Derailment of Train 5WX2
near Winton, Victoria
31 July 2008
Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office location: 62 Northbourne Ave, Canberra City, Australian Capital Territory, 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsinfo@atsb.gov.au
Internet: www.atsb.gov.au

© Commonwealth of Australia 2009.

This work is copyright. In the interests of enhancing the value of the information contained in this publication you may copy, download, display, print, reproduce and distribute this material in unaltered form (retaining this notice). However, copyright in the material obtained from other agencies, private individuals or organisations, belongs to those agencies, individuals or organisations. Where you want to use their material you will need to contact them directly.

Subject to the provisions of the Copyright Act 1968, you must not make any other use of the material in this publication unless you have the permission of the Australian Transport Safety Bureau.

Please direct requests for further information or authorisation to:
 Commonwealth Copyright Administration, Copyright Law Branch
 Attorney-General’s Department, Robert Garran Offices, National Circuit, Barton, ACT 2600

ISBN and formal report title: see ‘Document retrieval information’ on page v
## CONTENTS

THE AUSTRALIAN TRANSPORT SAFETY BUREAU ........................................... vi
TERMINOLOGY USED IN THIS REPORT ....................................................... vii
EXECUTIVE SUMMARY .............................................................................. viii

1 FACTUAL INFORMATION ........................................................................... 1
  1.1 Overview .............................................................................................. 1
  1.2 Location ................................................................................................ 1
    1.2.1 Train information ......................................................................... 2
  1.3 The occurrence ..................................................................................... 2

2 ANALYSIS ..................................................................................................... 5
  2.1 Sequence of events analysis ................................................................. 5
  2.2 Examination of rolling stock ............................................................... 7
    2.2.1 Summary of rolling stock examination ........................................ 10
  2.3 Examination of track geometry .......................................................... 11
    2.3.1 Track geometry assessment – Unloaded condition .................... 12
    2.3.2 Track geometry assessment – Loaded condition ......................... 13
    2.3.3 Combinations of track geometry defects .................................... 14
    2.3.4 Summary of track geometry ...................................................... 15
  2.4 Vehicle dynamic analysis .................................................................... 15
    2.4.1 Simulation results ........................................................................ 16
    2.4.1 Summary of dynamic analysis .................................................. 22
  2.5 Dynamic behaviour of rolling stock .................................................... 23
    2.5.1 Controlling harmonic behaviour ................................................. 24
  2.6 Track inspection and assessment ........................................................ 25
    2.6.1 Assessment of track geometry defects ....................................... 26
    2.6.2 Assessment of track geometry quality ....................................... 27
    2.6.3 Assessment of ride quality ......................................................... 27
    2.6.4 Track geometry and undesirable vehicle harmonics .................. 28
    2.6.5 Summary of track inspection and assessment ............................ 30
  2.7 Similarities to other incidents ............................................................... 30
    2.7.1 Similarities to derailment of 5WX2 ............................................. 32

3 FINDINGS .................................................................................................... 33
  3.1 Context .................................................................................................. 33
3.2 Contributing safety factors ................................................................. 33
3.3 Other safety factors............................................................................. 34
3.4 Other key findings.............................................................................. 34

4 SAFETY ACTION........................................................................................ 35
  4.1 Australian Rail Track Corporation ..................................................... 35
     4.1.1 ARTC Code of Practice ........................................................... 35
  4.2 Pacific National .................................................................................. 35
     4.2.1 Loose and broken wedge wear plates ...................................... 35
     4.2.2 Tread fracture........................................................................... 36

APPENDIX A : SOURCES AND SUBMISSIONS.............................................. 37
Abstract
At approximately 2030 on 31 July 2008, freight train 5WX2 derailed near Winton, Vic. (between Glenrowan and Benalla). The derailment occurred about 10 track km north of Benalla. Thirteen freight wagons were derailed but there were no injuries.

The investigation concluded that both rolling stock and track related factors combined to increase the likelihood of a flange-climb derailment, although individually, these factors did not exceed the acceptable limits documented in the relevant standards.

The ATSB identified and recommended that action be taken to address a number of safety issues relating to:

• the documented process for inspection and assessment of track irregularities with consideration to the possibility for some rail vehicles to develop an undesirable harmonic response; and
• the condition of rolling stock suspension components.
The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory Agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

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 enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is a function of the ATSB to apportion blame or determine liability. However, 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 proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

When safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement 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, the person, organisation or agency must provide a written response within 90 days. That response must indicate whether the person, organisation or agency accepts 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.
**TERMINOLOGY USED IN THIS REPORT**

**Occurrence:** accident or incident.

**Safety factor:** an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, risk controls and organisational influences.

**Contributing safety factor:** a safety factor that, if it had not occurred or existed at the relevant time, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

**Other safety factor:** a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report.

**Other key finding:** any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

**Safety issue:** a safety factor that (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 operational environment at a specific point in time.

Safety issues can broadly be classified in terms of their level of risk as follows:

- **Critical safety issue:** associated with an intolerable level of risk.
- **Significant safety issue:** associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable.
- **Minor safety issue:** associated with a broadly acceptable level of risk.
EXECUTIVE SUMMARY

At approximately 2030\(^1\) on 31 July 2008, freight train 5WX2 derailed near Winton, Vic. (between Glenrowan and Benalla). The train was owned and operated by Pacific National. It was 810 m long, weighed about 3500 t and was conveying predominantly steel products between Port Kembla, NSW and Port Augusta, SA.

Freight train 5WX2 had passed through Glenrowan at about 2020 and was travelling towards Benalla. About 10 km north-east of Benalla (near Winton) while travelling at about 80 km/h, the train drivers noticed a reduction of brake pipe pressure indicating that brake pipe air was exhausting to the atmosphere and the train brakes would begin to apply. Train 5WX2 came to a stop and the driver contacted the Australian Rail Track Corporation (ARTC) train controller to advise that train 5WX2 had stopped due to a loss of brake pipe pressure.

The second driver walked back to investigate the loss of brake-pipe air and discovered that 13 of the 44 freight wagons had derailed; some were obstructing the adjacent broad gauge passenger line and about 700 m of track was damaged. The drivers contacted the ARTC train controller and advised that train 5WX2 had derailed and a significant portion of track had been destroyed. The ARTC train controller initiated the incident response process and terminated train traffic on both lines.

An investigation team from the Australian Transport Safety Bureau (ATSB) was dispatched to investigate the derailment. Initial observations indicated that a wheel had rolled across the head of the right rail (direction of travel) soon after traversing a section of track that exhibited a series of dips in the left rail. It is likely that the derailed wheels then impacted with the timber sleepers which ultimately failed to maintain track gauge and allowed further wagons to derail.

The wagon believed to have first derailed was wagon RCPF-31882C, loaded with two coils of steel, each weighing about 27 t. To assist in identifying the mechanism for the derailment, the ATSB engaged experts in computer simulation to model and analyse the dynamic response of the RCPF class wagons to the track irregularities found at Winton. The modelling revealed a number of factors that, when combined, were likely to have resulted in the derailment of train 5WX2.

Simulation found that track irregularities caused the wagon body to roll with sufficient force to unload both leading right wheels when close to the point of derailment. Simulation also showed that the wheel-sets under wagon RCPF-31882C were susceptible to lateral oscillation at some track speeds. The lateral oscillations were independent of the wagon body roll and could have brought the right wheels into flange contact at the point of derailment. When combined, the lateral wheel-rail force at the right rail and the high degree of unloading of the leading right wheel increased the likelihood of a flange-climb derailment.

Simulation results indicated that the body rolling behaviour was harmonic in nature and dependent on the spacing of the track dips, along with wagon type, wagon load and train speed. While the lateral oscillation behaviour was influenced by changes in wheel profile, it still required some form of external influence to initiate the

---

\(^1\) The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred.
behaviour. It is possible that the wheel-sets may have been oscillating to some
degree well before approaching the derailment site. Alternatively, it is possible that
a small lateral irregularity near the point of derailment may have initiated the lateral
oscillation of the wheel-sets.

An examination of wagon RCPF-31882C found evidence that the springs on the
trailing bogie had become fully compressed (solid), indicating that the wagon had
experienced high degrees of body roll. The trailing bogie was also found to have
loose and broken wedge wear plates which would significantly reduce the damping
performance of that bogie. It could not be verified whether the wedge wear plates
had broken free before the derailment or during the derailment sequence. However,
if the condition had existed prior to the derailment, it is likely that body roll
induced while traversing a series of track irregularities could result in un-damped
harmonic oscillations.

Assessment of the track irregularities leading up to the point of derailment found
they did not exceed the intervention limits that would require urgent attention for
trains travelling at 80 km/h. In each case, the relevant response would be for track
inspections to continue with consideration to detecting any deterioration in track
condition. However, the simulation results illustrated how a sequence of repetitive
track irregularities does not need to be significant in magnitude to increase the risk
of undesirable harmonic behaviour in rolling stock.

Considering the track maintenance processes, only assessment of ride quality (front-
of-train inspections and driver reports) appeared to identify undesirable conditions
(rough riding) in the area where train 5WX2 subsequently derailed. However, the
ARTC Code of Practice does not clearly address the possibility that a series of track
irregularities, even minor ones which do not exceed intervention limits, could cause
an undesirable harmonic response in some rail vehicles. Without any guidance to
the contrary, it is unlikely that track inspectors (front-of-train, hi-rail or on-foot)
would assess a series of ‘minor’ track irregularities and effectively determine the
potential for undesirable harmonic behaviour in all types of rolling stock.

The investigation concluded that the behaviour of rolling stock traversing a series of
minor track irregularities combined to increase the likelihood of a flange-climb
derailment, although the condition of rolling stock and track did not exceed the
acceptable limits documented in the relevant standards.

The ATSB identified and recommended that action be taken to address a number of
safety issues relating to:

• the documented process for inspection and assessment of track irregularities
  with consideration to the possibility for some rail vehicles to develop an
  undesirable harmonic response; and

• the condition of rolling stock suspension components.
1 FACTUAL INFORMATION

1.1 Overview

At approximately 2030\(^2\) on 31 July 2008, freight train 5WX2 derailed near Winton, Vic. Thirteen freight wagons were derailed and about 700 m of track was damaged. There were no injuries.

1.2 Location

The derailment occurred near Winton (Figure 1) on the main Sydney to Melbourne rail line which is part of the Defined Interstate Rail Network (DIRN). Winton is located about 10 km north-east of Benalla, Vic., approximately 180 km north-east of Melbourne and 550 km south-west of Sydney. This section of track consisted of a single standard gauge track running parallel to a single broad gauge intrastate track.

Figure 1: Location of Winton, VIC.

The track at the Winton derailment site was continuously welded rail secured to timber sleepers and supported on a bed of hard rock ballast. The track was leased by the Australian Rail Track Corporation (ARTC) with track maintenance contracted to Downer EDI Works.

\(^2\) The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred.
1.2.1 Train information

Freight train 5WX2 was owned and operated by Pacific National and consisted of three locomotives (NR1, AN11 and NR28) hauling 44 loaded freight wagons. The train originated at Port Kembla (NSW) and was travelling to Port Augusta (SA). It was mostly carrying steel products except for four hopper style wagons at the rear of the train that were carrying sugar. The train was 810 m long and weighed about 3500 t. The maximum allowable speed for train 5WX2 was 80 km/h.

The wagon believed to have first derailed was RCPF-31882C, the 29th wagon behind the locomotives. The RCPF class wagons (Figure 2) were originally built in 1968 as CG class open top zinc concentrate wagons. In the late 1980’s, the wagons were converted for carrying coiled steel by fitting large heavy beams and angled support frames. The wagons ride on three-piece bogies with gap/friction style side bearers. Due to dynamic behaviour limitations, RCPF class wagons are not permitted to exceed 80 km/h.

At the time of the derailment, wagon RCPF-31882C was carrying two coils of steel, each weighing about 27 t.

Figure 2: RCPF class wagon

Table 1: RCPF class wagon

<table>
<thead>
<tr>
<th>Tare weight</th>
<th>15 t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>10.9 m</td>
</tr>
<tr>
<td>Max gross weight</td>
<td>92 t (70 t bogies)</td>
</tr>
<tr>
<td></td>
<td>80 t (50 t bogies)</td>
</tr>
<tr>
<td>Capacity</td>
<td>77 t (70 t bogies)</td>
</tr>
<tr>
<td></td>
<td>65 t (50 t bogies)</td>
</tr>
<tr>
<td>Max allowable speed</td>
<td>80 km/h</td>
</tr>
</tbody>
</table>

Note: Wagon RCPF-31882C was fitted with 50t bogies

1.3 The occurrence

Freight train 5WX2 began its journey at Port Kembla (NSW) on 31 July 2008. At about 2020, the train had passed through Glenrowan and was travelling towards Benalla. About 10 km north-east of Benalla (near Winton), while travelling at about 80 km/h, the train drivers noticed a reduction of brake pipe air pressure and an increase in brake pipe air flow. Those conditions indicated that the brake pipe air had been vented, either at a fracture in the brake-pipe, a damaged brake hose or as a result of the train separating (possibly due to derailment). In an endeavour to keep
the train stretched, the driver bailed off\textsuperscript{3} the locomotive independent brake and brought train 5WX2 to a controlled stop using the train brake.

The driver contacted train control to advise that train 5WX2 had stopped due to a loss of brake pipe pressure and that his colleague was leaving the locomotive to investigate the cause. The second driver left the locomotive and walked back to investigate the cause of the brake application and discovered that the 29th wagon (RCPF-31882C) had derailed. The following wagon had also derailed, but the remaining wagons of train 5WX2 were not visible. A further 500 m back towards Glenrowan, the driver discovered the remainder of the wagons, mostly derailed with some obstructing the adjacent broad gauge line.

The drivers contacted the ARTC train controller and advised that train 5WX2 had derailed and a significant portion of track had been destroyed. The ARTC train controller initiated the incident response process and stopped train traffic on both lines.

**Figure 3: Derailment site**

Post occurrence

Investigators and recovery crews progressively arrived on site the following day (1 August 2008) and examined the site throughout the remainder of the day. Heavy lift cranes arrived on site later that day and began the recovery of derailed wagons.

\textsuperscript{3} Bail off is a term used to describe the action of:
\begin{itemize}
  \item preventing the locomotive(s) brake from applying automatically during a train brake application, or
  \item releasing the locomotive(s) independent brake during a train brake application.
\end{itemize}
The undamaged front portion of the train was released to continue its journey towards Melbourne while a locomotive was brought in from Glenrowan to recover the non-derailed wagons at the rear of the train.

Excavators were used to create access to the derailed wagons before the cranes lifted the wagons clear of the track to allow track restoration work to progress. The track was reopened for traffic at about 2150 on Sunday 3 August 2008 and the damaged rolling stock progressively recovered from the track side over the following weeks. A total of 13 wagons were damaged along with about 700 m of track.
2 ANALYSIS

An investigation team from the Australian Transport Safety Bureau (ATSB) was dispatched to investigate the derailment of train 5WX2 and arrived on site at about 0830 on 1 August 2008. Investigators examined and photographed the derailment site before releasing the site to permit recovery operations to begin. The wagon believed to have derailed first was recovered from the derailment site and reassembled at workshops in Bendigo for closer examination on 13 August 2008.

Evidence was sourced from various witnesses and rail companies including the Australian Rail Track Corporation (ARTC), Pacific National and Downer EDI Works. Preliminary examination and analysis of this evidence revealed that train 5WX2 was handled in a manner consistent with normal train driving practice. There was no evidence to suggest that train handling contributed in any way to the derailment of train 5WX2. However, the following factors associated with the accident were subject to further analysis:

• Rolling stock – The first derailed wagon (RCPF-31882C) appeared to have an unusual configuration.

• Track geometry – Initial observations indicated that a wheel had rolled across the head of the rail soon after traversing a section of track that exhibited a series of dips in the left rail (direction of travel).

2.1 Sequence of events analysis

On 25 June 2008, about 5 weeks before the derailment of train 5WX2, an inspection was carried out by the track geometry car4 of the track in the area where the derailment later occurred. Only one ‘wide gauge’ defect was reported near the point of derailment5 (POD).

In the 14 days before the derailment, three train driver reports were recorded by train control, identifying potential track geometry defects between the 205.000 and 206.000 track km points. Further inspections were carried out and records indicate that track irregularities and ‘soft ground’ were identified in the area.

On 24 July 2008, 7 days before the derailment, a track maintenance worker travelled in the driver’s cab of train 4MB2 and conducted a ‘front-of-train’ track inspection. The inspection identified a ‘priority rough ride location’ between 205.600 to 205.400 track km.

On 30 July 2008, the day before the derailment of train 5WX2, a track patrol inspection was conducted using a road/rail vehicle. No defect was reported near the POD.

Freight train 5WX2 departed Junee at about 1620 on 31 July 2008. At about 2030, the train was travelling through Winton (between Glenrowan and Benalla). The locomotive data logger showed the driver had advanced the throttle to notch 4, in order to maintain train speed at about 80km/h (recorded train speed was 81 km/h)

4 A rail vehicle with electronic recording equipment.

5 The point of derailment is defined as beginning of the wheel flange markings over the rail head (about the 205.370 track km point, measured using GPS and the 205 km post as a reference).
after transitioning from a slightly descending gradient onto a slightly increasing gradient. From this point, the data showed a reduction of brake pipe air pressure and a progressive reduction in train speed until train 5WX2 came to a complete stop.

While previous track inspections had identified various issues ranging from minor geometry defects to rough riding, the drivers of train 5WX2 did not notice anything unusual. However, it was evident that the train had traversed a series of dips and humps in the track (Figure 4) immediately before derailing.

**Figure 4: Irregularities in track geometry**

The first wagon to derail was RCPF-31882C, the 29th wagon behind the locomotives. The wheels from both axles on the lead bogie had derailed to the right side of the track. The trailing bogie had fallen between the two rails and the following wagon had also derailed completely (Figure 5). Examination of on-site evidence showed wheel flange markings over the rail head which continued for approximately 4 m before dropping off onto the outside of the rail. On-site evidence suggests the following as the most likely derailment sequence:

- The right wheel from the leading axle of wagon RCPF-31882C climbed and travelled over the top of the rail to the right side of the track.
- As train 5WX2 continued towards Benalla, the derailed wheels impacted with the timber sleepers. The sleepers ultimately failed to maintain track gauge which allowed further wagons to derail.
- The train parted behind the 30th wagon as the following wagons began to jack-knife. Wagons continued to derail and jack-knife as the rear portion of train collided with the rapidly slowing derailed wagons.
- Only three wagons from the rear portion of the train remained on the rails.
- Thirteen freight wagons in total were derailed.
2.2 Examination of rolling stock

Examination of wagon RCPF-31882C found that the bogies at each end of the wagon were of different designs, which had different suspension springs, wheel profiles and wheel diameters (Table 2). The trailing bogie was also found to have loose and broken wedge wear plates\(^6\), and its springs showed evidence of having fully compressed (solid).

Table 2: RCPF 31882C Bogie configuration

<table>
<thead>
<tr>
<th></th>
<th>Leading bogie ('B' end)</th>
<th>Trailing bogie ('A' end)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogie #</td>
<td>NXGB 6168</td>
<td>NXLB 8696</td>
</tr>
<tr>
<td>Bogie type</td>
<td>ASF Ride control</td>
<td>National wedge-lock</td>
</tr>
<tr>
<td>Side bearer gaps</td>
<td>Left – 10.5 mm Right – 10.5 mm</td>
<td>Left – 10.5 mm Right – 10.0 mm</td>
</tr>
<tr>
<td>Springs</td>
<td>D4</td>
<td>D5</td>
</tr>
<tr>
<td>Wheel profile</td>
<td>ANZR-1</td>
<td>WPR-2000</td>
</tr>
<tr>
<td>Wheel diameter</td>
<td>1012 mm</td>
<td>1040 mm</td>
</tr>
<tr>
<td>Wheel back-to-back</td>
<td>1357 mm</td>
<td>1357 mm</td>
</tr>
</tbody>
</table>

\(^6\) Bogie suspension dampers.
Rolling stock standards describe the minimum requirements applicable to the design, construction, operation and maintenance of railway rolling stock. At the time when train 5WX2 derailed, the relevant rolling stock standards were a combination of the *Railways of Australia – Manual of Engineering Standards and Practices* (ROA Manual) and a series of new Australian Rolling Stock Standards (some still under development) by the Rail Industry Safety and Standards Board (RISSB). The requirements documented in the RISSB standards are generally consistent with those in the ROA Manual. The documents relevant to wagon operation and maintenance are:

- ROA Manual, Section 24 – Freight Vehicle Field Inspection Limits for In-Service Use.
- RISSB standard, AS7517.2 – Railway rolling stock - Wheelsets Part 2 – Freight

**Bogie configuration**

The standards do not specify a requirement for identical bogie configurations to be installed under an individual wagon. The only requirement specified relates to variations in wheel diameter between bogies on the same wagon. The standards specify that the maximum variation for wheel diameter between bogies is 60 mm. In this case, the variation in wheel diameter was 28 mm. Pacific National also confirmed that it was not unusual for the RCPF class wagon to be configured in this way.

**Side bearer gap**

Section 24 of the ROA Manual specifies the limits for side bearer gap on bogies with 300 mm centre plates, and states:

> The clearance between the bogie and body side bearer contact surfaces shall be within the range of 10 mm to 14 mm when measured on level track ... The sum of the two side bearer clearances on any bogie shall be within the range of 20 to 28 mm to allow for variations in track levels.

In this case, the side bearer gaps on wagon RCPF-31882C were within the limits specified.

**Wheel profile**

Section 24 of the ROA Manual specifies the requirements for wheel condition, including wear limits for tread, flange and rim dimensions. In this case all wheel profiles were measured and found to be within the acceptable limits specified in the standards. While the amount of flange wear was generally consistent between wheels on the same bogie, one wheel on the lead bogie (right wheel, trailing axle) exhibited excessive flange wear when compared to the other wheels on that bogie. Pacific National engaged PearlStreet ETRS to conduct a metallurgical examination of the excessively worn wheel.

The examination found evidence of deformation of the wheel microstructure at the tip of the wheel flange (area of excessive wear). The grain structure revealed that material had been rolled over the flange tip from the back face towards the running face of the flange. The running face of the flange also contained a flattened area near the flange tip. The examination found that the deformation of the grain
structure in this area was more severe than that expected to be produced as a result of normal rolling contact.

The metallurgical examination concluded that deformation of the grain structure on the wheel flange was not consistent with normal machining or in-service loading of the wheel flanges. However, the deformation was consistent with lateral contact with the back face of the wheel and abrasive wear of the wheel flange. Those findings were consistent with the site observations showing wheel contact with the wagon body (Figure 6).

**Figure 6: RCPF 31882C, leading bogie, right wheel trailing axle**

![Wheel tread](image)

**Wheel tread**

Examination of wagon RCPF-31882C also revealed a crack on the tread of the right wheel on the second axle of the leading bogie. It was noted that no mention of the crack was made during the metallurgical examination of this wheel. Consequently, the extent of cracking could not be identified. In this case, the crack did not contribute to the derailment in any way. However, if a crack was to develop to such an extent that the wheel tread completely fractured, the risk of derailment is likely to increase significantly.
2.2.1 Summary of rolling stock examination

Wagon RCPF-31882C appeared to have an unusual configuration with bogies of different design installed at each end, with the bogies having different suspension springs, wheel profiles and wheel diameters. However, there is no requirement specified in the rolling stock standards for identical bogie configurations to be installed under an individual wagon. Pacific National advised that the practice of mixing bogie types on an individual wagon is a relatively common practice.

Wheel flange wear was generally consistent between wheels on the same bogie. However, one wheel on the lead bogie (right wheel, trailing axle) exhibited excessive flange wear when compared to the other wheels on that bogie. A metallurgical examination concluded the excessive wear was not consistent with normal operation, but was more consistent with lateral contact with the back face of the wheel and abrasive wear of the wheel flange, most likely occurring during the derailment sequence. Those findings were consistent with the site observations showing wheel contact with the wagon body.

The trailing bogie was found to have loose and broken wedge wear plates, and the springs showed evidence of full compression (solid). However, it could not be verified if the wedge wear plates had broken free before or during the derailment sequence.

Apart from the wedge wear plates, wagon RCPF-31882C appeared to have been maintained in a ‘fit for purpose’ condition.
2.3 Examination of track geometry

It was evident that train 5WX2 had traversed a series of dips in the left rail as wagon RCPF-31882C derailed. Consequently, about 100 m of track immediately before the POD was surveyed by the ARTC and Downer EDI Works. Visual assessment indicated minimal horizontal deviation, so lateral alignment was not measured. Figure 8 illustrates the surveyed geometry in terms of the variation in track level from the estimated average gradient. The main features of the track survey were three dips in the left rail (direction of travel) in the 50 m leading up to the point of derailment. A sharp dip measured in the right rail, about 32 m before the POD (illustrated on the blue trace in Figure 8), was not evident from on-site observation or photographs. This dip was assumed to be a measurement error and not included in the following assessment.

Figure 8: Vertical alignment

During the retrieval of non-derailed wagons, the opportunity was taken to measure the track’s deflection under load. Measurements were taken for each rail over a distance of about 20 m before the POD. Each rail exhibited some degree of deflection under load, but neither rail deflected more than 12 mm.

Track geometry assessment standards

Guidelines for the inspection and assessment of track geometry are documented in the ARTC Track and Civil Code of Practice (CoP). Track geometry defects are assessed based on a series of defect categories. Measurements are analysed with reference to the defect categories, and compared to a table of defect limits and associated response codes which are also dependent on rated track speed. The response codes define the appropriate response required to control any risk to railway operational safety (Table 3).
Table 3: Definition of response codes

<table>
<thead>
<tr>
<th>Response category</th>
<th>Inspect</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (Emergency)</td>
<td>Prior to next train</td>
<td>Stop trains, carry out repairs, see note [2]</td>
</tr>
<tr>
<td>U1 (Urgent Class 1)</td>
<td>within 12 hrs</td>
<td>Reinspect within 24 hrs, See Note [1]</td>
</tr>
<tr>
<td>U2 (Urgent Class 2)</td>
<td>within 48 hrs</td>
<td>Reinspect within 7 days, See Note [1]</td>
</tr>
<tr>
<td>P1 (Priority Class 1)</td>
<td>within 7 days</td>
<td>Reinspect within 28 days, See Note [1]</td>
</tr>
<tr>
<td>P2 (Priority Class 2)</td>
<td>within 14 days</td>
<td>Inspect by exception on regular patrols</td>
</tr>
</tbody>
</table>

Note [1] - Repair the defect or apply an appropriate TSR\(^7\). If a TSR is applied, reinspect within the defined period, assess rate of deterioration and continue to reinspect defect until repaired.

Note [2] - Trains can pass over the defect when under the control of a pilot.

Manual measurement and assessment is usually conducted without any loading on the rails, while assessment under loaded conditions is usually achieved using the track geometry car\(^8\). In this case, the track geometry at the derailment site was examined and assessed against the ARTC CoP under both loaded and unloaded conditions. Note that while train 5WX2 may have been limited to 80 km/h, the rated track speed for freight trains over this section of track was 115 km/h.

### 2.3.1 Track geometry assessment – Unloaded condition

The most regular form of track inspection is conducted by scheduled track patrols (refer to Section 2.6, Track inspection and assessment). If geometry measurements are taken, they are generally taken without any loading on the rails. The following information examines the track geometry at the derailment site in the unloaded condition (that is, no train on the track), as would be expected during a scheduled track patrol.

**Vertical Alignment**

Vertical alignment, commonly referred to as ‘top’, is the difference in rail level over a defined distance. Manual measurement and analysis of vertical alignment is achieved using two criteria. ‘Long top’ is measured at the mid-ordinate offset of a 20 m chord. ‘Short top’ is measured at the mid-ordinate offset of a 4 m chord.

- The two larger dips in the left rail (direction of travel), located about 10 m and 36 m before the POD, measured 26 mm and 20.5 mm respectively for long top. Short top for the same dips measured 5 mm and 4.8 mm.
- The hump between the two dips, located about 26 m before the POD, measured 18.5 mm for long top and 4.5 mm for short top.

When assessed against the CoP, these measurements are all below the documented defect limits and associated response codes.

---

\(^7\) TSR – Temporary Speed Restriction.

\(^8\) The track geometry car is a rail vehicle with electronic recording equipment.
**Cross level variation**

The cross level measurement (cant) is the difference in level of the two rails at a single point along the track. The cross level variation is the difference between this measurement and the design cant.

The track at the derailment site was tangent track where the design cant was zero. Survey measurements show that the maximum variation from zero cant was 38 mm at a point 10 m before the POD. When assessed against the CoP, this geometry defect equates to a response code of P2 for all track speeds.

**Twist**

Twist is the variation in actual track cross level over a defined distance. Two distances are defined in the CoP, 14 m for long twist and 2 m for short twist. Survey measurements show that the maximum long twist measurement was 32 mm about 11 m before the POD, while short twist was measured as 10 mm about 5 m before the POD.

When assessed against the CoP, the long twist measurement equates to a response code of P1 for freight train track speeds up to 115 km/h and would be below the minimum response code if track speed had been 80 km/h. The short twist measurement is below the documented defect limits and associated response code for all speeds.

**Horizontal alignment**

Horizontal alignment refers to the difference in lateral rail alignment over a defined distance. Manual measurement and analysis of horizontal alignment is achieved using the mid-ordinate offset of a 10 m chord.

In this case, manual measurement was not conducted since visual observation indicated minimum horizontal deflection of the rail.

**Gauge**

Track gauge is measured between the inside face (gauge face) of each rail. Survey measurements show track gauge as wide (greater than design gauge) with a maximum recorded wide gauge of 17 mm measured about 11 m before the POD. When assessed against the CoP, this measurement is below the documented defect limits and associated response codes.

### 2.3.2 Track geometry assessment – Loaded condition

When taking rail deflection due to load into account, the measurements for vertical alignment increased to 29.5 mm for long top and 7 mm for short top. Those measurements remain below the defect limits and associated response codes documented in the CoP. However, changes to cross level variation and twist resulted in higher level response codes when assessed against the CoP:

- Cross level variation increased to 43 mm when rail deflection due to load was considered, equating to a response code of P1 for all track speeds.
- Twist, increased to 41 mm for long twist and 16 mm for short twist. When assessed against the CoP, the long twist measurement equates to a response code
of U1 for freight train track speeds up to 115 km/h, reducing to P1 if track speed had been 80 km/h. Short twist equates to a response code of U2 for freight train track speeds up to 115 km/h, reducing to P2 if track speed had been 80 km/h.

It should be noted that the opportunity to measure the track’s deflection under load was taken to assist the understanding of factors that may have contributed to this derailment. It is not normal practice to conduct these measurements as part of the scheduled inspection and assessment process. Inspection under loaded conditions is usually achieved using the track geometry car. In this case, the track geometry car (operated about 5 weeks before the derailment) did not detect any cross level or twist defects in this area (refer to Section 2.6, Track inspection and assessment).

2.3.3 Combinations of track geometry defects

Track geometry defects are generally assessed against the ARTC CoP as single isolated defects or irregularities. Some defects are normally expected to occur together, such as vertical alignment and twist defects. In such cases, the CoP states that ‘... the most stringent response criterion of the two should be selected’. If more unusual combinations occur, the CoP states that ‘... A more stringent response than that specified for rectifying the defects individually should be considered’. However, the CoP does not provide any guidance on how to evaluate these defects as a combination.

The multiple irregularities found at the Winton derailment site were not unusual combinations, but existed in the form of repetitive irregularities over distance. Under the CoP, this type of multiple irregularities only requires an increased response if the individual defects require an ‘urgent’ response. The CoP states:

Combination of faults at U1 or U2 levels - if faults occur within 20 m of each other, apply TSR at appropriate lower speed band and inspect within 24 hrs. Then reinspect every 24 hrs until repaired.

Figure 9 shows the track geometry car graph for the 500 m leading up to the POD and compares this with a site located 3 km away. While it was evident that the track suffered from repetitive twist and cross level irregularities, examination of the survey measurements for the 100 m leading up to the derailment point indicated that only one irregularity (assessed under loaded conditions) equated to an ‘urgent’ response (U1 or U2).

---

9 Data recorded by the track geometry car on 25 June 2008, about 5 weeks before the derailment of train 5WX2.
2.3.4 Summary of track geometry

Track assessment based on the surveyed measurements showed some irregularities in track geometry. Only cross level and twist measurements equated to defects that would have required a maintenance response. However, assessment in the context of track maintenance is based on the rated track speed. In the context of determining factors that contributed to this derailment, the speed of train 5WX2 should be taken into consideration.

In this case, train speed was 80 km/h. With no rail deflection due to load taken into account, the highest relevant response code was P2 (cross level), which would require continued inspection by regular patrols to detect any deterioration in track condition. If rail deflection due to load is taken into account, the highest relevant response code increases to P1 (twist), which would require inspection within 7 days and continued monitoring to detect any deterioration in track condition.

The track irregularities did not occur as unusual combinations, but existed in the form of repetitive irregularities over distance. Assessment against the CoP found that only one irregularity (assessed under loaded conditions) required an ‘urgent’ response (U1 or U2). Consequently, the CoP did not require the multiple irregularities to be assessed as a combination of defects.

2.4 Vehicle dynamic analysis

While the investigation found some irregularities in relation to both track and rolling stock, assessment against the relevant standards found that the irregularities were either not prohibited or did not exceed the intervention limits that would require urgent attention for trains travelling at 80 km/h. However, wagon RCPF-31882C still derailed soon after it traversed the series of dips in the left rail.

To assist in identifying the mechanism for the derailment, the ATSB engaged experts in computer simulation to model and analyse the dynamic response of the RCPF class wagons to the track defect found at Winton.
The Vampire\textsuperscript{10} software package was used to assist in calculating the predicted dynamics of train 5WX2 travelling over the POD. Vampire is one of the world’s leading rail vehicle simulation packages. As with most computer-based simulations, there is a level of assumption within both the software and the data used. Consequently, the results should only be used in conjunction with other analysis to draw appropriate conclusions.

**Rolling stock model**

Two rolling stock models were developed within Vampire, each based on a loaded RCPF class freight wagon.

- Model 1 was an ‘as-derailed’ model – This model replicated the different bogie configurations with as-measured wheel profiles.
- Model 2 was a symmetrical model – This model incorporated identical ASF Ride control bogies at each end of the wagon.

**Track model**

About 100 m of track, immediately before the POD, was surveyed by the ARTC and Downer EDI Works. In addition, track deflection under load was measured for about 20 m before the POD. The track model was derived from this data giving vertical, cross-level and gauge geometry measurements. Lateral alignment was not measured and was assumed to be straight track. There were three dips in the left rail leading up to the POD (Figure 8). A sharp dip illustrated in the right rail, approximately 32 m before the POD, was likely to be a measurement error and was omitted from the track model.

A 200 m ‘lead-in’ was added to the surveyed track in order to provide a gradual transition from smooth track to the measured track. Since the rail profiles were not measured, the unworn, tangent track rail profile documented in the ARTC Track and Civil Code of Practice (CoP) was used (Rail grind profile RTG2000).

### 2.4.1 Simulation results

Initial simulation was conducted and the results analysed. Based on those results, further simulation was conducted to examine the relationship between various factors and the wagon’s dynamic behaviour.

**Initial simulation**

The initial simulation was conducted using rolling stock Model 1 and simulated travelling over the track model at speeds of 75, 80, 81 and 85 km/h. The results indicated that the series of three dips in the left rail caused the vehicle body to increasingly roll on its centreplate. At the second dip, the vehicle rolled sufficiently to contact the left side-bearer. It then rebounded to contact the right side-bearer before rolling back to the left side-bearer at the third dip with sufficient impact force to cause the centreplate to momentarily lift. The high load on the left side-

\textsuperscript{10} ‘Vampire’ is a rail vehicle dynamics simulation package allowing the modelling of a virtual rail vehicle traversing measured track geometry.
bearer of the lead bogie corresponded to unloading of both right wheels close to the POD.

A maximum wheel unloading of about 80% was predicted at a speed of 75 km/h. Wheel unloading at the recorded train speed of 81 km/h was about 70%. At each speed, the lateral position of the wheel-set was such that the right wheel was not in flange contact with the right rail. Consequently, the L/V ratio\(^{11}\) at the leading right wheel was negligible, suggesting that flange-climb was unlikely. However, the wheel-set lateral displacement was observed to become ‘lively’ when the wagon passed from the 200 m track lead-in and entered the section derived from the measured track geometry.

**Dynamic stability simulation**

Simulation was conducted to examine the relationship between dynamic stability and wheel profile. The simulations were conducted for vehicle speeds, at 10 km/h increments, between 50 km/h and 90 km/h.

The track model was straight and level, except for a small lateral kink\(^{12}\) inserted 5 m into the 200 m lead-in track. The kink forced the wheel-sets to deflect laterally and oscillate relative to the rails. While the oscillations for a dynamically stable vehicle should decrease rapidly, for an unstable vehicle the oscillations would be expected to continue (in extreme cases, the behaviour is commonly referred to as hunting).

Table 4 illustrates the rolling stock configurations used for dynamic stability simulation. Those configurations consisted of four variations of Model 2 and the as-derailed vehicle (Model 1).

---

\(^{11}\) Safety against flange-climbing derailment is assessed by calculation of the ratio L/V where:

- L is the lateral force of a wheel on the rail
- V is the vertical load of that wheel on the rail.

Generally, an L/V ratio of 1.2 or more indicates that a flange-climb derailment is likely.

\(^{12}\) The small lateral kink was a bend in the track at an angle of 10 milli-radians (about 0.5 degrees). The bend is equivalent to the initial change in direction when passing over the point of a blade at a turnout (that is, without the continuing curve of a turnout).
Table 4: Rolling stock models for dynamic stability simulation

<table>
<thead>
<tr>
<th>Rolling stock model</th>
<th>Model configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 2.1</td>
<td>Model 2 with - new ANZR-1 wheel profiles on front and rear bogies</td>
</tr>
<tr>
<td>Model 2.2</td>
<td>Model 2 with - new WPR-2000 wheel profiles on front and rear bogies</td>
</tr>
<tr>
<td>Model 2.3</td>
<td>Model 2 with - new ANZR-1 wheel profiles on the front bogie, and new WPR-2000 wheel profiles on the rear bogie</td>
</tr>
<tr>
<td>Model 2.4</td>
<td>Model 2 with - as measured wheel profiles on front and rear bogies</td>
</tr>
<tr>
<td>Model 1</td>
<td>As-derailed with different bogie configurations and as-measured wheel profiles</td>
</tr>
</tbody>
</table>

Simulation results showed that the wheel-sets stabilise quickly for Model 2.1 at speeds up to 70 km/h. At 80 km/h, the wheel-sets took longer to decrease oscillation, indicating that the vehicle was heading towards instability at the higher speed. At 90 km/h, the wheel-sets continued to oscillate at maximum amplitude. The maximum amplitude of oscillation was about ±10 mm.

Oscillation of wheel-sets on Model 2.2 also decreased quickly at the lower speeds of 50 and 60 km/h. However, on this model, the wheel-sets continued to oscillate at maximum amplitude when travelling at speeds of 70 and 80 km/h. At 90 km/h, stability improved slightly, but still took some time to decrease oscillation. Again, the maximum amplitude of oscillation was about ±10 mm.

The wheel-sets stabilised quickly for Model 2.3 at all speeds up to 90 km/h. The improvement in stability appeared to be due to the bogies influencing each other through the rigid wagon body. The simulation results for Model 2.4 clearly showed the leading bogie heading towards instability at each test speed above 50 km/h. Compared to previous simulations, the maximum amplitude of oscillation for the leading bogie increased to about ±15 mm. The rear bogie in this simulation demonstrated similar behaviour, albeit at a reduced amplitude (about ±10 mm). This suggested that the instability was driven by the leading bogie.

Simulation of the as-derailed configuration (Model 1) showed the leading bogie heading towards instability at 60, 70 and 80 km/h. While the wheel-sets were more stable at 50 and 90 km/h, the oscillations did take some time to decrease in magnitude. Again, the maximum amplitude of oscillation was about ±15 mm. As for Model 2.4, the rear bogie demonstrated similar behaviour at reduced amplitude, suggesting that the instability was driven by the lead bogie.

**Unstable wagon dynamics over measured track geometry**

The lateral kink was relocated to a point about 100 m into the lead-in section. The unstable behaviour of the vehicle was then examined as it travelled over the track model section derived from measured data.

The first stage of simulation was to determine two behavioural relationships. Firstly, examine how track geometry may provide additional influence to wheel-set lateral displacement (initially caused by vehicle instability). Secondly, examine how vehicle instability may provide additional influence to wheel unloading (initially
caused by track geometry). This was achieved by examining the simulation results at the POD as the position of the lateral kink was shifted in 2 m increments, effectively phase shifting the frequency of oscillations. Simulation showed that the behaviour of the wagon body (roll and yaw) was dominated by track geometry. That is, irrespective of the lateral kink position, maximum body roll and body yaw results were in phase\textsuperscript{13} at the POD. Conversely, wheel-set lateral position appeared to be unaffected by track geometry with the position of maximum displacement being dependent on the position of the lateral kink.

Additional simulation was conducted to examine the likelihood of a flange-climb derailment when maximum lateral wheel-set displacement and maximum wheel unloading were in-phase. Several positions of the kink were used in order to alter the lateral position of the leading wheel-set close to the POD. Results show that the L/V ratio at the leading right wheel was between 1.2 and 1.4 depending on the position of the lateral kink. An L/V ratio greater than 1.2 predicts that a flange-climb derailment is likely. The high L/V ratio was due to the combination of lateral wheel-rail force at the right rail due to the oscillating wheel-set and the high degree of unloading of the leading right wheel at the POD due to the track irregularity at the derailment site.

**Effect of vehicle configuration**

The configuration of wagon RCPF-31882C was such that each end of the wagon was fitted with different bogies, suspension springs and wheel profiles. Analysis was conducted to assess how these differences affected the wagon’s dynamic behaviour as it travelled over the track model section derived from measured data.

Simulation found that wheel unloading was largely unaffected by different combinations of wheel profile, bogie type and suspension springs. Simulation also found that the L/V ratio was generally unaffected by different combinations of bogie type and suspension springs. However, changes in wheel profile did influence wheel-set oscillation and flange contact with the rail which, when in-phase with wheel unloading, resulted in high L/V ratios.

**Effect of rail profile**

The interface between wheel and rail can also influence the dynamic stability of a rail vehicle. Unfortunately, the ideal interaction between wheel profile and rail profile cannot always be achieved, due (in part) to wear of both wheel and/or rail.

In this case, rail profile was not measured and an unworn profile was used for simulation. Consequently, an exact cause of any wagon instability due to wheel rail interaction could not be determined. However, early simulations using a ‘new’ unground rail profile\textsuperscript{14} showed similar behaviour to the later simulations using the preferred profile for tangent track (specified in the ARTC CoP). While not

\textsuperscript{13} Movement of the wagon body (in roll and yaw) was found to behave in a sinusoidal fashion. The term ‘in phase’ refers to the two elements registering their maximum (and minimum) values at the same time.

\textsuperscript{14} New rail is manufactured to a specific cross-sectional profile, but this profile is not the preferred profile for rail operations. Consequently, when installed on-site, and periodically thereafter, rail grinding is conducted to ensure the appropriate rail profile is maintained for that installation.
conclusive, this would indicate that the behaviour of the wagon was not greatly dependent on rail profile.

**Effect of track configuration**

On-site observations noted that vertical and cross level irregularities existed in the track for some distance before the surveyed section. This raised the possibility that the wagon could have exhibited some level of initial dynamics such as body roll and yaw, which may have increased (or decreased) the amount of wheel unloading at the POD. Similarly, the track model assumed straight track since the survey did not measure lateral track position. This raised the possibility that any existing lateral track irregularities may have initiated vehicle instability before the POD.

Additional track data was derived from the track geometry car measurements, taken about 5 weeks before the derailment. Adding the cross level and lateral alignment data to the track model had almost no effect when compared to the original simulation results. This suggested that wheel unloading at the POD was primarily caused by the track geometry within 100 m of the POD and not the track irregularities that existed well before the derailment site.

While it was reasonably clear that vertical track geometry contributed to wheel unloading, it could not be determined what track feature may have initiated wheel-set oscillation. It was possible that the wheel-sets had been oscillating to some degree well before approaching the derailment site. Alternatively, it was possible that a small lateral irregularity near the POD could have initiated sufficient lateral oscillation such that the wheel-set came into flange contact at the POD.

Measurement of lateral geometry was not conducted since visual observation indicated minimal horizontal deflection of the rail. Examination of the track geometry car measurements also showed only small lateral deflections, well below the intervention limits specified in the ARTC CoP. However, considering that simulation implied that a minor deflection could initiate sufficient lateral oscillation, a closer examination of video and photographic evidence was conducted.

Figure 10 illustrates a slight lateral kink (right rail in direction of travel), estimated to be about 10-20 m before the POD. There did not appear to be a corresponding kink in the left rail. Angle and magnification of this image exaggerates the size of the rail deflection, but analysis indicated that the irregularity was unlikely to have exceeded documented defect limits. However, simulation indicated that a rail deflection such as this may have been sufficient to have initiated wheel-set oscillations.
Effect of wagon speed

Simulation showed that wheel-set oscillation could occur at different wagon speeds, depending on what wheel profiles were used. Oscillation could begin and grow worse as the wagon speed increased. For other wheel profiles, oscillation could occur at intermediate speeds and then recover as wagon speed increased.

The relationship between wagon speed and wheel unloading was more predictable. The simulation results showed that, for Model 2 (symmetrical wagon model), the amount of dynamic wheel unloading peaked at about 80 km/h when travelling over the measured track geometry. If the wagon speed was reduced to 60 km/h, the amount of dynamic wheel unloading reduced by almost 50% (Figure 11).
2.4.1 Summary of dynamic analysis

Simulation found that track irregularities caused the wagon body to roll with sufficient force to unload both right wheels on the leading bogie when close to the point of derailment. Simulation also showed that the wheel-sets under wagon RCPF-31882C were susceptible to lateral oscillation at some track speeds. The lateral oscillations were independent of the wagon body roll and could have brought the right wheels into flange contact at the point of derailment. When combined, the lateral wheel-rail force at the right rail due to wheel-set oscillation and the high degree of unloading of the leading right wheel due to body roll, increased the likelihood of a flange-climb derailment.

Train 5WX2 was travelling at about 80 km/h. Simulation found that wheel unloading peaked at about this speed when travelling over the measured track geometry and reduced rapidly if speed was increased or decreased. This implied that the behaviour was harmonic in nature and dependent on the spacing of track dips, along with wagon type, wagon load and train speed.

The cause of wheel-set lateral oscillation was less clear. While the behaviour was influenced by changes in wheel profile, it still required some form of external influence to initiate the behaviour. It is possible that the wheel-sets may have been oscillating to some degree well before approaching the derailment site. Alternatively, it is possible that a small lateral irregularity near the point of derailment may have initiated the lateral oscillation of the wheel-sets.

Both elements of wheel unloading and wheel-set oscillation were found to be largely unaffected by different combinations of bogie type and suspension springs.
2.5 Dynamic behaviour of rolling stock

Examination of wagon RCPF-31882C and assessment against the relevant operation and maintenance standards (Section 2.2) was conducted with the wagon in a static condition. However, computer simulation concluded that the dynamic behaviour of the rolling stock, travelling over a series of track irregularities, contributed to the derailment. Consequently, it is pertinent to examine wagon RCPF-31882C in relation to its dynamic performance.

Dynamic behaviour is usually assessed during a series of physical tests as part of the design and construction of rolling stock. The standards relevant to the dynamic behaviour of rolling stock are:

- ROA Manual, Section 3 – Road Worthiness Acceptance Standards for Rail Freight Vehicles
- RISSB standard, AS7509 – Dynamic Behaviour – Freight (draft at time of derailment)

With respect to dynamic behaviour, the ROA Manual specifies a twist test and a pitch and bounce test. The twist test evaluates a wagon’s ability to accommodate track twist (such as transitions at curves) without unacceptable reductions in the wheel load. The pitch and bounce test examines a wagon’s ability to safely negotiate a series of irregularities in each rail that are in phase\(^\text{15}\).

The RISSB standard (AS7509) includes additional tests, some of which evaluate a wagon’s ability to negotiate cyclic track irregularities. Included, is a test for harmonic roll which is similar to that for pitch and bounce, but uses a series of track irregularities that are ‘out-of-phase’. The harmonic roll test is used to excite a resonant response at a critical speed and evaluate the wagon’s ability to negotiate the track without unacceptable reductions in the wheel load.

The documented tests are intended to examine the dynamic behaviour of new or substantially modified rolling stock before they are put into service. While it is expected that test results are recorded for all classes of rolling stock, in practice, test results are not always available, as was the case for the RCPF class wagon. Since test results were not available, the simulated behaviour of the wagon travelling over the track geometry measured at the derailment site was compared to the acceptance criteria from the standards. The intent of this comparison was not to verify compliance or non-compliance, but to build an understanding of the RCPF class wagon’s dynamic behaviour with reference to documented acceptable behaviour.

The RCPF class wagon model was simulated passing over the measured track geometry model at various speeds. A simulation at very low speed was used to examine if the track geometry at the derailment location was likely to have induced excessive twist on the RCPF class wagon. A series of simulations, conducted at speeds up to 90 km/h\(^\text{16}\), were conducted to examine the wagon’s behaviour with respect to cyclic track irregularities. Table 5 illustrates the simulation results and compares them with the acceptance criteria for the tests documented in the standards.

\(^{15}\) A series of irregularities in each rail that are ‘in phase’ means that the dips and bumps in the left rail coincide with the dips and bumps in the right rail. Conversely, the term ‘out-of-phase’ means that a dip in the left rail coincides with a bump in the right rail (and vice versa).

\(^{16}\) Note that the rated speed for the RCPF class wagon was 80 km/h.
Table 5: Dynamic behaviour - RCPF class wagon

<table>
<thead>
<tr>
<th>Test type</th>
<th>Acceptance criteria</th>
<th>Simulated results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twist</td>
<td>wheel unloading &lt; 60%</td>
<td>&lt; 15%</td>
</tr>
<tr>
<td>Pitch and bounce</td>
<td>wheel unloading &lt; 90% at any speed up to 110% of design speed</td>
<td>Not simulated</td>
</tr>
<tr>
<td>harmonic roll</td>
<td>wheel unloading &lt; 90% at any speed up to 110% of design speed</td>
<td>&lt; 80%</td>
</tr>
</tbody>
</table>

Note: In this case, pitch and bounce was not a relevant test since the track geometry did not exhibit irregularities that were in phase.

Simulation found that the RCPF class wagon did not exceed the acceptance criteria of the standards when traversing the measured track irregularities. While the outcome cannot be used to verify compliance against the standard, it does indicate that wheel unloading was likely to have approached the specified limits for harmonic roll when traversing the track geometry at the derailment site. This would imply that the RCPF class wagon may exhibit unacceptable wheel unloading when a resonant response is induced under some track and speed conditions.

2.5.1 Controlling harmonic behaviour

A rail vehicle (simplified view) is a mechanical system of mass and springs, which will vibrate (or resonate) at a natural frequency (harmonic frequency) when excited by an external force. For example, if a force is applied that causes the wagon body to roll, the springs on one side of the bogie will compress. The energy stored in the springs will then feed back into the wagon body to propel it back to compress the springs on the opposite side of the bogie. This behaviour will continue at a constant frequency and amplitude unless an additional force or damping is applied. If damping is applied without any addition excitation, the resonant response will decrease in amplitude until the system stabilises. However, if additional force is applied in phase with the resonant frequency, the amplitude of oscillations can increase rapidly and significant wheel unloading may occur.

A number of factors determine the harmonic behaviour of rail vehicles:

- Wagon dimensions – a short rigid wagon will generally be more susceptible to undesirable harmonics caused by track irregularities, compared to a longer more flexible wagon.
- Spring characteristics – while spring rates will affect the harmonic frequency, their selection is more dependent on the load carrying requirements of the wagon.
- Damping characteristics – if oscillation starts, damping is required to decrease the amplitude of oscillation until the wagon stabilises.
- Side bearer clearance – excessive side bearer gap will permit a wagon body to roll (almost unrestrained) on its centre plate until it rests on the side bearers, increasing the energy compressed into the springs.
- Load – Total mass borne by the springs will affect the harmonic frequency.
- Centre of gravity – A higher centre of gravity will not only affect the period of oscillation, but will also increase the energy compressed into the springs.
Control over some of these factors is limited. For example, wagon dimensions are fixed, while load and centre of gravity are dependent on the wagon’s purpose (in this case, carrying coiled steel). However, the condition of springs, dampers and side bearers are items that may be subject to appropriate maintenance.

The side bearer gaps on wagon RCPF-31882C were found to be within the limits specified in the ROA Manual. The suspension springs were not broken, damaged or missing, but the trailing bogie showed evidence of the springs becoming fully compressed (solid) which indicated that the wagon had experienced high degrees of body roll. The trailing bogie was also found to have loose and broken wedge wear plates (Figure 12) which would significantly reduce the damping performance of that bogie.

It could not be verified if the wedge wear plates broke free before or during the derailment sequence. If the condition existed prior to the derailment, it is likely that body roll induced while traversing a series of track irregularities could result in undamped harmonic oscillations.

Figure 12: Wedge wear plates – Trailing bogie (Left & Right)

2.6 Track inspection and assessment

Track inspection and assessment is a critical part of the infrastructure maintenance process aimed at managing undesirable track geometry. In this case, simulation found that the track geometry contributed to the derailment of train 5WX2 even though the irregularities did not appear to exceed the intervention limits that would require urgent attention for trains travelling at 80 km/h. Consequently, the inspection and assessment process was examined to identify possible limitations that may have permitted undesirable track conditions to develop without identifying the potential risk to rail operations.
The inspection process consists of two complementary inspection types:

- scheduled inspections; and
- unscheduled inspections.

Scheduled inspections are usually performed by track patrols (at intervals not exceeding 7 calendar days), the track geometry car (at intervals not exceeding 4 months) and ‘front-of-train inspections’ (at intervals not exceeding 6 months).

Unscheduled inspections usually occur in response to defined events such as extreme weather conditions that are known to increase the risk of geometry defects. However, unscheduled inspections can also be initiated through third-party reporting such as train driver reports. This is recognised in the ARTC CoP which states:

Problems or defects identified by drivers at any time should be documented as suspected defects and acted upon accordingly.

2.6.1 Assessment of track geometry defects

Identification of track defects is usually achieved by way of track patrol or track geometry car inspections. Defects are recorded and actioned in accordance with acceptance criteria documented in the ARTC CoP.

**Track patrol**

A track patrol inspection was conducted using a road/rail vehicle on 30 July 2008, the day before the derailment of train 5WX2. No defect was reported near the point of derailment (205.370 track km point). This result is not consistent with the assessment based on the post-derailment survey result, which found that measurement of twist equated to a response code of P1 for freight train track speeds up to 115 km/h. However, track inspections are usually visual and detailed measurements are not generally taken, nor are they mandatory under the ARTC CoP. Irrespective of the result, a P1 response would require inspection within 7 days and continued monitoring to detect any deterioration in track condition. It could be argued that this requirement would be met by the scheduled track inspections.

Records indicate that about 11 track patrol inspections are conducted per month. An examination of maintenance records showed the last defect recorded by a track patrol near the point of derailment was on 6 March 2008. The defect was identified as a track twist at the 205.370 track km point (same location as the point of derailment) and was repaired on 7 April 2008.

**Track Geometry Car**

An inspection was carried out by the track geometry car on 25 June 2008, about 5 weeks before the derailment of train 5WX2. Only one defect was reported near the POD. The defect was identified as wide gauge, but was at the 205.348 track km point, about 22 m past the point where train 5WX2 derailed. This result is not consistent with the assessment based on the post-derailment survey result (including rail deflection due to train load), which found that measurement of twist equated to a response code of U1 for freight train track speeds up to 115 km/h. However, no consideration has been made regarding the tolerance of the survey measurements, plus, it is possible that the track may have deteriorated during the 5-
week period between the inspection and the derailment.

**Summary**

The ARTC CoP defines specific actions to be taken depending on the type and magnitude of defect. However, if a track irregularity does not fall within the defined range (that is, it is not categorised as a defect), the location is generally not identified for any specific maintenance action.

### 2.6.2 Assessment of track geometry quality

The quality of the track condition is quantified using a ‘Track quality index’ (TQI) calculated over 100 m sections of track. The TQI for each 100 m section of track is derived from the statistical analysis of track geometry car data. The analysis applies a ‘three-standard-deviation’ calculation on vertical alignment, horizontal alignment, twist and gauge, to provide an indication of track condition over that section. TQI values are then averaged to give a TQI for larger sections of track or a rail corridor. The TQI is not used for reactive maintenance; this is driven by the flagging of track geometry car data which exceeds the defect limits documented in the CoP. However, TQI data does allow for longer term trend analysis and assists with strategic programming of track improvement works on the rail corridor.

For the track geometry car inspection carried out on 25 June 2008, the highest TQI figure near the derailment point was 40.2, compared to a corridor average of 28.3 (ARTC’s target ‘corridor average’ TQI for 2007/08 was 29.9). While this would imply that the track condition near the derailment location was below the average for this corridor, other locations exhibited poorer condition and would therefore attract more attention for strategic planning.

It should also be noted that an overall improvement in track condition was evident for this rail corridor over the previous 12 months and the average TQI figure was at its lowest since February 2005 (data before this date was not provided). This would indicate that the ARTC had actively targeted and improved priority areas of poor track condition. However, in the context of this derailment, it is unlikely that analysis of TQI data alone would have identified the derailment location as a priority area at risk of contributing to undesirable harmonic behaviour in some rolling stock.

### 2.6.3 Assessment of ride quality

Ride quality is assessed by experiencing the ride performance while travelling in the cab of a locomotive. Ride quality is generally assessed by conducting scheduled front-of-train inspections, but reports from train drivers can also provide an indication of ride quality.

**Front-of-train inspection**

Front-of-train inspections were carried out on 30 April 2008 and 24 July 2008 (1

---

17 Standard deviation is a statistical calculation that indicates how tightly a selection of data points is clustered around the average for that data.

18 A high TQI figure implies poor track condition.
week before derailment). Six ‘priority rough ride’ locations, between Melbourne and the Vic/NSW border, were identified during each inspection. One location, recorded as between 205.600 km and 206.400 km, and identified on 24 July 2008, was near the point where train 5WX2 derailed 7 days later (205.370 km).

**Train driver reports**

In the 2 months preceding the derailment of train 5WX2, at least seven train driver reports were recorded by train control, identifying potential track geometry defects between the 205.000 and 206.000 track km points. Three of these reports occurred within 14 days of the derailment. Inspections were carried out and records indicate that track irregularities and ‘soft ground’ were identified in the area. However, apart from some minor repair work on two occasions, the recorded response was for the ‘section of track to be tamped as part of normal program when tamper in the section’.

Each of the train driver reports were made by drivers of XPT passenger services, while the front-of-train inspection was conducted from the cab of a freight locomotive. It should also be noted that the driver of freight train 5WX2 had experienced an ‘unsettled’ ride when operating a previous train at 110 km/h, though he did not report the issue at the time.

**Summary**

In most cases, when rough riding has been reported, an unscheduled inspection would be conducted to assess the location against documented defect limits. This inspection would generally be conducted by a qualified worker walking the track in the area or possibly in a hi-rail vehicle. If rough riding is detected as part of a front-of-train inspection, the inspecting worker may, if deemed necessary, contact train control and impose a speed restriction.

**2.6.4 Track geometry and undesirable vehicle harmonics**

Analysis indicated that the wagon behaviour, as it traversed a series of track irregularities, was most likely to have been harmonic in nature. There appeared to be no defined criteria in the ARTC CoP that considered the possibility that a series of track irregularities, even minor ones which do not exceed intervention limits, could cause a harmonic response in some rail vehicles. Considering each of the inspection and assessment processes, only assessment of ride quality appeared to identify possible issues (rough riding) in the area where train 5WX2 subsequently derailed.

When considering train driver reports, it was evident that not every train experienced ride quality that was rough enough to prompt the driver to report the issue to train control. Similarly, the vehicles involved were of differing type, weight and speed. For example, the lead locomotive of train 5WX2 was about 22 m long and weighed about 132 t. The driver reported that the ride was normal travelling at 80 km/h, while analysis showed that a wagon within that train (RCPF-31882C at about 10 m long and 69 t) had become unstable at 80 km/h. When driving a similar locomotive at about 110 km/h, the same driver noted an ‘unsettled’ ride. The experience on the XPT is likely to be different again, since the XPT power car is about 17 m long, weighs about 76 t and can travel at up to 160km/h. The front-o-
train inspection that reported rough riding was carried out while travelling in the
cab of a freight train locomotive.

Those differences in reported ride quality provide a level of support to the theory
that the deficiencies in ride quality were a result of the harmonic behaviour in some
rolling stock. A characteristic of harmonic behaviour is that vehicles travelling over
the same track irregularities could behave differently depending on speed, weight
and vehicle configuration. However, it would appear that the actions taken as a
result of the reported ride quality deficiencies did not take into account the possible
harmonic behaviour of different rail vehicles.

Figure 13 illustrates an exaggerated view (due to angle and magnification of the
photograph) of repetitive track geometry irregularities leading up to the derailment
site. The track geometry was not surveyed in this area following the derailment, but
similar to the surveyed area, it is possible that these irregularities did not exceed the
defect limits documented in the CoP. It is possible that different rolling stock may
become unsettled at different speeds when travelling over track irregularities such
as these. It is also likely that the track irregularities in this area were the subject of
some ‘rough riding’ reports and were subsequently assessed as part of unscheduled
inspections.

Figure 13: Track geometry defects (looking back from the derailment site)

Note: The angle and magnification of the photograph provides an exaggerated view of the
track geometry defects

There is no requirement in the ARTC CoP for an inspector, conducting an
unscheduled inspection as a result of reported rough riding, to experience or
observe the behaviour of rail vehicles travelling through the identified location.
Consequently, it is unlikely that this method of inspection could adequately assess
the location with respect to induced harmonic behaviour in locomotives or other
railway rolling stock.

For front-of-train inspections, the ARTC CoP notes that some locomotives may
exhibit better ride quality than others, but it only does so with reference to the
inspector’s knowledge and expectation that existing track defects may induce poor
ride quality. The CoP makes no mention about the possibility for undesirable
harmonic behaviour to develop in some rail vehicles. Consequently, it is unlikely
that the inspector would impose a speed restriction unless the ride was particularly
severe during the inspection.

Without any guidance to the contrary, it is unlikely that track inspectors (front-of-
train, hi-rail or on-foot) would give consideration to undesirable harmonic
behave and induced in locomotives or other railway rolling stock when assessing a series of minor track irregularities.

2.6.5 **Summary of track inspection and assessment**

In general, the inspection and assessment processes only require maintenance action if the track irregularity falls within defined limits specified in the ARTC CoP. Considering each of the inspection and assessment processes, only assessment of ride quality (front-of-train inspections and driver reports) appeared to identify undesirable conditions (rough riding) in the area where train 5WX2 subsequently derailed. However, the ARTC CoP does not clearly address the possibility that a series of track irregularities, even minor ones which do not exceed intervention limits, could cause an undesirable harmonic response in some rail vehicles. Consequently, the response taken to examine reported rough riding usually resulted in an unscheduled inspection without the requirement for the track inspector to experience, or observe, the behaviour of rail vehicles travelling through the identified location.

Without any guidance to the contrary, it is unlikely that track inspectors (front-of-train, hi-rail or on-foot) would assess a series of ‘minor’ track irregularities with consideration to undesirable harmonic behaviour induced in locomotives or other railway rolling stock.

2.7 **Similarities to other incidents**

The investigation looked at a number of other incidents, some of which had similarities to the derailment of train 5WX2 near Winton on 31 July 2008.

**Benalla - 23 September 2004**

On 23 September 2004, Train 4VM9-V derailed while travelling southwards between Glenrowan and Benalla, Vic. The train consisted of a single locomotive hauling 15 wagons loaded with dry bulk cement, four of which derailed while travelling at about 75 km/h. The wagons were a covered hopper style construction (VPBX class wagon) that have a very rigid body structure and are rated for a maximum speed of 80 km/h.

---

19 ATSB Transport Safety Investigation Report, Rail Occurrence Investigation 2004/005.
Figure 14: VPBX class wagon

The section of track where the derailment occurred was rated for a track speed of 115 km/h. Due to uneven track and a number of pronounced dips, a temporary speed restriction of 80 km/h had been applied. However, since the cement wagons were rated for 80 km/h, there was no requirement to reduce the speed of train 4VM9-V.

The investigation concluded that the combination of wagon stiffness and deteriorated track condition associated with track twist, created conditions where the cement wagon sustained roll-induced wheel unloading and subsequent flange-climb followed by derailment.

Roopena - 22 May 2007

On 22 May 2007, ballast train 3MR2 derailed near Roopena, SA (between Whyalla and Port Augusta)\(^\text{20}\). The train consisted of two locomotives hauling a ballast plough, 35 loaded ballast wagons with a second ballast plough at the rear of the train. Initially, one of the ballast wagons (AHWX class wagon) derailed as it passed over a track irregularity. Track damage caused by the first derailed wagon, subsequently caused the following wagons to derail.

In this case, the track irregularities consisted of a cross-level track geometry defect combined with a horizontal and vertical alignment defect. Assessment of these irregularities as single isolated defects indicated that an 80 km/h speed restriction and action to inspect/repair within 7 days would have been an appropriate action. However, train 3MR2 derailed while only travelling at 79 km/h.

Similar to the cement hopper wagon (Benalla derailment), the AHWX class wagon is a hopper wagon (open top) which is relatively short, rigid, has gap/friction style side bearers and is rated for a maximum speed of 80 km/h. The investigation concluded that the dynamic behaviour of this wagon was influenced by the combination of track geometry defects such that the risk of a flange-climb increased at the point of derailment.

2.7.1 Similarities to derailment of 5WX2

In all three derailments, the wagons involved were relatively short, had very rigid bodies, had a relatively high centre of gravity when loaded, travelled on bogies that incorporated gap style side-bearers and were rated for a maximum speed of 80 km/h. Similarly, each wagon derailed while traversing track irregularities that either did not exceed the intervention limits or had been assessed as suitable for rail traffic travelling at 80 km/h (as per the ARTC CoP).

In each case, investigation found that a series (or combination) of track irregularities caused the wagon body to roll with sufficient force to cause wheel unloading such that the risk of a flange-climb increased at the point of derailment. It was also found that inspection and assessment of the track irregularities was unlikely to have considered the dynamics of poorer riding rolling stock.

The investigation into the derailment at Roopena also examined the wagon dynamics with respect to the type of side bearer. The investigation found that it was possible the gap/friction style side bearers provided less control over body roll than a similar wagon with constant contact side bearers. While not examined for the other incidents, the similarities suggest that the same conclusion may be possible in relation to the other wagon classes.
3 FINDINGS

3.1 Context

At approximately 2030 on 31 July 2008, freight train 5WX2 derailed near Winton, Victoria. Thirteen freight wagons were derailed. There were no injuries.

The investigation determined that it was likely that a number of factors combined to cause the derailment. Any one factor in its own right was unlikely to have resulted in a derailment, but all factors acting together greatly increased the likelihood of the derailment.

From the evidence available, the following findings are made with respect to the derailment of train 5WX2 and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

• A series of track irregularities caused the wagon body to roll with sufficient force to unload both leading right wheels when close to the point of derailment. It is likely that the dynamic behaviour of the wagon was harmonic in nature and dependent on spacing of the irregularities, along with wagon type, wagon load and train speed.

• The wheel-sets under wagon RCPF-31882C were susceptible to lateral oscillation at some track speeds. For a flange-climb derailment to occur, it is likely that the oscillations caused the right wheels of the lead bogie to be in flange contact at the point of derailment.

• The combination of wheel unloading and flange contact at the point of derailment increased the risk of a flange-climb derailment.

• The ARTC Code of Practice does not clearly address the possibility that a series of track irregularities, even minor ones which do not exceed intervention limits, could cause an undesirable harmonic response in some rail vehicles. [Safety issue]

• It is likely that the usual response taken to examine reported rough riding locations resulted in an unscheduled inspection without the requirement for the track inspector to experience, or observe, the behaviour of rail vehicles travelling through the identified location.

• Without any guidance to the contrary, it is unlikely that track inspectors (front-of-train, hi-rail or on-foot) would give consideration to undesirable harmonic behaviour induced in locomotives or other railway rolling stock when assessing a series of ‘minor’ track irregularities.
3.3 Other safety factors

- The trailing bogie of wagon RCPF-31882C was found to have loose and broken wedge wear plates. It could not be verified whether the wedge wear plates had broken free before or during the derailment sequence. However, if the condition had existed prior to the derailment, it is likely that body roll induced while traversing a series of track irregularities could result in undamped harmonic oscillations. [Safety issue]

- Examination of wagon RCPF-31882C revealed a crack on the tread of a wheel on the second axle of the leading bogie. While not contributing to this derailment, if the crack were to develop to such an extent that the wheel tread completely fractured, the risk of derailment would increase significantly. [Safety issue]

3.4 Other key findings

- A series of track irregularities existed in the area leading up to the point of derailment. Assessment against the relevant standards found that the irregularities did not exceed the intervention limits that would require urgent attention for trains travelling at 80 km/h. In each case, the relevant response would be for track inspections to continue with consideration given to detecting any deterioration in track condition.

- Examination of wagon RCPF-31882C found that the bogies at each end of the wagon were of different designs and configuration. However, the standards do not prohibit the configuration and simulation implied that the configuration played no part in the derailment of train 5WX2.

- Excessive flange wear was found on one wheel. However, metallurgical examination concluded the excessive wear was not consistent with normal operation, but was more consistent with lateral contact with the back face of the wheel and abrasive wear of the wheel flange. Those findings were consistent with the site observations showing wheel contact with the wagon body during the derailment sequence.

- An investigation into a previous (similar) derailment found it was possible that gap/friction style side bearers provided less control over body roll than a similar wagon with constant contact side bearers. While not examined in detail for the RCPF class wagon, the similar nature of the derailments suggest that the same conclusion may be possible.
4 SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

4.1 Australian Rail Track Corporation

It is recognised that some safety actions may be best actioned by the track maintenance organisation (Downer EDI Works). However, since the actions of Downer EDI Works are subject to contractual arrangements, recommendations have been directed to the Australian Rail Track Corporation as the contract managers.

4.1.1 ARTC Code of Practice

Safety Issue

The ARTC Code of Practice does not clearly address the possibility that a series of track irregularities, even minor ones which do not exceed intervention limits, could cause an undesirable harmonic response in some rail vehicles.

*ATSB safety recommendation RO-2008-009-SR-029*

The Australian Transport Safety Bureau recommends that the Australian Rail Track Corporation takes safety action to address this safety issue.

4.2 Pacific National

It is recognised that some safety actions may be best actioned by the rolling stock maintenance organisation. However, since the actions of the maintenance provider are subject to contractual arrangements, recommendations have been directed to Pacific National as the contract managers.

4.2.1 Loose and broken wedge wear plates

Safety Issue

The trailing bogie of wagon RCPF-31882C was found to have loose and broken wedge wear plates. It could not be verified whether the wedge wear plates had broken free before or during the derailment sequence. However, if the condition had
existed prior to the derailment, it is likely that body roll induced while traversing a series of track irregularities could result in undamped harmonic oscillations.

**ATSB safety recommendation RO-2008-009-SR-030**

The Australian Transport Safety Bureau recommends that Pacific National takes safety action to address this safety issue.

### 4.2.2 Tread fracture

**Safety Issue**

Examination of wagon RCPF-31882C revealed a crack on the tread of a wheel on the second axle of the leading bogie. While not contributing to this derailment, if the crack were to develop to such an extent that the wheel tread completely fractured, the risk of derailment would increase significantly.

**ATSB safety recommendation RO-2008-009-SR-031**

The Australian Transport Safety Bureau recommends that Pacific National takes safety action to address this safety issue.
Sources of information
Australian Rail Track Corporation
Downer EDI Works
Pacific National

References
ARTC Track and Civil Code of Practice, April 2007
Draft standards under development by the Rail Industry Safety and Standards Board (RISSB):
• AS7509 – Dynamic Behaviour – Freight
• AS7514 – Wheels – Freight

Submissions
Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to:
• Australian Rail Track Corporation
• Interfleet Technology
• Office of the Chief Investigator (Victoria)
• Pacific National
• Victorian Railway Safety Regulator, and
• a small number of individuals.

Submissions were received from the Australian Rail Track Corporation, Pacific National and Interfleet Technology. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.
Derailment of Train 5WX2 near Winton, Victoria

31 July 2008