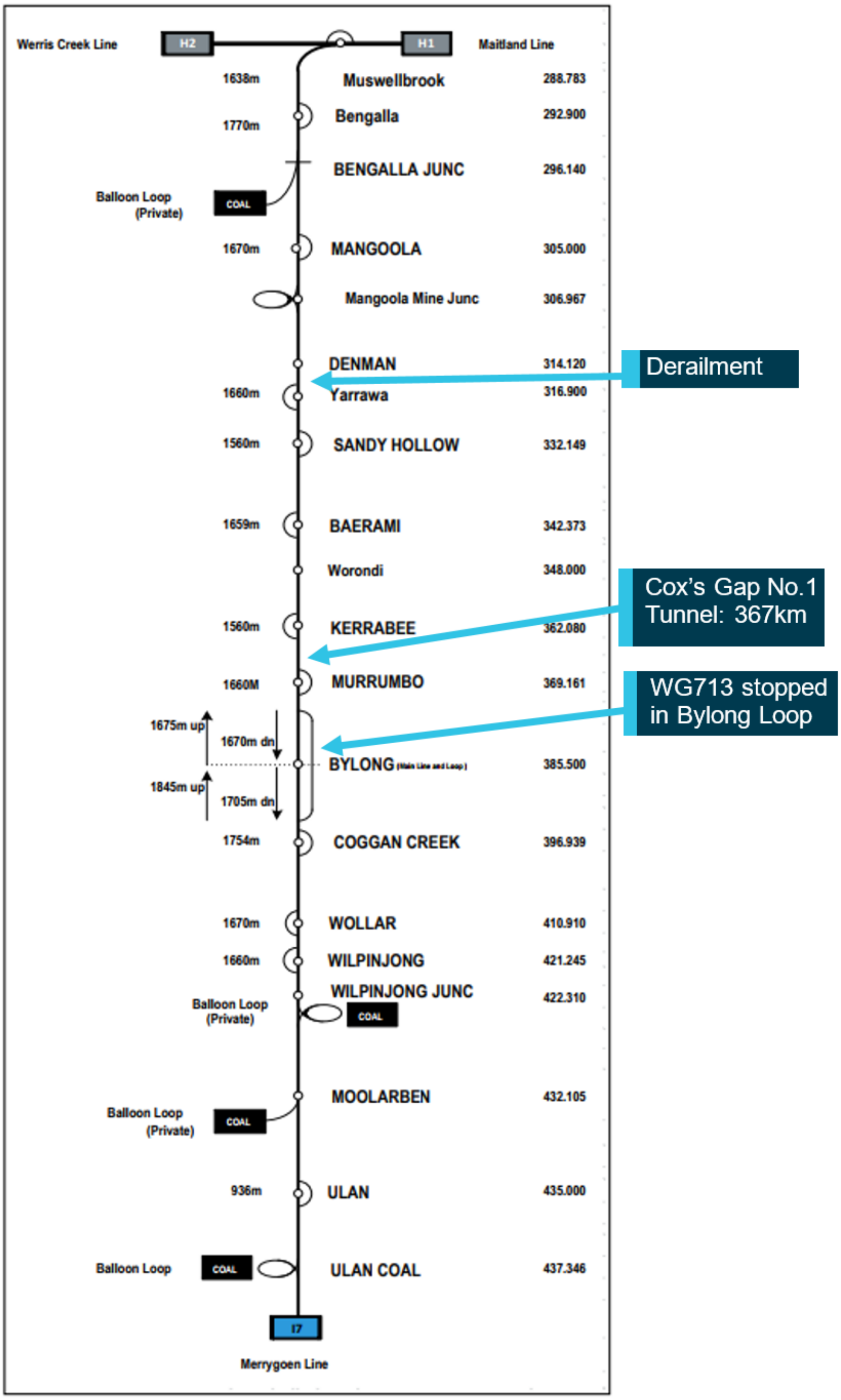
The incident occurred on the Ulan Line as the train passed through Denman in NSW, part of the the Australian Rail Track Corporation (ARTC) network in the Hunter Region.

Figure 4: Incident location map

Source: Geoscience Australia, modified by the ATSB

The area was controlled through Centralised Traffic Control (CTC) and there were lineside signals to regulate the passage of rail traffic. Track circuits associated with the signals allowed the NCO to see the location of trains in that area.

Figure 5: Track diagram, Muswellbrook to Ulan Coal



Source: ARTC (Annotated by the ATSB)

Rail infrastructure information

The track at the incident location was a Class-1C single bi-directional line with 60 kg/m head hardened rail. The sleeper type was heavy-duty concrete, clipped together with pandrol e-clip resilient fastenings. The track bed formation consisted of firm to stiff silty clay, underlain by stiff sandy clay.

The track between 314.400 km and 314.450 km had an average falling gradient of 1:382 in the Down direction[5]; the track then began to climb at an average gradient of 1:63 between 314.450 km and 315.000 km. A culvert and open drain was located at 314.450 km, approximately five metres from the Ogilvie Rd level crossing in the Down direction (see Figure 6). The gradient of the Up side cess adjacent to the track was relatively flat from the Point of Mount (POM) to the culvert. The POM was within a 600 m radius right-hand curve just after a transition where superelevation was at its maximum (see Figure 6).

A wayside monitoring station was located approximately 75 m before the POM in the Up direction (see Figure 6). It measured bearing temperature, train speed and axles passed.

Train information

Train WG713 was an empty coal train operated by Pacific National. It consisted of three 90-class locomotives and 92 coal wagons. The total mass of the train was 2099.2 tonnes (not including locomotives). The total length of train was 1510.32 m.

The wagons of WG713 were coal hoppers, a mix of RHFH, RHCH and NHYC types. The lead bogie of the 64th wagon (RHCH 7293A) behind the locomotives in the consist derailed.

The condition and maintenance history of the incident wagon was examined. RHCH 7293A had been maintained at the required frequency and there were no outstanding defects. Post incident testing of the rolling stock did not reveal any significant defects that may have contributed to the derailment.

Site observations post-incident

ATSB investigators examined the incident site on 19 January 2016. The ATSB completed measurements and identified a number of twist defects with the largest being a 77 mm Emergency 1[6] long twist between 314.500 km and 314.550 km. Top[7] loss in the Up rail was also observed at the incident location.

It was further observed that the derailed wheels had damaged a number of concrete sleepers, track fastenings and rail welds. Upon examining the damage at the site, it was evident that at least two wheel sets had derailed.

The steel crossing plate of the Rosemount Road level crossing, 690 m away from the derailment location, displayed damage consistent with rail wheels striking and running over the crossing (see Figure 2). The wheel strike marks indicate a direction of travel back onto the rail track and no damage was evident after the level crossing. This indicated that a combination of the tensile draft longitudinal forces and the wheel striking the road crossing plate elevated the wheel flange sufficiently to assist re-railing the train.

Upon inspection of the wagons of train WG713, the ATSB identified wheel damage on the leading bogie of the 64th wagon. The wheel damage observed was consistent with damage typically found as a result of a wheel having operated in a derailed state for a period of time (see Figure 7).

ATSB investigators inspected the train which traversed the affected location before WG713 and no evidence of damage on that train was found.

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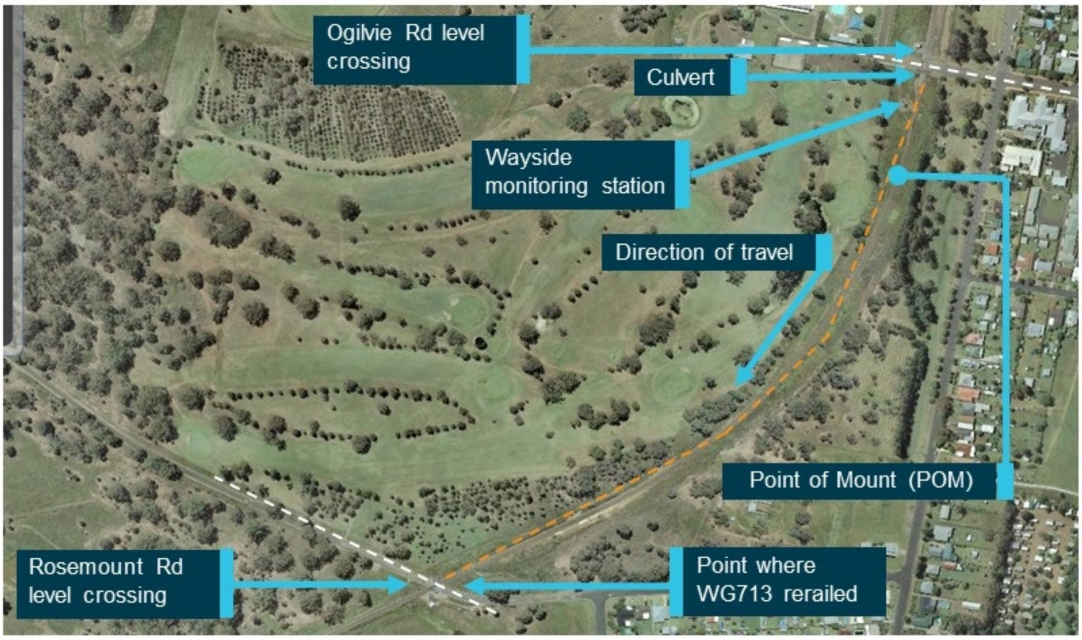
5 In NSW, Up direction: Towards Sydney, Down direction: Away from Sydney.

6 Emergency 1: The most severe defect classification as per ARTC's COP. An Emergency 1 defect is required to be inspected prior to the next train passing and/or repaired before the next train.

7 Top: Top is the vertical alignment measured for each rail. Top loss refers to a loss of vertical alignment for a length of rail and a top defect refers to top loss which passes a certain threshold within ARTC's Code of Practice.

Figure 6: Incident location aerial view



Source: Six Maps, Annotated by the ATSB

Figure 7: Wheel damage (all four wheels displayed similar damage)

Source: ATSB

Safety analysis

The investigation determined the derailment likely occurred because of a known long twist defect in an area with other known twist defects. The long twist defect had deteriorated at a faster rate than anticipated to a point where it exceeded the tolerance limits specified within the Australian Rail Track Corporation's (ARTC) Civil Code of Practice (COP). The long twist defect's increased rate of deterioration was likely due to the known problematic formation in the area.

This section examines the factors which likely contributed to the track deteriorating leading up to the derailment. It also examines the actions taken to manage risk on the network after the train derailed.

Defect identification and prioritisation

ARTC's COP, specifically Civil Technical Maintenance Plan (TMP) ETE-00-03, requires the routine inspection of its railway infrastructure for track geometry defects. The methods of routine inspection within this plan included, but were not limited, to the use of hi-rail vehicles, track geometry recording car and walking inspections. Track and civil defects could also be identified from reviewing train driver reports, in which case, the affected area would be inspected and verified by maintenance personnel.

Defects identified were then entered into ARTC's defect management system 'Ellipse'. The defects were then managed in accordance with the COP.

Track and civil defects were repaired based on the risk they presented and were prioritised. The priority of a defect was determined by considering the size of the defect and the track speed. The classification of priority within ARTC's COP ranged from 'Emergency 1' (E1) which was the highest and 'Priority 3' (N) which was the lowest priority. The repair of a defect could be delayed (priority reduced) by the application of a suitable Temporary Speed Restriction (TSR) in accordance with 'Table 5.5 – Section 5' of the COP. It must be noted that in some cases, a TSR may not be an effective risk control and a more stringent maintenance response should be considered. This is dependent on the nature of a defect and the track's characteristics which may contribute to further deterioration. The following was stipulated in ARTC's COP:

> The responses defined in Table 5.5 are based on isolated geometric defects. A more stringent response than that mandated by the geometry alone may be necessary if deterioration of the infrastructure both at the defect and on adjoining track is in evidence.

Track maintenance history

On 20 May 2015, ARTC identified a P3 long twist defect at 314.550 km through a routine hi-rail inspection. Subsequently, on 27 May 2015, a track formation failure was recorded in the vicinity of the defect. As a result of this, a geotechnical inspection was scheduled and the track was tamped[8] on 17 June 2015.

The geotechnical inspection was completed on 21 July 2015 by an ARTC geotechnical engineer. The inspection identified a weakened formation which was heaving towards the Up cess[9] (see Figure 10). As an outcome, the geotechnical engineer recommended the track formation be reconditioned. This work was scheduled to be completed in the 2017/2018 Annual Maintenance Plan (AMP).

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[8] Tamping is the process by which the rails are lifted by a track machine called a tamper and ballast is packed underneath the reails to restore track alignment.

[9] The cess is the area along either side of a railway track; the Up cess is the area alongside the UP rail and the Down cess is the area alongside the Down rail.

As a temporary solution to address the formation problem, the geotechnical engineer recommended the installation of a shear key[10] at the most affected area '314.510 – 314.535'. Its purpose was to improve drainage and strengthen the formation. This was installed on 21 August 2015.

On 12 September 2015, a routine track geometry recording car inspection identified a P1 long twist defect and top loss in both rails in the vicinity of the shear key at 314.523 km (see Figure 8). The track was again tamped and the defects were repaired on 7 October 2015.

On 12 January 2016, the driver of loaded coal train UL112 reported "rough riding" at approximately 314.500 km. Train UL112 was travelling at 50 km/h (35 km/h below the maximum allowable speed). The driver recommended a TSR of 40 km/h through the area. The track was assessed by ARTC and a P2 top defect was entered into their defect management system (Ellipse). A 40 km/h TSR was then imposed extending from 314.450 km to 314.600 km.

On 14 January 2016, a scheduled track geometry recording car inspection through the area identified the following (see Figure 9):

- Top loss on both the Up and Down rail between 314.450 km – 314.550 km
- An Emergency 1 short twist defect at 314.544 km
- Two Emergency 1 long twist defects at 314.504 km and 314.546 km
- A Priority 1 short twist defect at 314.499 km
- A Priority 1 long twist defect at 314.513 km.

In response to the defects identified by the track geometry car, the 40 km/h TSR was reduced further to 20 km/h. The application of the 20 km/h TSR was in accordance with Section 5 - Table 5.5 of ARTC's COP and hence reduced the defective area's repair priority. The area was scheduled to be tamped (realigned) on 20 January 2016 to repair the identified defects.

On 15 January 2016, the crew of loaded coal train, UL234, called network control and reported that their train had experienced substantial lean as it passed through the affected area at 20 km/h. ARTC responded to this by inspecting the track and observed an empty coal train pass through the area at 20 km/h. ARTC maintenance personnel did not record any issues and certified the track for the existing 20 km/h speed restriction.

On 19 January 2016, the defective area had deteriorated to a point where the 64th wagon of train WG713 likely could not negotiate the defective area and derailed then re-railed at the Rosemount Rd level crossing (see Figure 6).

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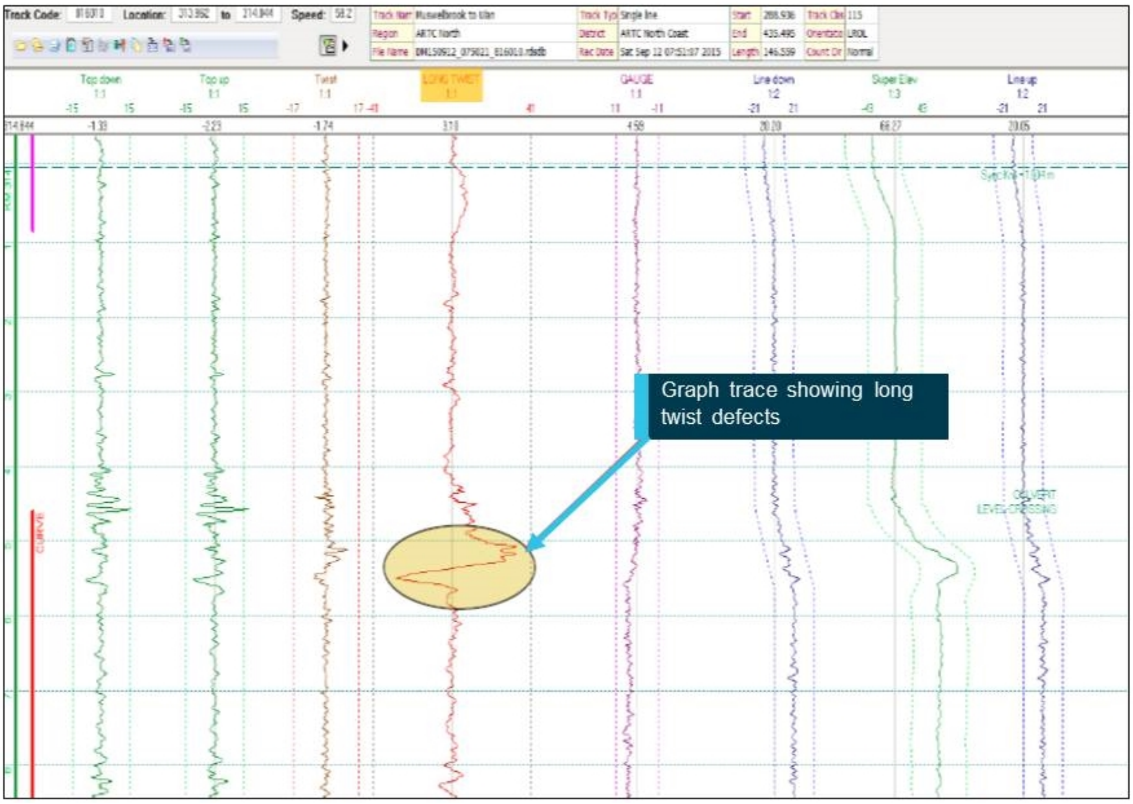
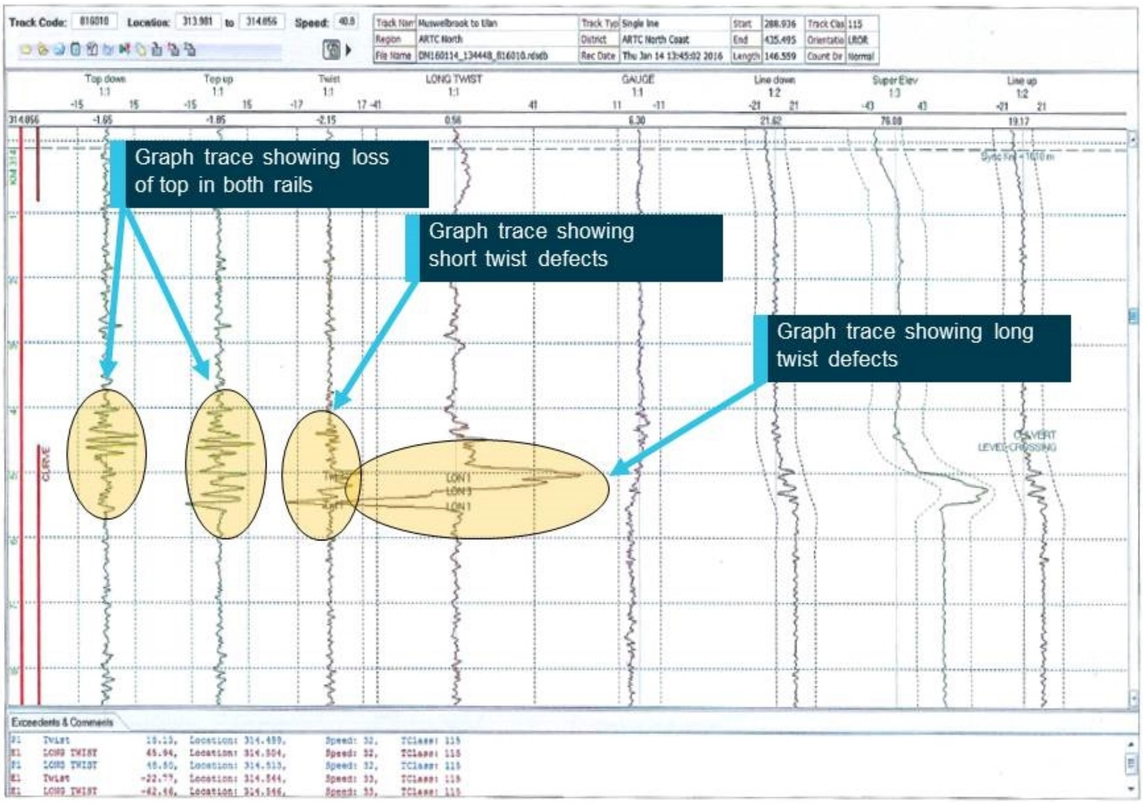
10 A shear key is an earth-retaining structure which in this case was a trench adjacent to the track filled with gabion rock (see Figure 12).

Figure 8: Track geometry recording car's graph 12 September 2015



Source: ARTC (Annotated by the ATSB)

Figure 9: Track geometry recording car's graph 14 January 2016



Source: ARTC (Annotated by the ATSB)

Track infrastructure and maintenance analysis

Track formation

The track at the incident location was built on a low height fill embankment which levelled out in the Up direction. The formation comprised of sandy gravelly clay (fill) which was overlying a firm to stiff clay subgrade[11]. The track was built many years ago and ARTC data suggests that the capping layer[12] was built with a grade towards the Up cess so that rainfall onto the track would be directed to the Up side cess drain. This grade would have assisted in directing water away from the formation and reduced the likelihood of formation problems as a result of water ingress. The capping layer would have also protected the track from the migration of fines from the formation which could lead to ballast fouling which could affect drainage and stability.

The ARTC geotechnical inspection following the formation failure in May 2015 identified:

- Variable ballast and capping layer depths
- Perched water at the ballast level
- Ballast fouling, likely due to fines migrating up from the formation
- Softened subgrade due to water penetration
- Cess heave on the Up-side of the track.

ARTC determined that the formation failure was due to a ballast pocket which had developed due to cumulative plastic strain[13]. It is likely that this was caused over time because of cyclic loading from normal train operations.

The ballast pocket would have prohibited water from draining away from the track as intended which likely contributed to the formation becoming saturated. This likely provided an environment for localised formation displacement under train loading (cumulative shear failure). As a consequence of this, it is likely that the formation displaced to a point where it was observed as heaving towards the Up cess which was identified by ARTC maintenance personnel on 20 May 2015 (see Figure 10).

Track geometry defects are typically associated with ballast pockets. The track geometry can be temporarily repaired by track tamping to keep the line operational, however the defects will continue to reappear overtime until the underlying formation problem is rectified.

As a result of the geotechnical inspection completed by ARTC, the following was recommended by the geotechnical engineer:

1. A long-term solution to recondition the area by removing track panels, replacing the soft formation and restablishing the capping layer/ballast depths
2. A short-term solution by installing a shear key which would remove the softened formation adjacent to the track and replace it with a stronger backfill.

As mentioned in the previous section, a shear key was installed in August 2015 as a temporary solution to the formation problem and track reconditioning was included into the 2017/2018 AMP.

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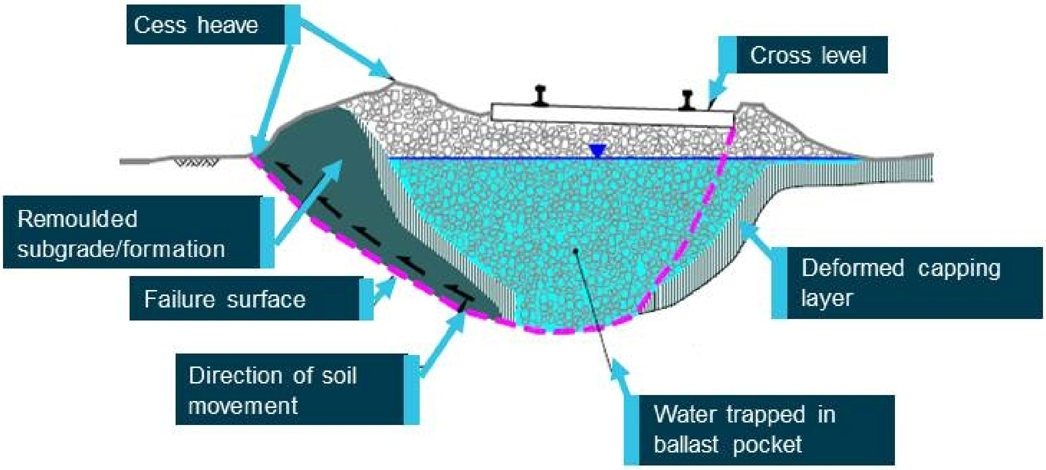
11 Subgrade: The native soil which forms part of the track formation

12 Capping layer: A well-compacted layer of fine aggregate material (sand or gravel) which sits above the formation. It prevents water from penetrating the formation and prevents the migrations of fines up into the ballast.

13 Plastic Strain: Strain induced by load which causes irreversible deformation of the formation

Figure 10: Image depicting a ballast pocket caused by cumulative shear failure



Source: ARTC, annotated by the ATSB

Track drainage

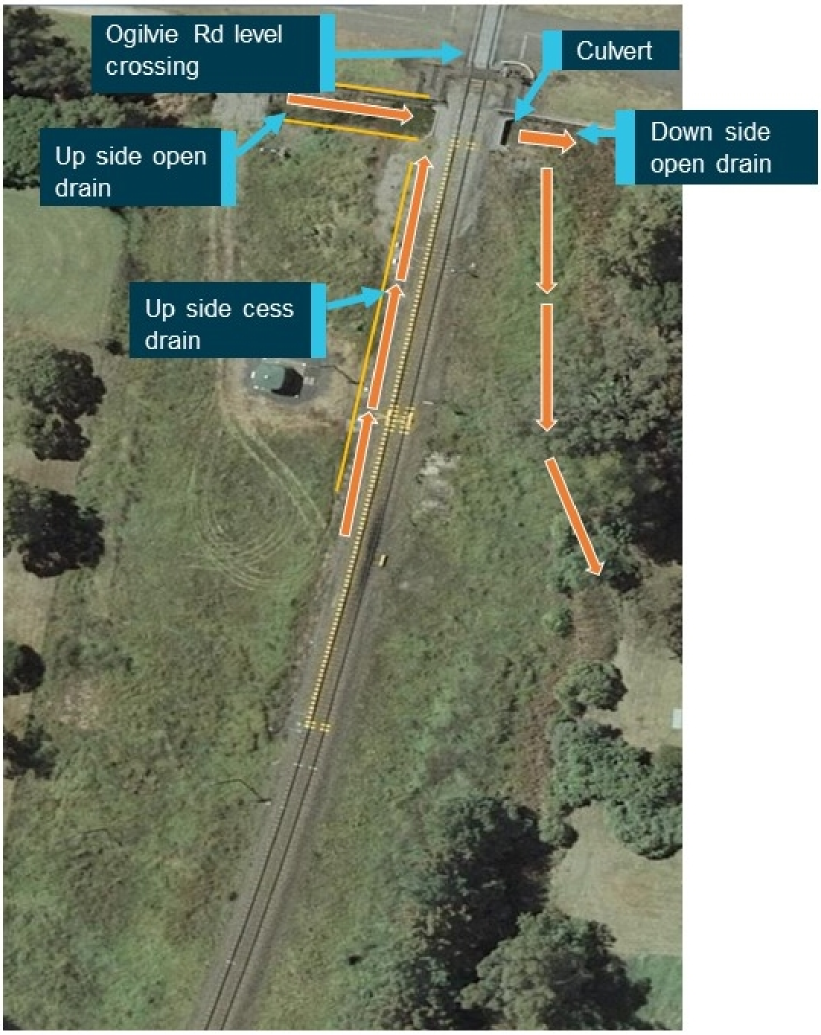
Water entering the formation likely comprised of overland flows from slightly elevated terrain (up slopes) from the north and northwest. The incident location was also within a 'sag point'. A sag point is the low point between two uphill gradients. Sag points are known to be more susceptible to water pooling than other locations due to the capture of water between the adjacent descending gradients.

A cess drain was observed on the Up-side of the track. The cess drain was likely designed to direct water to an open drain adjacent to the Up-side culvert at 314.450 km. The culvert was likely designed to direct water from the Up side open drain to a connected open drain on the Down side. The culvert consisted of three 600-mm reinforced concrete pipes laid under the track from the Up side to the Down side. The Down-side open drain likely directed water away from the track (see Figure 11).

The ATSB observed that the Up-side cess drain was shallow and had a relatively flat gradient. Vegetation was also observed in both the Up and Down open drains, as well as the Up-side cess drain. The ATSB determined that the vegetation in the Up-side cess drain, its level gradient and shallow depth likely restricted drainage in rainy periods from the up slopes.

The Bureau of Meteorology (BOM) recorded 49.4 mm of rainfall at the Muswellbrook Lindisfarne metereological station over two days, on 14 and 15 January 2016, four days before the derailment. The recorded rainfall was approximately 10 km away from Denman. This rainfall combined with the track's less than effective drainage and existing ballast pocket, likely contributed to further water entering the formation before the derailment. This may have increased the track's susceptibility to displace and deteriorate at a faster rate under train loading.

Figure 11: Drainage at incident location, orange arrows showing the expected flow of water



Source: Google Earth, annotated by the ATSB

Shear key

The geotechnical engineer recommended that a shear key be installed between 314.510 km and 314.535 km to strengthen the formation which had experienced the failure. The scope of work was to include; digging a trench by excavating soft formation adjacent to the Up side of the track and backfilling the trench with an aggregate material. The geotechnical engineer recommended the following specifications for the shear key:

1. The shear key be 25 m long extending from 314.510 km to 314.535 km (area of heave)
2. The width be at least 1.2 times the depth excavated
3. The backfill be angular, clean, free-draining material with a wet strength of 100 kN
4. The backfill material have an aggregate size between 100 mm and 250 mm (large aggregate gabion rock)
5. Deepening of the cess in front of the shear key (Up-side cess)
6. Including one 300-mm-wide cross-drain on the country end of the shear key at a depth of at least 200 mm below the ballast pocket.
7. Extending the cross-drain to the Down rail at a grade of 1 in 20 sloping down to the deepened Up-side cess drain.

ARTC advised that the shear key was installed on 21 August 2015 and was 25 m long, 1.2 m deep and 1.2 m wide. The backfill material used was clean, angular gabion rock of an aggregate size between 100 and 250 mm and no geo-fabric was used (see Figure 12).

Figure 12: Shear key construction at Denman

Source: ARTC

The ATSB found that the actual shear key width was 20% less than the recommended width specified by the geotechnical engineer. This meant that the shear strength of the shear key would have been lower than what was specified by the geotechnical engineer. It was also identified that a cross-drain was not installed as per the geotechnical engineer's recommendation.

The absence of the specified cross-drain would have contributed to unwanted water entering the shear key and formation adjacent to the track. This likely assisted further displacement of the formation under train loading after its installation.

The use of large aggregate gabion rock as a backfill material likely introduced voids between the rock particles adjacent to the track. The absence of a geo-fabric and these voids likely provided a pathway for sludge (soft formation and water) to move into the voids. Without the shear key having any drainage capability, the water was likely trapped and contributed to degrade the track formation over time.

The ATSB determined that removing soft formation adjacent to the ballast pocket and replacing it with a non-cohesive, higher strength backfill likely improved the formations shear strength immediately after installation. However, without the specified drainage, combined with the large aggregate size of the backfill without a geo-fabric, likely contributed to continued formation displacement over time.

The ATSB found that, three weeks after the installation of the shear key, a P1 long twist defect was identified in the vicinity at 314.523 km. This was probably due to soft fill and water moving into the backfill voids causing the track to settle and twist.

The ATSB also found that the shear key's location was incorrectly recorded at 314.600 km – 314.630 km. The incorrect record of the shear keys location may have contributed to unreliable monitoring of its performance after being installed.

Impact of applied temporary speed restrictions

Speed restrictions are typically applied to reduce the dynamic impacts exerted by trains on existing track defects. These impacts can worsen a track defect and may increase the likelihood of a derailment. Although speed restrictions are applied to protect defects by reducing these dynamic impacts, reducing train speeds in some circumstances can further degrade a defect and/or increase risk of derailment. This is dependent on the nature of the defect and the track characteristics.

A train negotiating through a curve at speed experiences centrifugal force[14]. To prevent a train from becoming unstable as a result of this force, superelevation is designed into a curve. Superelevation is a difference in height between two rails, with the higher rail being the outer rail. This height difference assists in balancing the effect of centrifugal and gravitational forces exerted on the track.

Centrifugal force is a function of train speed, mass and a curve's radius. A higher anticipated centrifugal force will require a higher superelevation design to mitigate its effects. Reducing the speed of a train on superelevated track can therefore transfer a greater proportion of the train's mass onto the low rail and overload it. This can also reduce the force applied onto the higher rail increasing the risk of high-rail wheel climb.

A transition is designed between tangent and curved track. This is a gradual uniform change in superelevation and curvature. A transition prevents a train from becoming unstable due to a sudden change in direction. The superelevation within a transition increases to a maximum as it approaches a curve and reduces as it approaches a straight section of track.

The derailment occurred approximately five metres after the transition (highest superelevation in the curve) for a 600 m radius curve in an area with a known problematic formation (see Figure 6). The normal line speed at the incident location was 85 km/h for freight trains and 110 km/h for passenger trains. A TSR of 40 km/h was imposed on 12 January 2016 due to an identified top defect and two days later, the track geometery recording car identified five twist defects in the area. This deterioration was likely a result of the track settling due to a displaced formation.

As a response to the identified defects, ARTC reduced the speed at the location further to 20 km/h. The 20 km/h speed restriction reduced the defect priorities and hence extended their repair times as per ARTC's COP. 132 trains passed over the defective area between the time that the 20 km/h TSR was imposed before the derailment.

Considering the frequency of trains through the area, high axle loads (loaded coal trains) and that the track was superelevated, the 20 km/h TSR likely exposed the low rail (Up rail) to an unintended increase in cyclic load. This loading condition on the Up side combined with the weakened formation, probably contributed to further degradation of the already existing twist defects.

One day after the application of the 20 km/h TSR, a loaded coal train reported "*substantial lean*" while passing through the affected area. This should have indicated that the TSR may not have been an appropriate maintenance response for the location considering it was superelevated and had a weakened formation.

As a response to the driver's report, maintenance personnel inspected the track and observed an empty coal train pass over the affected area. Maintenance personnel reported no problems and certified the track for the existing 20 km/h TSR in place. It is likely that the empty coal train observed to pass over the defective area would not have provided a reflection of the track condition under fully loaded conditions. The loaded coal train wheels would have likely depressed the low rail more than the unloaded coal train.

The largest defect recorded at the incident location after WG713 derailed on 19 January 2016 was a 77-mm-long twist defect (high superelevation). The defect's size was outside the tolerance limit within ARTC's COP for any speed and was determined to be the likely contributing factor to the derailment.

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[14] Centrifugal force: A force which acts on a body which is moving in a circular path and is directed away from the centre around which the body is moving.

Incident management

Train WG713 had travelled for approximately 70 minutes between the time the NCO was alerted to a signal failure and the time the signal electrician confirmed track damage. The signal electrician formed the opinion that the track damage was as a result of train WG713 dragging equipment.

The NCO was in contact with the two trains travelling in the opposite direction to WG713, however did not request the train crews to report on the track condition between Denman and Wilpinjong. Track damage between Denman and Wilpinjong may have increased the two trains' operating risk if WG713 was indeed dragging equipment.

With the exception of the above, the ATSB determined that the affected area was adequately protected and train movements in approach to Denman were adequately managed after the derailment.

TSR procedure compliance

ARTC's TSR procedure requires a Speed Restriction Notification Form PP163F-01 be completed by the local maintenance depot. This form was required to be sent to train control to allow the track speed database to be updated. The track speed database provides all NCOs with TSR information so that they can communicate accurate data to rolling stock operators. Without this database being updated correctly, train drivers would rely on speed boards for speed limit information only.

This form was completed on 13 January 2016 for the 40 km/h TSR imposed on 12 January. However, it was not updated for the 20 km/h TSR imposed on 14 January. This meant that while the correct speed (20 km/h) was displayed on track, the higher (40 km/h) TSR was still recorded on the track speed database.

The wayside monitor located approximately 75 m from the POM recorded the speeds of all passing trains. It was found that train WG713 complied with the 20 km/h TSR. This was also verified by examining the locomotive's on-board data loggers.

Of the 132 trains passing the location, 11 exceeded the 20 km/h TSR with six of the exceedances being over 40 km/h. Three of these trains exceeded 60 km/h with the highest recorded speed being 65 km/h on 18 January.

It was evident that speed boards alone were not reliable in managing the application of the TSRs. An updated database would have provided additional information to NCOs and train drivers for the required speed for that section.

The train speed exceedances likely exposed the track to dynamic forces which may have contributed to the defective area deteriorating at a faster rate and increased the risk of a derailment at a higher speed.

Train management

Train WG713's speed was managed appropriately on approach to and through the TSR. Due to the uphill grade, locomotive power was applied continuously after the initial speed reduction for the TSR. The power applied likely induced tensile draft forces which assisted in re-railing the derailed wagon at the level crossing. It was found that the driver's actions did not contribute to the incident and that the uphill grade ahead of the Rosemount Rd level crossing likely mitigated the consequence of the derailment.

Incident wagon

The incident wagon, RHCH 7293A was transported to Pacific National's One Spot maintenance facility at Newcastle for inspection and testing. A twist test was conducted on the incident wagon and no defects were recorded. The ATSB concluded that it is likely that the wagon did not contribute to the derailment.

Findings

From the evidence available, the following findings are made with respect to the derailment of empty coal train WG713 at Denman NSW on 19 January 2016. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing factors

The investigation determined that the following factors likely contributed to the derailment:

- A known long twist defect in an area with other known twist defects which deteriorated at a faster rate than anticipated.
- The deterioration rate in the area was due to a known degraded formation between 314.450 km and 314.550 km.
- **The location did not have adequate surface drainage which likely contributed to formation degradation over time. [Safety Issue]**
- **The shear key was not installed in accordance with the geotechnical engineer's specification with respect to the following: a) It did not include a cross-drain b) Its actual width was less than the specified width. [Safety Issue]**
- **A more stringent maintenance response than that for an isolated track geometry defect was not considered or implemented in accordance with ARTC's COP. A more stringent maintenance response should have been considered given the degraded formation and the track's rapid deterioration between 12-14 January 2016, two days prior to the derailment. [Safety Issue]**
- The application of a 20 km/h TSR on superelevated track likely distributed train loads onto the lower rail which exposed it to an unintended increase in cyclic load. This loading condition likely contributed to deteriorating the already existing twist defects.

Other factors that increased risk

- The actual location of the shear key was incorrectly recorded. This may have contributed to unreliable monitoring of its performance.
- 49.4 mm of rainfall during the four days before the derailment likely softened the formation and may have made it prone to further displacement.

Safety issues and actions

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the rail industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report

Surface drainage in areas with degraded formations

Number:	RO-2016-001-SI-02
Issue owner:	Australian Rail Track Corporation
Operation affected:	Railway Infrastructure
Who it affects:	Rail Infrastructure Managers (RIMs)

Safety issue description:

The location did not have adequate surface drainage which likely contributed to formation degradation over time.

Proactive safety action taken by ARTC

Action number: RO-2016-001-NSA-012

Since the derailment of train WG713, ARTC has:

- Completed a review of its civil and track standards and reinforced the importance of drainage in areas with a degraded formation to its track and civil staff
- Completed reconditioning of the track formation at the incident location in Denman.

ATSB comment/action in response

The Australian Transport Safety Bureau notes the response provided and is satisfied with the action taken by ARTC.

Shear key installation

Number:	RO-2016-001-SI-01
Issue owner:	Australian Rail Track Corporation
Operation affected:	Railway Infrastructure
Who it affects:	Rail Infrastructure Managers (RIMs)

Safety issue description:

The shear key was not installed in accordance with the geotechnical engineer's specification with respect to the following:

a) It did not include a cross-drain.

b) Its width was less than the specified width.

Proactive safety action taken by ARTC

Action number: RO-2016-001-NSA-011

Since the derailment of train WG713, ARTC has:

- Completed a review of its civil and track standards and reinforced the importance of drainage in areas with a degraded formation to its track and civil staff
- Completed reconditioning of the track formation at the incident location in Denman.

ATSB comment/action in response

The Australian Transport Safety Bureau notes the response provided and is satisfied with the action taken by ARTC.

Maintenance response to recurring track defects in areas with a degraded formation

Number:	RO-2016-001-SI-03
Issue owner:	Australian Rail Track Corporation
Operation affected:	Railway Infrastructure
Who it affects:	Rail Infrastructure Managers (RIMs)

Safety issue description:

A more stringent maintenance response than that for an isolated track geometry defect was not considered or implemented in accordance with ARTC's COP. A more stringent maintenance response should have been considered given the degraded formation and the track's rapid deterioration between 12-14 January 2016, two days prior to the derailment.

Proactive safety action taken by ARTC

Action number: RO-2016-001-NSA-013

Since the derailment of train WG713, ARTC has:

- Completed a review of its civil and track engineering standards
- Completed reconditioning of the track formation at the incident location at Denman.

ATSB comment/action in response

The Australian Transport Safety Bureau notes the response provided and is satisfied with the action taken by ARTC.

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk.

General details

Occurrence details

Date and time:	19 January 2016 – 0400 AEDT	
Occurrence category:	Incident	
Primary occurrence type:	Derailment	
Location:	Denman, NSW	
	Latitude: 32° 23.36' S	Longitude: 150° 40.99' E

Rail Infrastructure details

Rail Infrastructure Manager	The Australian Rail Track Corporation Ltd.
Line	Ulan
Section	Mangoola - Yarrawa
Track details	Single track with 60 kg/m head-hardened rail on heavy-duty concrete sleepers.

Train details

Train operator:	Pacific National Pty Ltd.	
Train No.	WG713	
Type of operation:	Bulk coal.	
Persons on board:	Crew – 2	Passengers – Nil
Injuries:	Crew – Nil	Passengers – N/A
Damage:	Minor	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- The Australian Rail Track Corporation Ltd.
- Pacific National Pty Ltd.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

Enquiries 1800 020 616
Notifications 1800 011 034
REPCON 1800 020 505
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au
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Research

ATSB Transport Safety Report
Rail Occurrence Investigation
Derailment of freight train WG713
Denman, New South Wales on 19 January 2016

RO-2016-001

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