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Australian Transport Safety Bureau

Derailment of freight train 3MP9

East of Malbooma, South Australia | 10 April 2014

Investigation

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Addendum

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Safety summary

What happened

At about 0011 on 10 April 2014, SCT Logistics train 3MP9 derailed after travelling over track that had been undercut by floodwaters near a culvert at the 535.150 km mark between Tarcoola and Malbooma, South Australia. The floodwaters caused scouring of the track formation, compromising its capacity to support the train.

About 300 metres behind the lead locomotive, the first of 18 wagons derailed including eight that rolled onto their sides.

There were no injuries to the train crew however there was significant damage to the track, rolling stock and freight goods.

Track washaway

Source: ATSB

What the ATSB found

The ATSB determined that runoff from the heavy rain that had fallen in the catchment area adjacent to Malbooma on 9 April 2014 caused a flash flood event. The volume of floodwater exceeded the capacity of a double drainage culvert designed for a 1:50 year average flood recurrence interval. This resulted in water overtopping the track formation with ballast and sub-grade scouring on the south side of the track.

The magnitude of the scouring meant that the track could not support the weight of train 3MP9 as it passed over the affected areas. The resulting deformation in the alignment of the track initiated the derailment.

From a risk control perspective, the ATSB found that the Australian Rail Track Corporation's (ARTC) processes were ineffective in developing and implementing changes to operational procedures from the findings of previous incident investigations. The ARTC did not have a comprehensive system in place to identify and actively manage the risks to their network from severe weather events, and had not established a register for recording 'special locations' for the management of track infrastructure prone to flooding.

There were no anomalies found with the operation of the train or the condition of rolling stock before the derailment.

What's been done as a result

The ARTC has implemented Operational Procedure OPP-01-05 *'Monitoring and Responding to Extreme Weather Events in the East-West Corridor'* and has purchased and installed remote weather monitoring and recording stations at Barton, Cook, Rawlinna and Zanthus. The weather station data will be linked to the Early Warning Network to provide automated alerts. Four water flow monitors have been installed at culverts identified through a hydrology study of the Trans Australia Railway. Field evaluation of this equipment is being undertaken.

Upgrades of the ARTC's electronic asset management system are underway to optimise inspection and maintenance activities, including recording of 'special locations' affected by severe weather events.

Safety message

To ensure that the safety of rail operations is not compromised during severe weather events, it is essential that rail transport operators have robust and responsive systems in place to actively monitor and manage the foreseeable risks.

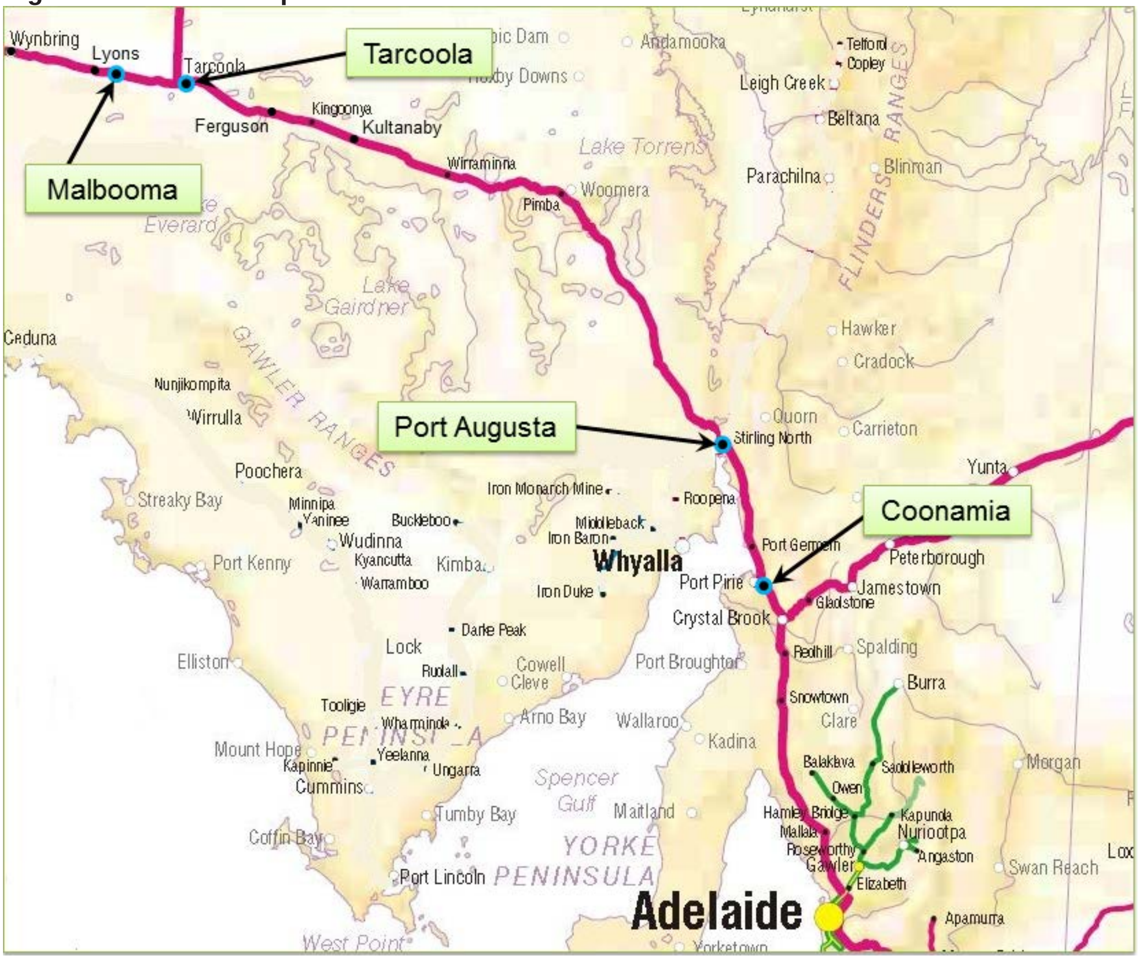
Contents

The occurrence

In early April 2014, a slow moving low-pressure trough generated a broad rain band across the Northern Territory and South Australia. The Bureau of Meteorology (BoM) had forecast heavy rainfall and issued flood warnings for various areas of South Australia, including locations around the Malbooma region.

At about 1742[1] on 9 April, SCT Logistics (SCT) train 3MP9 departed Port Augusta (Figure 1). It was raining on departure and continued to rain as the journey progressed. A crew change occurred at Kultanaby, with the new driving crew taking the train on to Tarcoola as rain continued to fall.

Figure 1: Location map - South Australia



Source: NatMap Railways of Australia annotated by ATSB

At 2350, after train 3MP9 departed Tarcoola, the driver commented 'when we started to head west' there was hardly any rain'. About 28 km later, as the train travelled downhill towards the base of a grade near the 532 km post[2], the crew observed water running swiftly in the cess drain[3] down the south side of the track.

As the train climbed the next grade, the driver began slowing the train in preparation for entering the crossing loop at Malbooma (about 8 km away). The train crew then saw water beginning to overtop the track a short distance ahead. The second driver immediately contacted the network

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1 The 24 hour clock is used in this report to describe the local time of day, Central Standard Time (CST)
2 Distance in kilometres from the reference point located at Coonamia, South Australia.
3 Cess drain: refers to the surface drain provided outside the sleepers to drain water from the ballast.

control officer (NCO) to suggest that trains be held until the track could be inspected for water damage. At about the same time (about 0011 on 10 April), while travelling at about 90 km/h, the train crossed a culvert at the 535.150 km mark and passed through the overtopping water. The crew heard a 'big bang' and felt the locomotive pitch sharply before the train's brakes automatically applied and the lead locomotive came to a stop near the 536.035 km mark.

The second driver alighted from the locomotive and walked back along the northern side of the train to check for damage. He found that the brake hose coupling and jumper cable between the trailing locomotive and the refuelling tanker had uncoupled. He reconnected the couplings, but the train brake system did not re-establish a reading from the end-of-train monitoring system[4] (ETMS).

The second driver, accompanied by another driver who had been resting in the crew van, then walked further back along the train and found a separation between wagons and a derailed wheelset. Further in the distance, the drivers could see wagons lying on their sides to the north of the track (Figure 2).

Figure 2: Derailed wagons north side of track.

Source: ATSB

While the crew of 3MP9 were inspecting the damage, the crew of another west bound train (3MP1) contacted the NCO (at about 0014) to report their departure from Lyons (about 30 km west of the derailment location). Aware that the crew of 3MP9 had reported water topping the track, the NCO asked if the crew (3MP1) had observed water near the track at the 535 km post when they passed that area. The driver replied '…water was encroaching on the ballast but it wasn't up to the ballast to wash it away'.

At about the same time, the drivers of 3MP9 returned to the front of the train and reported to the NCO that train 3MP9 had derailed and provided details of the known damage.

Events post-derailment

By 0045, the floodwaters had subsided sufficiently for the crew of 3MP9 to carry out a further inspection of the train. The crew reported to the NCO that about 20 wagons had rolled on their side. The NCO advised the train crew that a track supervisor had been dispatched from Tarcoola to inspect the damaged track. About 1 hour after the train derailed, the drivers reported that all the water that had been flowing down the south side of the track had dispersed through the culverts and into streams to the north of the track.

At about 0124, the track supervisor arrived at the derailment site and reported to the NCO that approximately 40 sleepers were undercut, the ballast had been washed away by the floodwaters

[4] End of train device which forms part of the end of train monitoring system (ETMS). Sends a signal to the in-cab integrated function display (IFD).

and sections of the train remained suspended on skeletal track after the floodwaters had subsided (Figure 3).

Figure 3: Well wagons suspended on skeletal track near point of derailment.

Source: ATSB

At about 1115 on 11 April, Australian Rail Track Corporation (ARTC) staff and Australian Transport Safety Bureau (ATSB) investigators arrived at the derailment site to assess damage to track infrastructure and rolling stock and to commence the investigation.

The crew of train 3MP9 remained with the train until about 1300, when they were transferred by road-rail vehicle to Tarcoola before travelling back to their home depots.

Track, train maintenance and rolling stock recovery crews commenced recovery and restoration works on 12 April and the railway was re-opened to traffic at about 1052 on 17 April.

Context

The location

Malbooma is located on the Defined Interstate Rail Network, approximately 450 rail km west-northwest of Port Augusta, South Australia (Figure 1). The derailment occurred about 5.5 km east of Malbooma at the 535.170 km mark.

Track information

The ARTC manages the railway where the derailment occurred, with the movement of rail traffic controlled from the ARTC's Network Control Centre located at Mile End in South Australia.

The standard gauge (1435 mm) track at the derailment location consisted of 47 kg/m rail fastened to concrete sleepers by resilient clips. The track formation comprised sand/clay based soil, topped with a capping layer and overlaid with ballast to a nominal design depth of 250 mm – forming the track bed. The track bed supported prestressed concrete sleepers spaced nominally at 667 mm centres.

Approaching from Tarcoola, the track near the derailment site was tangent[5] and the terrain undulating. The track gradient leading to the derailment site transitioned from a falling grade[6], to a rising grade of 1:300 through the point of derailment (PoD). The posted maximum track speed was 100 km/h.

Train and train crew information

Train 3MP9 was a freight service operated by SCT between Melbourne and Perth. The train consisted of two locomotives (SCT002 leading and SCT011 trailing) hauling an in-line fuel wagon, a crew van and 73 freight wagons. The train was 1782.5 m in length and had a trailing mass of 5502.4 t.

The crew consisted of four qualified drivers who had commenced duty at Spencer Junction at about 1630 on 9 April. The plan was for the drivers to work the train in pairs, operating in rotating relay shifts through to Perth, Western Australia.

The driver and co-driver in charge at the time of derailment had about 23 and 39 years' experience respectively in the rail industry. They had been assessed as fit for duty in accordance with the requirements of the National Standard for Health Assessment of Rail Safety Workers.

On-site inspection and examination of train data found there was no anomaly in the train speed, train handling, rolling stock condition or operational performance leading up to the derailment.

While the consignment of train 3MP9 included 'non-placarded[7]'dangerous goods, there was no loss of containment of these goods as a result of the derailment.

Environmental conditions

Prior to the derailment, rainfall was generated by an inland surface trough that triggered thunderstorms and rain in the Kimberley region of Western Australia. The BoM Monthly Weather Review reported; 'by the 8 April, the surface trough extended from the northern tropics to a cold front south of Australia, causing a band of heavy rain between the Kimberley's and southern

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5 Straight track with no applied cant.

6 A measure of the rate at which the railway is inclined (rising or falling). Gradients are signed +ve (rising) or –ve (falling) in respect of the direction of travel.

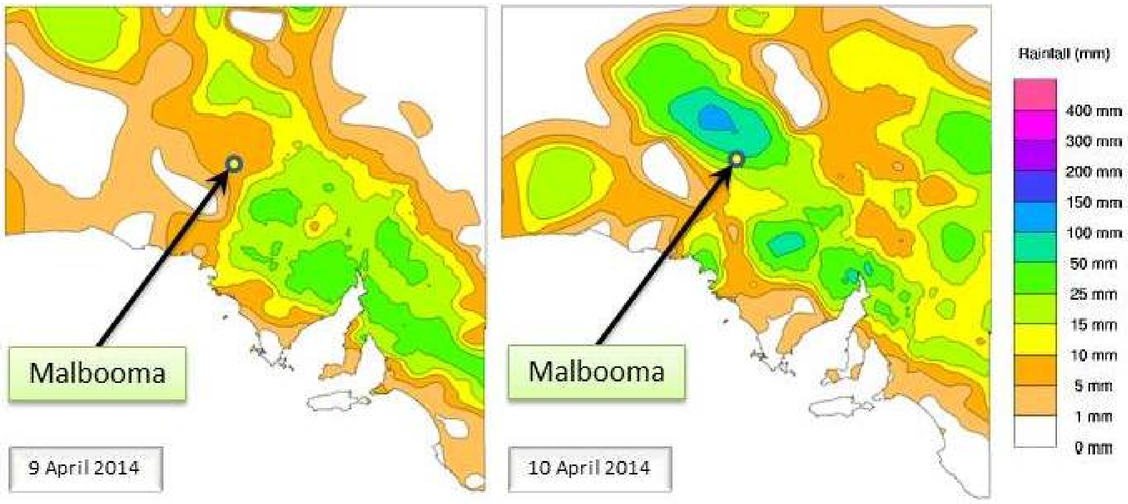
7 Small quantities of consumer dangerous goods intended for personal care or household use as part of a load of retail goods.

Victoria. This persisted until the 10th, breaking April daily rainfall records over many inland South Australian (weather recording) stations.'

While significant rainfall was recorded at Coober Pedy (about 190 km north-northeast of Tarcoola), over the period 9 to 10 April, only 20 mm was recorded at Tarcoola Aerodrome (about 31 km from the derailment site).

The rainfall persisted, breaking April daily rainfall records over many inland areas of South Australia (Figure 4). The BoM data showed that in April 2014, rainfall in South Australia was 257% above the monthly average, with record-breaking rains falling on April 9 and 10.

Figure 4: Daily rainfall intensity maps - April 2014

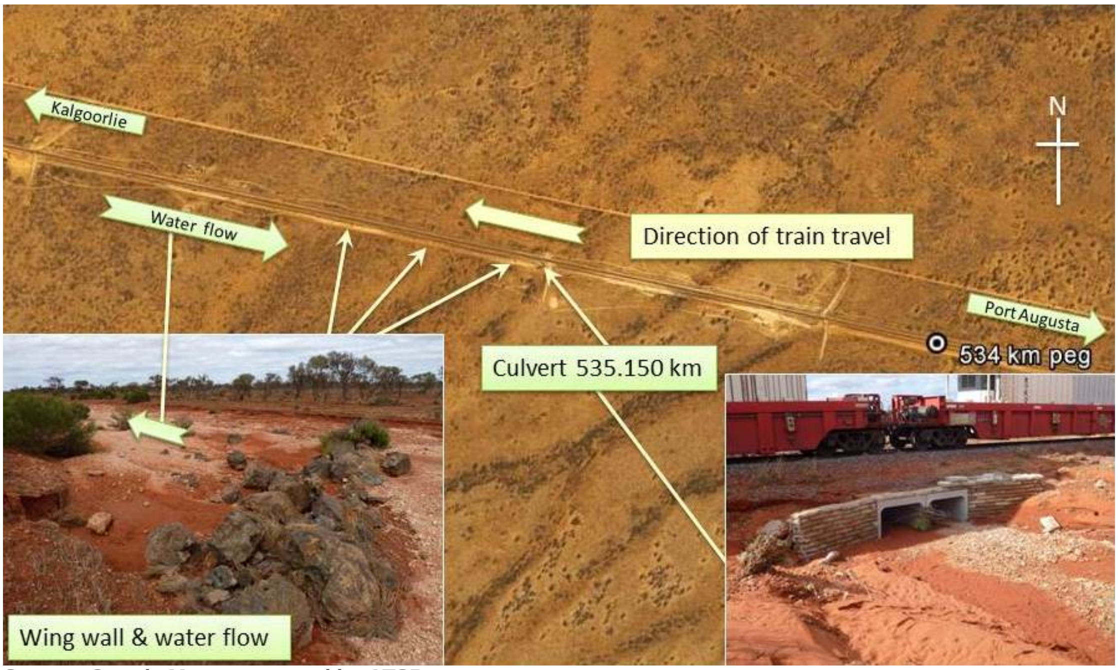


Source: Bureau of Meteorology annotated by ATSB

Track drainage

The under-track drainage system installed between Tarcoola and Malbooma consisted of culverts of varying types, including concrete box, rail deck, corrugated steel pipe and reinforced concrete pipe. The type of culvert installed near the point of derailment was a double span 1500 mm concrete box culvert (Figure 5).

Figure 5: Derailment location showing barrier wall, diversion channel and culvert.



Source: Google Maps annotated by ATSB

In March 2001, the ARTC constructed a barrier wall between the 532 km and 540 km marks. The wall ran parallel to the track, about 6 m from the southern side, to reduce the volume of water flowing against the track formation and consequential scouring. The barrier wall, measuring about 4 m wide and 1 m high, was formed using existing spoil and imported fill (Figure 6).

Prior works

In June 2004 the ARTC carried out further works between the 532 km and 540 km marks. The channels either side of the barrier wall were reshaped. To reduce water velocity, rock wing walls at intervals of about 100 m were added to the barrier wall near the culverts at the 539.250 km and the 534.350 km marks (Figure 5). Near the east end of the barrier wall, a mounded end wall was constructed to re-direct water at an angle of about 90 degrees toward the railway and the double box culvert located at the 535.150 km mark. Other works included repairs to three culvert aprons, increased culvert headwalls at 536.700 km and 532.000 km, and construction of a channel to reduce water ponding near the track.

Erosion events

Between 9 and10 April 2014, rainfall resulted in significant water run-off towards the barrier wall on the south side of the track. As the water accumulated and flowed along the barrier wall in an easterly direction, the volume of water increased to the point where the wing walls were unable to interrupt and divert the flow. As a consequence, the water over-topped and eroded the barrier wall. The barrier wall was breached in two places between the 536 km post and the culvert, allowing excess water from the diversion channel to flow against the railway track formation (Figure 6).

Figure 6: Water diversion channel and barrier wall near the point of derailment

Source: 7 News

About 8 m before the double box concrete culvert at the 535.150 km mark, it was evident that an eddy current[8] had formed before the water was redirected through the culvert. The circular motion of the eddy current progressively eroded the track formation and ballast, weakening the track structure and causing it to slump.

The water level continued to rise with excess water flowing over the track to join the stream exiting the culvert on the north side. The track formation continued to erode after the train had derailed,

8 A current of water that moves against the main current in a circular pattern.

leaving a double-stacked container well wagon suspended on a 13 m section of skeleton track structure (Figure 3).

It was evident that widespread rainfall in the Northwest Pastoral District, and heavy rain at several locations (Figure 4), resulted in water flowing against the track formation in a number of areas between Kingoonya (about 80 km east of Tarcoola) and Malbooma. The extent of flooding that occurred through the derailment site was witnessed by the drivers of train 3MP9 and visible evidence of debris deposited on the track formation remained after the water had subsided.

Other weather related derailments

Prior to this incident, the ATSB had investigated three similar flood-related derailments:

- Golden Ridge[9], Western Australia (ARTC managed track)

  On 30 January 2009, Pacific National freight train 5PS6 derailed after localised flash flooding damaged the track formation.

  The ATSB identified safety issues concerning the specification of hydrological design parameters in the ARTC (Track & Civil) Code of Practice - Flooding- ETG-10-01, the audit and assessment of the track drainage arrangements, and the timely access to reliable weather information that identified localised severe weather events that may affect the safety of the track.

  In late July 2009, the ARTC undertook a track wash-away risk assessment in relation to a hypothetical track wash-away occurring either to the east or to the west of Coonamia, South Australia. The final report for the assessment was completed in May 2011, however two other flood-related derailments occurred before responses to the risk assessment had been initiated.

- Edith River[10], Northern Territory (Genesee and Wyoming Australia (GWA) managed track)

  On 27 December 2011, GWA freight train 7AD1 derailed at the Edith River rail bridge after the bridge embankment was washed-away by floodwaters. In terms of contributing factors and safety issues, the ATSB identified limitations in the policies, procedures and training provided to employees in managing severe weather events, as well as the ineffectiveness of flood severity warning systems.

  GWA initiated a review of their *Extreme Weather Event Monitoring and Response Procedure* and their *Cyclone Response Plan* to incorporate learnings from the occurrence. Awareness training packages were developed to provide guidance for operational staff, track inspectors and management on the recommended responses to flooded track, storms and extreme wind events. In conjunction with the above, GWA instigated systems to detect stream flow and alert train control and train crews. Arrangements were also formalised with a number of agencies (including the BoM), for the reporting and monitoring of extreme weather events.

- Roto[11] New South Wales (ARTC managed track).

  On 4 March 2012, Pacific National freight train 7SP3 derailed after entering floodwaters that had overtopped the track near Roto.

  Like the Edith River event, the ATSB identified safety issues around the ARTC's systems and operational procedures for managing potential threats to infrastructure resulting from significant weather events. The ATSB also noted that the ARTC had

[9] ATSB investigation number, RO-2009-003 - Derailment of Train 5PS6 near Golden Ridge WA 30 Jan 2009

[10] ATSB investigation number, RO-2011-019 - Derailment of freight train 7AD1 at Edith River near Katherine NT on 27 December 2011

[11] ATSB investigation number, RO-2012-002 - Derailment of freight train 7SP3 near Roto, NSW on 4 March 2012

initiated risk assessments in July 2009, following the Golden Ridge derailment about 6 months earlier. However, at the time of the Roto derailment, the ARTC had not yet implemented any actions as a result of the assessment findings.

In November 2012, the ARTC trialled a meteorological advanced warning service for certain weather events such as high rainfall, winds and fire. Full subscription to this service was implemented and advanced warnings received by the ARTC from March 2013. In addition, in June 2013, the ARTC completed a review of the hydrology design for the track west of Broken Hill and through South Australia.

Culvert maintenance and inspections

The Engineering (Track & Civil) Code of Practice - Section 10 - Flooding (CoP) states that waterways that are blocked due to debris or rubbish greater than 20% in area shall be cleared within 28 days.

A review of the ARTC's records for inspections carried out before the derailment of 3MP9 found the last drainage inspection between Tarcoola and Malbooma was carried out on 12 March 2014. Twenty seven culverts were checked for obstructions and structural integrity with nine requiring clearing of inlets and outlets. Eight of these culverts west of the derailment location required clearing, with the closest about 4.6 km from the PoD.

The inspection records did not quantify the blockage area or record if these culverts were cleared before the derailment on 10 April. It is probable however, that the nature and extent of the culvert obstructions (light vegetation from the surrounding landscape) would not have adversely reduced their discharge capacity, given the significant volume of water that was available to pass through them – particularly the culvert near the PoD.

Flood risk

The flood risk study commissioned by the ARTC (final report dated 20 May 2011) provided an understanding of the existing flood risk, and an indication of works required to increase the immunity level of bridges and culverts on this network to a 100 year Average Recurrence Interval (ARI)[12]. The study included an assessment of the hydrological conditions associated with the track washaway and derailment of Pacific National train 5PS6 near Golden Ridge, Western Australia on 30 January 2009. The study also considered the Department for Transport, Energy and Infrastructure's hydrological investigations around 19 multiple-span bridges, the drainage register for the design flow capacities of bridges and major culverts, and anecdotal flooding information provided by track inspection staff.

The study used design rainfall data for 50 and 100-year events; these being estimated using the BoM Rainfall Intensity-Frequency-Duration (IFD) data system. The IFD uses pooling samples of rainfall events 'from recording stations across a compatible region to produce design point rainfall estimates for durations from 5 minutes to 72 hours and from 1 year to 100 year ARI design events' (Table 1).

12 The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random.

Table 1: Design rainfall data – Tarcoola

	Rainfall intensity mm/hr						
Duration	***1 year***	***2 years***	***5 years***	***10 years***	***20 years***	***50 years***	***100 years***
5 min	39.5	54.6	81.8	102.0	129.0	169.0	203.0
6 min	36.6	50.5	75.8	94.4	119.0	156.0	188.0
10 min	29.5	40.7	61.2	76.3	96.3	126.0	152.0
20 min	21.3	29.4	44.2	55.2	69.6	91.4	110.0
30 min	17.1	23.6	35.5	44.3	55.9	73.4	88.6
1 hr	11.0	15.3	23.0	28.7	36.3	47.7	57.6
2 hr	6.72	9.29	14.0	17.6	22.2	29.2	35.4
3 hr	4.94	6.83	10.3	12.9	16.4	21.6	26.2
6 hr	2.88	3.99	6.07	7.61	9.64	12.7	15.4
12 hr	1.7	2.35	3.57	4.48	5.68	7.51	9.1
24 hr	1.01	1.39	2.11	2.65	3.36	4.43	5.36
48 hr	0.584	0.805	1.22	1.53	1.93	2.53	3.06
72 hr	0.410	0.558	0.848	1.06	1.33	1.75	2.12

Source: Bureau of Meteorology

The ARTC CoP states that while under-track culverts and drains are designed to the Australian Rainfall and Runoff and Bridge Design Code for a 50 year precipitation event, 'the effect of a 100 year precipitation event should be considered'. The flood risk study found about 50% of bridges and culverts between Tarcoola and Kalgoorlie were 'at a medium or high risk of flooding' and 41% of these structures didn't 'have sufficient flow capacity to pass the 50 year ARI flood event'.

The report recommended an investigation of lateral flows along the railway embankments and the impacts on bridges and culverts identified at a medium and high risk. Following assessment of the consultant's report, the ARTC inserted additional culverts and increased the capacity of others, to reduce the likelihood of water flooding over and scouring of the track formation at high risk locations. At 535.150 km (about 20 m from the PoD), a new double 1500 mm concrete box culvert was installed in conjunction with earthwork adjustments to embankments designed to reduce water velocity and divert water away from the track.

There is limited weather monitoring stations recording real time weather conditions in remote areas. There was no BoM weather monitoring station at Malbooma to record rainfall, and the closest weather station to the derailment site was the Tarcoola Aerodrome, about 30 km to the east. The design rainfall data for Tarcoola (Table 1) shows that a 1-in-50 year ARI requires 21.6 mm of rain per hour over a period of 3 hours; amounting to about 65 mm of rain for the 3 hour period. For a 24 hour period, a rainfall rate of 4.4 mm per hour equates to a total of 105.6 mm for the period. Rainfall recorded at Tarcoola Aerodrome between 9 and 10 April 2014 was 6 mm and 14 mm respectively and no flooding was reported in the vicinity. These measurements are well below criteria for a 50 year ARI design event.

Contrastingly, train driver statements and floodwater debris that remained around the track indicated significant rainfall within the catchment near Malbooma. Examination of BoM rainfall records from other monitoring stations in the path of the weather system showed significantly different results to those recorded at Tarcoola. For example, rainfall recorded at Coober Pedy Airport on 9 April between 0900 and 1600 was 45 mm, with a further 30 mm falling in one hour between 1600 and 1700. The total rainfall for Coober Pedy Airport over the 24 hour period (0900, 9 April to 0900 10 April 2014) was 115 mm. These measurements easily exceed the criteria for a 100 year ARI design events.

Based on the available evidence therefore, it is very likely that the rainfall and subsequent floodwaters produced by the weather system that passed through Malbooma between 9 and 10 April 2014, exceeded the culvert design parameters and the 1:50 ARI design criteria for the area.

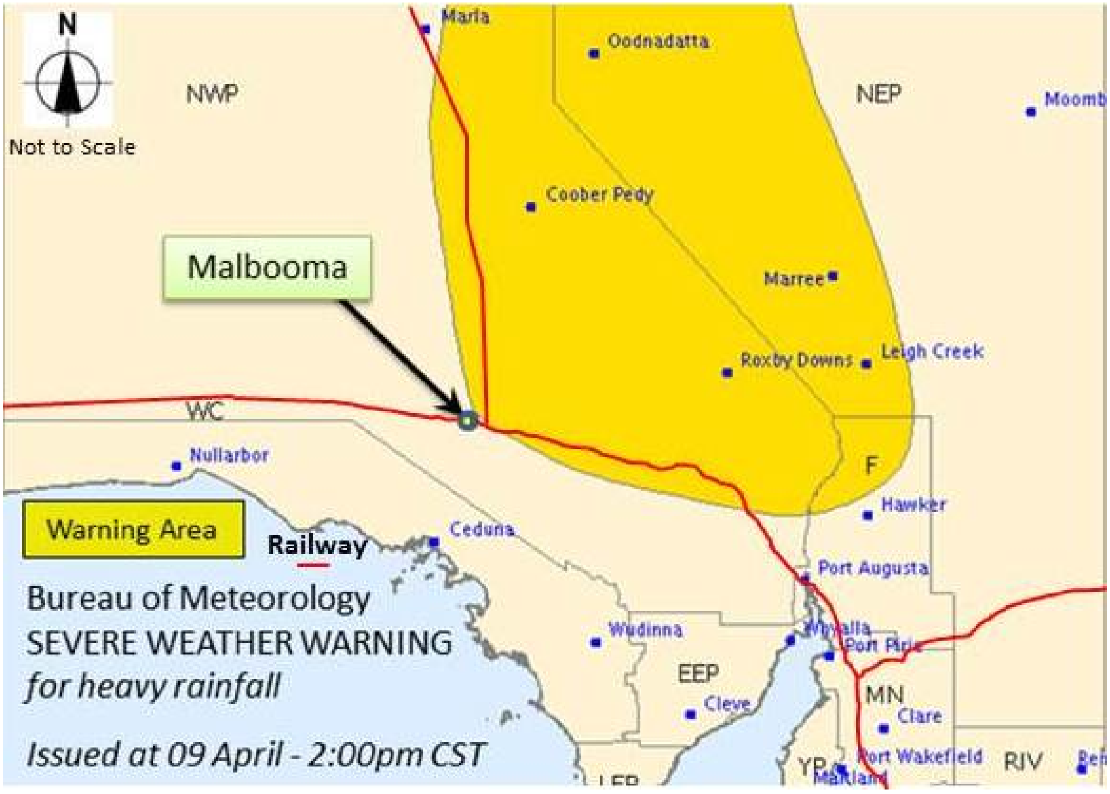
Weather warnings

Subscribers to a service provided by the Early Warning Network (EWN) are issued Weather Alert bulletins based on information sourced from the BoM. Dependant on the severity of the forecast weather conditions, the alert intervals may be daily, 12 hourly, 6 hourly or 3 hourly.

Six severe weather warning alerts were issued by the EWN on Wednesday 9 April, at 0756, 1100, 1400, 1700, 1951 and 2252, with last alert being issued about 1 hour 20 minutes before the derailment. All alerts reported an extensive cloud band associated with an upper level disturbance with areas of heavy rain.

The warning at 1400 (Figure 7) forecast areas of heavy rain and isolated thunderstorms and these were expected to extend further south. This was the third warning of the day and the first to include a large section of track between Port Augusta and Malbooma. The forecast stated that 60 - 100 mm of rain may fall, leading to flash flooding within the affected area.

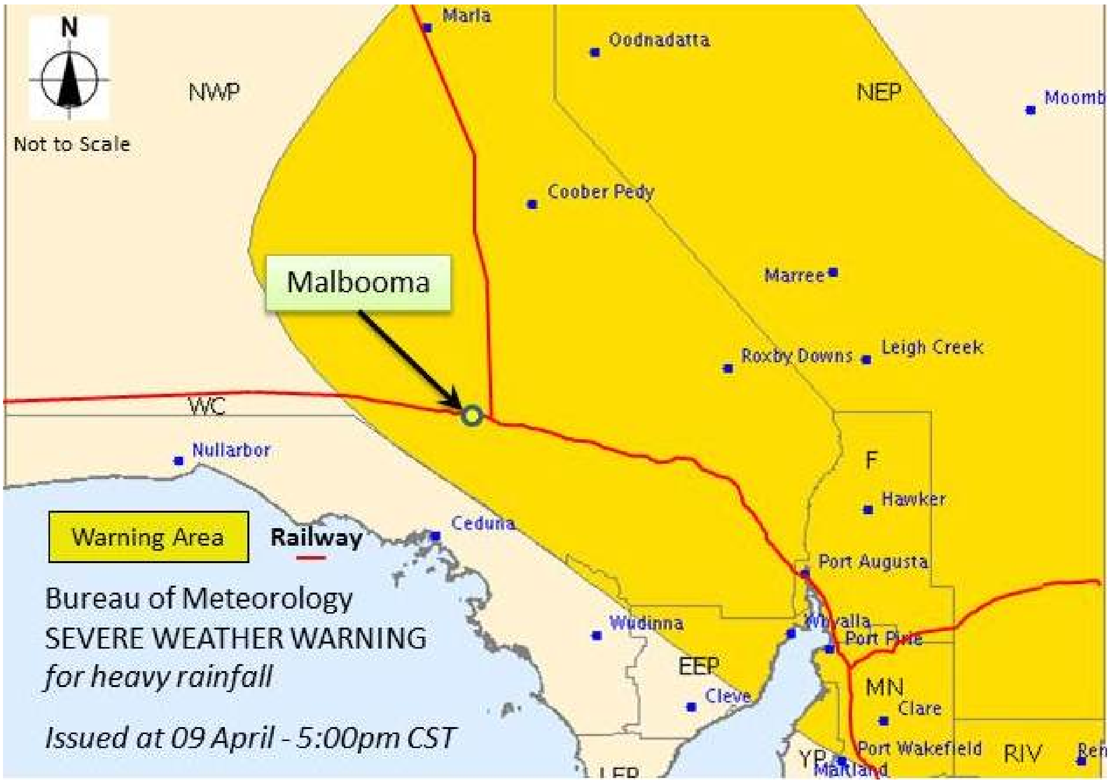
Figure 7: Severe Weather Warning Alert – 1400 - 9 April 2014.



Source: Bureau of Meteorology annotated by ATSB

The warnings at 1700 and 1951 were almost identical; forecasting thunderstorms and flash flooding for the Northwest and Northeast Pastoral, Flinders, Mid North and Riverland districts extending south-east to parts of Eyre Peninsula, Yorke Peninsula and the Murraylands (Figure 8).

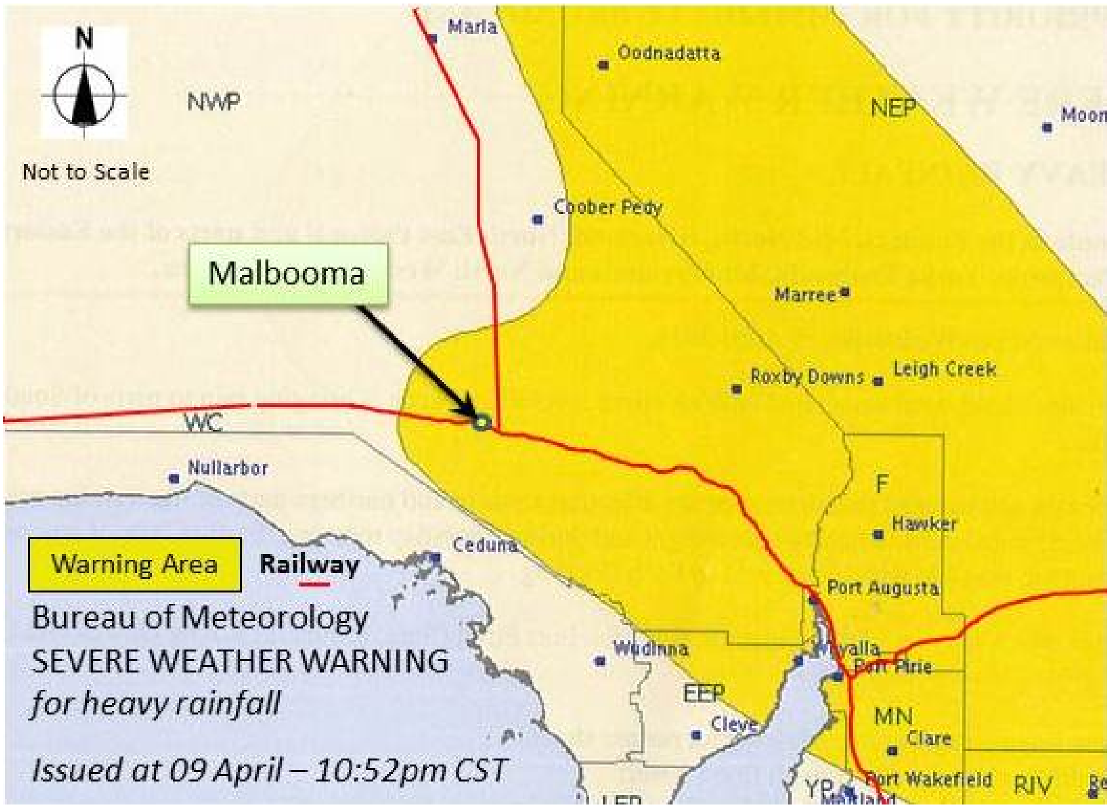
Figure 8: Severe Weather Warning Alert – 1700 - 9 April 2014.



Source: Bureau of Meteorology annotated by ATSB

As the weather system travelled in a south-easterly direction, the EWN warning issued at 2252 (Figure 9) remained over the Malbooma region. Rainfall between 50 - 80 mm was forecast for all previously affected regions and was expected to continue during the morning of 10 April.

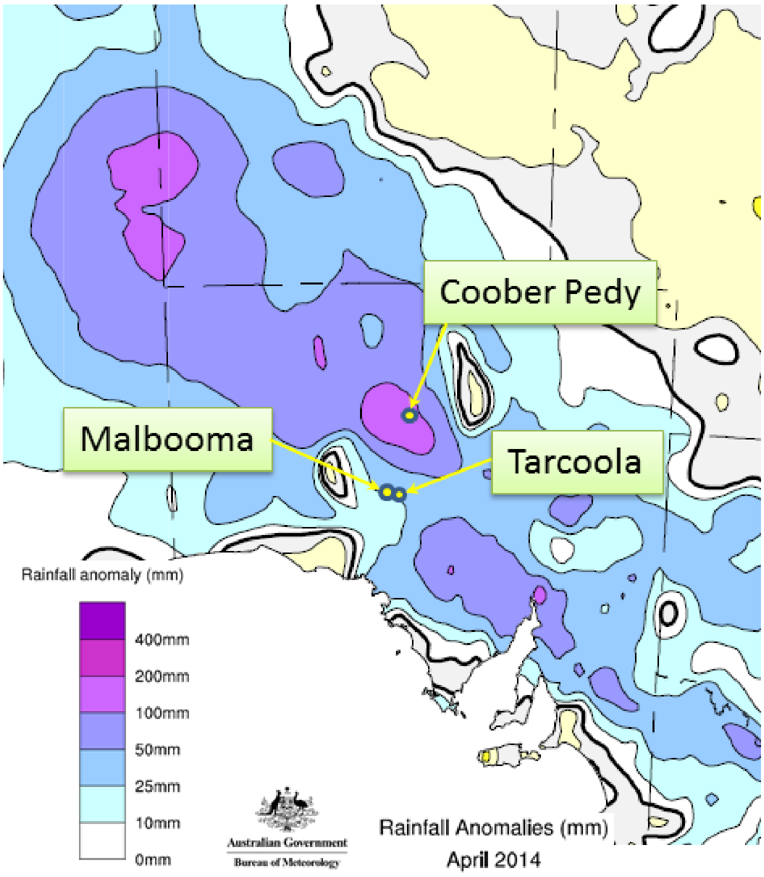
Figure 9: Severe Weather Warning Alert – 2252 - 9 April 2014.



Source: Bureau of Meteorology annotated by ATSB

An anomalies map published by the BoM for April 2014 (Figure 10) showed areas of concentrated rainfall throughout South Australia, including localities north of Tarcoola. The BoM monthly rainfall summary also reported the 115 mm of rain at Coober Pedy airport on 10 April 2014 was the highest daily rainfall for more than 20 years.

Figure 10: Rainfall anomalies map of Central and South Australia – April 2014



Source: Base map - Bureau of Meteorology – Rainfall Anomalies April 2014

It was evident that prior to the derailment of train 3MP9, areas of heavy rain and isolated thunderstorms had extended throughout the Northwest Pastoral District, with severe weather warnings issued by the BoM at 3-hourly intervals. Water had flowed alongside and pooled against the track formation at a number of locations between Malbooma and Kingoonya. The extent of flooding that occurred through the derailment site was witnessed by the drivers of trains 3MP1 and 3MP9 while near Kingoonya. A section of track had also washed away, though by that time train services had been suspended in the area.

Safety analysis

Response to previous investigation findings

ATSB safety investigation findings are considered as learning opportunities, enabling and encouraging actions to minimise the likelihood and/or consequence of similar occurrences.

The investigation into the Golden Ridge derailment (January 2009) identified safety issues concerning hydrological design parameters, assessment of the track drainage arrangements, and timely access to information identifying localised severe weather events that may affect the safety of the track. Following this event, the ARTC initiated an assessment of track wash-away risk, but had not implemented any actions from that assessment (or in relation to other identified issues) before the Roto derailment occurred in March 2012. The weather event at Roto likely exceeded the track drainage design criteria, so it is reasonable to conclude that hydrological assessments and/or upgrades may not have prevented the washaway. Nevertheless, the limited availability of timely information regarding localised severe weather events, and the limited guidance and procedural requirements for acting on such information prior to dispatching trains increased the risk to operations on the railway.

The investigation into the Roto derailment reinforced the importance of access to information and guidance for actioning potential threats resulting from significant weather events. Responding to the issue, the ARTC trialled an advance warning service for weather events, and had subscribed to the service by March 2013. While records show that severe weather warnings were obtained by the ARTC during the day before the derailment at Malbooma, it was evident that the information was not effectively communicated to network staff that may have been in a position to assess and act on the information. The section following discusses this further.

Management of weather warnings

Following the derailment of train 3MP9 at Malbooma and the ARTC's response to the derailment of train 7SP3 near Roto, the ATSB sought information on the ARTC's progress with the identified safety issues and documenting processes 'in network control for the interaction between infrastructure managers and rail operators during imminent and actual severe weather events'.

The ARTC advised that in March 2013, the organisation had approved a subscription to the BoM Weather Alert service for severe weather warning information that may affect safe operations of their network. The BoM weather warnings are emailed to the ARTC when severe wind, heavy rain/flooding events are predicted in each state or territory.

Over a period of about 9 hours (between 0756 and 1700) on 9 April 2014 (the day before the derailment at Malbooma), the ARTC received at least four BoM severe weather / heavy rain warnings for South Australia. There were two subsequent alerts published at 1951 and 2252. The last four alerts between 1400 and 2252 encompassed the Malbooma region and all alerts forecast heavy rain, isolated thunderstorms and flash flooding.

The ATSB's investigation found that the detail and potential severity of these alerts had not been distributed to east-west network staff within the ARTC, or made known to the NCOs managing train movements on the east-west rail network. Despite the ARTC having received the information prior to the derailment of train 3MP9, the NCO was not aware of potential or imminent track flooding west of Tarcoola until about 0012 hrs on 10 April, when the driver advised that there was water flowing over the track, the ballast had been washed away and the train had lost air as they passed the 535 km post.

The Code of Practice – Operations and Safeworking (CoP) states that the train crew shall; 'keep a sharp look out for flooding or fires by the side of the track, or on adjacent land or property' and 'report incidents to train control'. In this case, the NCO's awareness about the potential for flooding in the broader region around Tarcoola only came after speaking to the crew of trains 3MP9 and 3MP1, after train 3MP9 had derailed. When the crew of 3MP1 was near the 535 km post, about 1 hour before the passage of 3MP9, water observed flowing near the track was not considered a threat to the track infrastructure and was not reported to the network controller.

It was evident that following the introduction of the BoM Weather Alert service, a procedure for the management and dissemination of this information had not been developed or incorporated within the ARTC's Safety Management System (SMS). Had the NCO been aware of the BoM severe weather warning information that was received by the ARTC on 9 April 2014, and had a procedure been developed for management of the network under these conditions, the opportunity may have existed to take pre-emptive or precautionary action in response to the perceived or real risk to network safety.

Infrastructure flood management

Where previous flood events have occurred near, and/or damaged railway track infrastructure, the ARTC manages these events through the Engineering (Track & Civil) Code of Practice - Section 10 - Flooding (CoP), which states:

> 'The defined events at flood special locations shall be determined and reviewed through detailed inspection and analysis in accordance with the above manuals and codes, or from records of actual flood events. The analysis should take into account the environmental conditions at the location and documentation relating to unscheduled inspections resulting from previous defined event occurrences.
> A register of flooding special locations and the defined events requiring actions should be established and maintained.'

The CoP shows for the purposes of flood inspection and assessment, 'track sections prone to (e.g. with a history of) flood damage shall be identified and managed as special locations'.

The ARTC had previously encountered track infrastructure erosion and wash-away events due to flooding between Kingoonya and Malbooma. ARTC records and anecdotal information from track inspection staff showed:

- (1995) Overtopping of the culvert near 532.700 km in the Tarcoola to Malbooma section.
- (1995) Severe scouring between 541.000 km and 532.700 km in the Tarcoola to Malbooma section.
- (1997) Washaway and severe scouring around the culvert at 491.000 km in the Ferguson to Tarcoola section.
- (1997) Washaway and severe scouring between 500.000 km to the 502.000 km in the Ferguson to Tarcoola section.
- (2001) Severe scouring between 509.000 km and 511.000 km in the Tarcoola to Malbooma section.
- (18 February 2003) Flood damage track inspector imposed two temporary speed restrictions. 40km/h 512.650 km to 512.700 km signs erected - 40km/h 525.500 km to 534.500 km signs erected - water scouring.
- (08 March 2009) Report of Flooding - Malbooma Yard (541.500 km).
- (10 April 2014) Washaway and severe scouring resulting in derailment of train 3MP9 Tarcoola – Malbooma 535.170 km.

The ATSB investigation extracted records of flooding events recorded on Train Control Reports (TCR's), where track infrastructure was damaged or significantly exposed to flooding. While it was evident that records existed that could identify the area between Kingoonya and Malbooma as at increased risk of flooding, a register of identified special locations on the Trans Australian Railway had not been established.

Findings

From the evidence available, the following findings are made with respect to the derailment of SCT Logistics train 3MP9 near Malbooma, South Australia on 10 April 2014.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

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

Contributing factors

- In the hours leading up to the derailment, significant rainfall near Malbooma, South Australia very likely exceeded the Average Recurrence Interval of a 1:50 year event for which track infrastructure was designed.
- The barrier and wing walls constructed parallel to the track were unable to control and divert floodwater in the diversion channel that subsequently breached its banks, allowing scouring of the track formation.
- The double span 1500 mm concrete box culvert at 535.150 km was unable to discharge the significant volume of flood water before the ballast and track formation was washed away.
- **The ARTC's processes for developing and implementing changes to operational procedures as a result of incident investigation findings were ineffective at mitigating the risk of future similar incidents. [Safety Issue]**
- **The ARTC did not have a comprehensive system in place to identify and actively manage risks associated with severe weather events that were likely to affect the safety of their rail network. [Safety Issue]**

Other factors that increased risk

- **A register for recording 'special locations' in accordance with the ARTC Engineering (Track & Civil) Code of Practice - Section 10 - *Flooding*, had not been established to manage track infrastructure prone to flood damage. [Safety Issue]**

Other findings

- On-site inspection and examination of train data found there was no anomaly in the train speed, train handling, rolling stock condition or operational performance leading up to the derailment.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and 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 directly involved parties were provided with 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.

Response to flood event investigations

Number:	RO-2014-006-SI-01
Issue owner:	The Australian Rail Track Corporation
Operation affected:	Rail: Operations control
Who it affects:	Rail network managers and train operators

Safety issue description:

The ARTC's processes for developing and implementing changes to operational procedures as a result of incident investigation findings were ineffective at mitigating the risk of future similar incidents.

Proactive safety action taken by the ARTC

Action number: RO-2014-006-NSA-005

The ARTC has implemented Operational Procedure OPP-01-05 - *Monitoring and Responding to Extreme Weather Events in the East-West Corridor*. The procedure has been developed to provide guidance to the ARTC managers and network control officers, its contractors, network users and other affected parties, relative to the monitoring and response to extreme weather events in the east-west corridor.

The procedure has been designed to support risk-based decision making, with the aim of reducing risk associated with extreme weather events *so far as is reasonably practical* (SFAIRRP).

Current status of the safety issue

Issue status: Adequately addressed

Justification: The ATSB is satisfied that the action taken by the ARTC addresses this safety issue.

Management of weather warnings

Number:	RO-2014-006-SI-02
Issue owner:	The Australian Rail Track Corporation
Operation affected:	Rail: Operations control
Who it affects:	Rail network managers and train operators

Safety issue description:

The ARTC did not have a comprehensive system in place to identify and actively manage risks associated with severe weather events that were likely to affect the safety of their rail network.

Proactive safety action taken by the ARTC

Action number: RO-2014-006-NSA-003

In conjunction with the implementation of Operational Procedure OPP-01-05, remote weather monitoring and recording stations were commissioned on the Trans Australian Railway at Barton, Cook, Rawlinna and Zanthus on 19 December 2014. Data from these weather stations will be linked to the Early Warning Network service to provide automated alerts.

Four water flow monitors have been installed at culvert locations identified through a hydrology study of the Trans Australia Railway. Field evaluation of this equipment is being undertaken.

Current status of the safety issue

Issue status: Adequately addressed

Justification: The ATSB is satisfied that the action taken by the ARTC addresses this safety issue.

Infrastructure flood management

Number:	RO-2014-006-SI-03
Issue owner:	The Australian Rail Track Corporation
Operation affected:	Rail: Operations control
Who it affects:	Rail network managers and train operators

Safety issue description:

A register for recording 'special locations' in accordance with the ARTC Engineering (Track & Civil) Code of Practice - Section 10 – *Flooding*, had not been established to manage track infrastructure prone to flood damage.

Proactive safety action taken by the ARTC

Action number: RO-2014-006-NSA-004

The ARTC is upgrading its electronic asset management system to optimise inspection and maintenance activities including recording of special locations. Coordinated with information provided by the Early Warning Network service, the asset management system can generate specific maintenance scheduled tasks (MST) where unscheduled track inspections may be carried out when there is an identified risk to safe operations. Additionally, special locations are incorporated in the track patrol technical maintenance plans in accordance with the ARTC Engineering (Track & Civil) Code of Practice.

Current status of the safety issue

Issue status: Adequately addressed

Justification: The ATSB is satisfied that the action taken by the ARTC addresses this safety issue.

General details

Occurrence details

Date and time:	10 April 2014 – 0006 CST	
Occurrence category:	Serious incident	
Primary occurrence type:	Derailment - Running Line	
Location:	535.170 km - Malbooma	
	Latitude: 30° 41.18.0’ S	Longitude: 134° 14.52.7’ E

Train details

Train operator:	SCT Logistics	
Registration:	3MP9	
Type of operation:	Rail Freight	
Persons on board:	Crew – 4	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- SCT Logistics
- The Australian Rail Track Corporation
- The drivers and crew of train 3MP9

References

Australian Dangerous Goods Code – 7th edition, Retail Distribution Loads Chapter 7.3

Australian Rail Track Corporation, Monitoring and Responding to Extreme Weather Events in the East-West Corridor - OPP-01-05

Australian Rail Track Corporation, (Track & Civil) Code of Practice – Flooding - Section 10

Australian Rail Track Corporation, (Track & Civil) Code of Practice - Specification Clauses – Flooding- ETG-10-01

Bureau of Meteorology, - Daily Rainfall, Tarcoola Aerodrome

Bureau of Meteorology, - Glossary for Water status: Design rainfalls

Bureau of Meteorology, - Monthly Weather Review, Australia, April 2014

Bureau of Meteorology, - Weather Alerts – SA Severe Weather Warnings: Heavy Rain - 9 April 2014

Bureau of Meteorology, - Weather Services Handbook

Kellogg Brown & Root Pty Ltd, Trans Australian Railway Preliminary Flood Risk Assessment Progress Report - (AET008.001-TD-WE-REP-0001 Rev A)

Rail Industry Safety and Standards Board, Glossary of Railway Terminology – Guideline

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (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:

- SCT Logistics
- The Australian Rail Track Corporation
- The drivers and crew of train 3MP9
- The Office of the National Rail Safety Regulator

Submissions were received from:

- SCT Logistics
- The Australian Rail Track Corporation
- The Office of the National Rail Safety Regulator

The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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

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

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

Purpose of safety investigations

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

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

Developing safety action

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

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

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

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

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
Derailment of freight train 3MP9 East of Malbooma, SA,
10 April 2014

RO-2014-006
Final – 25 March 2015