Australian Government

Australian Transport Safety Bureau

Collision with floodwater involving freight train 6792

Little Banyan Creek, Queensland, on 7 March 2018

ATSB Transport Safety Report

Rail Occurrence Investigation

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Addendum

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Safety summary

What happened

At 0152 on 7 March 2018, freight train 6792, operated by Aurizon, departed Cairns, Queensland, for a journey on Queensland Rail's North Coast Line. A condition affecting the network (CAN) due to wet weather had been declared, and the train crew were required to operate at controlled speed for a significant part of the journey, which meant they were to be able to stop short of an obstruction within half the distance of clear line that was visible ahead.

At 0612, the train rounded the curve prior to the Little Banyan Creek rail bridge, which was under 0.6 m of flowing water. With a sighting distance of about 60 m to the bridge, the train's speed (50 km/h) was significantly in excess of the controlled speed, and the train entered the floodwater. The train crew were not injured, but there was some damage to the train's rolling stock, caused by immersion in water.

What the ATSB found

The Little Banyan Creek weather monitoring station's water level sensor had been out of service for 57 days, and therefore no flood alarm was provided to network control and passed on to the train crew. Further, although there was a closed circuit television camera (CCTV) at the location to enable monitoring of water levels, the illuminator to enable effective operation at night had been out of service for 14 days. Queensland Rail (QR) also did not have an effective means of ensuring that, during situations such as a CAN, network control personnel were aware of the relevant weather monitoring systems that were unserviceable. In addition, QR did not have procedures that required network control personnel to actively search for information about track conditions ahead of a train during situations when conditions had the realistic potential to have deteriorated since the last patrol or train had run over the relevant sections.

The ATSB also found that QR did not have any restrictions on the distance or time that controlled speed could be used as a risk control for safe train operation in situations such as a CAN. The effectiveness of controlled speed has the significant potential to deteriorate over extended time periods due to its effect on driver workload, vigilance, fatigue and risk perception. In addition, Aurizon's procedures and guidance for two-driver operation during situations such as a CAN did not facilitate the effective sharing of duties and teamwork to minimise the potential effects of degraded conditions on driver workload and fatigue.

What's been done as a result

Following the occurrence, QR improved its processes for ensuring the reliability of weather monitoring systems, and its procedures for ensuring network control personnel were aware of any faults. QR also developed new procedures and training for network control personnel for managing a CAN, including for proactively monitoring conditions on the network. In addition, QR is undertaking further work to guide the use and conditions around controlled speed and restricted speed, and Aurizon is undertaking further work to review its procedures for the management of workload in two-driver operations during a CAN.

Safety message

This occurrence highlights the importance of having serviceable weather monitoring stations at known flooding locations on a rail network, especially during the tropical wet season, and ensuring that if these systems are not functioning then all relevant parties are aware of the problem.

This occurrence also highlights the importance of effective communication between all relevant parties during a condition affecting the network. In particular, train controllers need to ensure that all relevant information associated with the conditions is passed on to train crews and track maintenance personnel so that they can effectively perform their roles.

Contents

The occurrence

Overview

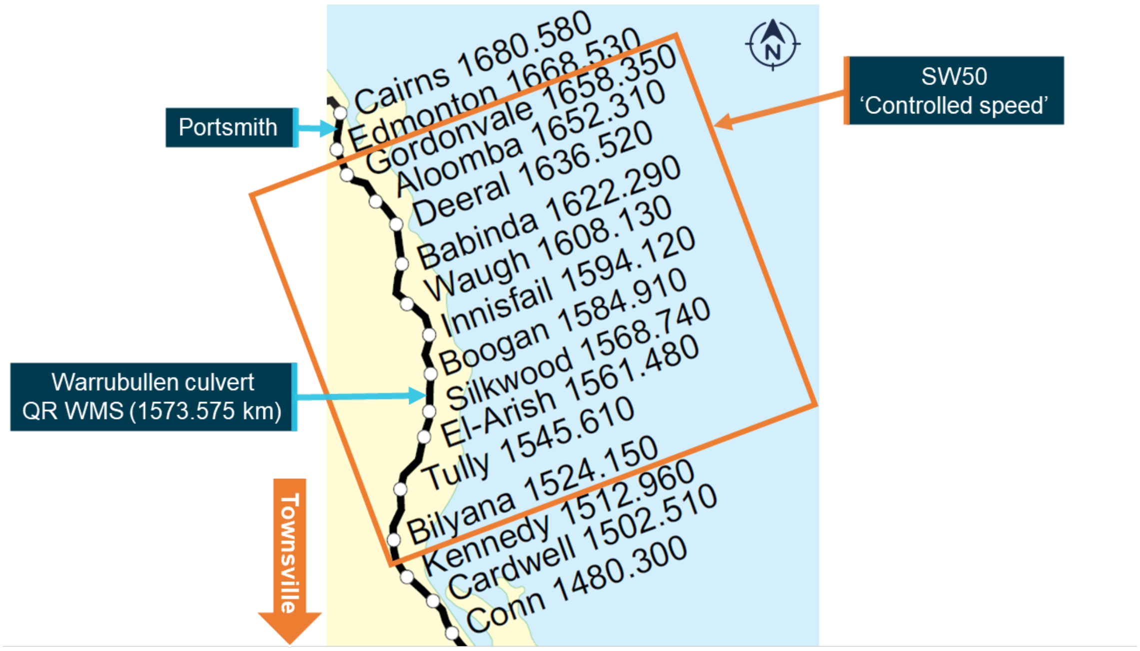
At 0152[1] on 7 March 2018, freight train 6792, operated by Aurizon, departed Cairns, Queensland, for a journey to Brisbane, Queensland.[2] Heavy rain had fallen in some areas of North Queensland in the preceding hours (night of 6 March) and continued to fall during 7 March. At 0612, the train ran into floodwater over the Little Banyan Creek rail bridge, 134 track km south of Cairns. The train crew were not injured, but there was some damage to the train's rolling stock, caused by immersion in water.

Events prior to train 6792's departure

During 5–6 March, Queensland Rail's (QR's) North Coast Line was closed for a 36-hour period for planned track maintenance near Rockhampton in Central Queensland. In addition, during the first week of March 2018, a significant amount of rain fell in some areas of North Queensland.

On 6 March, the track maintenance supervisor (TMS, see *Track inspection procedures*) based at Innisfail conducted a patrol of the track between the Babinda to Cardwell section (Figure 1). The patrol started at 0655 and was completed at 1145. No areas of concern were identified.

Figure 1: Section of North Coast Line from Cairns to Cardwell



The image shows stations and their distance (in track km) from Roma Street Station in Brisbane.
Source: QR, modified by the ATSB.

During 6 March, the Townsville network control centre commenced preparations to run Aurizon freight train 6792 and Pacific National freight train 67P8 south from Cairns, with the first train expected to depart early on 7 March. These would be the first trains on the Babinda to Cardwell section since the 6 March track patrol.

A 'condition affecting the network' (CAN) associated with the wet weather was declared before trains 6792 and 67P8 departed. The regional transit manager (RTM) on duty at the network

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1 All time references in this report are in local time (Eastern Standard Time).

2 The train departed from the Portsmith railway yards, about 2.5 km south of Cairns, and the intended destination was the Acacia Ridge intermodal terminal, about 12 km south of Brisbane.

control centre on 6 March (up until 2030) directed that trains 6792 and 67P8 were to run at 'controlled speed', which meant they were to be able to stop short of an obstruction within half the distance of clear line that was visible ahead (see *Controlled speed*).

At 0050 on 7 March, the train crew (consisting of a driver at the controls and a second driver) of Aurizon train 6792 signed on for duty. At 0127, the driver phoned the network control officer (NCO) on the Townsville North control board. The NCO issued the crew with a written authority for rail traffic (form SW50), which directed them to operate their train at controlled speed between Gordonvale (1658.350 km)[3] and Bilyana (1524.150 km) due to the weather conditions. The controller advised the driver that he did not think the conditions were 'anything to be too concerned about', but he requested that the train crew provide advice about the weather and track conditions while en route. The NCO advised that there was no opposing traffic and that train 67P8 would be following close behind them.

Cairns to Innisfail

At 0151, train 6792 left Cairns in heavy rain and at 0222 it passed through Gordonvale (1,658.350 km). At 0228, the driver reported very heavy rain at Aloomba (1,652.310 km), and the NCO reminded him to continue to report on the weather conditions as the train proceeded south.

At 0200, the driver of Pacific National train 67P8 contacted the NCO, and the NCO provided the train crew with a form SW50, which directed them to operate the train at controlled speed between Gordonvale and Bilyana due to the weather conditions. Train 67P8 departed Cairns at about 0220 and travelled about 30 minutes behind train 6792.

At 0308, the driver of the Aurizon train 6792 phoned the NCO[4] and advised that the creek at Babinda (1,622.290 km) was about 1 m from the bottom of the bridge and flowing quickly. He also noted that on the previous day the water was 2 m below the bridge. The driver stated that the rain had eased off, but he was unsure of what was happening in the nearby hills, where water could flow down rapidly. Soon after (at 0314), the NCO advised the driver that he could see on closed-circuit television (CCTV) images from Babinda that the water was about 1 m below the rails.

During the phone call, the NCO also provided the 6792 train crew with a form SW50 for the Mamu Road level crossing (1,602.913 km), located between Waugh and Innisfail. The level crossing had been indicating active to road vehicle users all night, and the form SW 50 required the crew to ensure there was no road traffic prior to entering the crossing.

At about 0333, train 6792 passed through Waugh (1,608.130 km). Soon after, the driver and NCO discussed aspects of the shunting the train crew needed to do in Innisfail. The driver reported it was raining heavily at that time.

At 0345, the driver advised they had passed through the Mamu Road level crossing. He also advised that they had stopped at the Garradunga tramway because the signal was incorrectly indicating red. The second driver had inspected the site and could not rectify the problem.

At about 0400, train 6792 arrived at Innisfail (1,594.120 km) and the train crew commenced shunting operations for the next hour. The crew subsequently reported that it was raining heavily at Innisfail during this period.

At 0400 there was an NCO shift change on the Townsville North control board. The incoming NCO received a handover from the outgoing NCO and a briefing from the RTM (on duty since 2030), and he was advised that trains 6792 and 67P8 were required to be running at controlled speed.

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3 All distances are in km from Roma Street station in Brisbane.

4 Most of the communications between the driver and the NCO after the train departed Cairns were via train control radio. However, the driver initiated some communications by mobile phone.

The Innisfail track maintenance supervisor (TMS) contacted the NCO by phone at 0456 and they discussed the overnight weather conditions. The NCO advised that there had been a rainfall alarm at Babinda (north of Innisfail) at 2340, indicating more than 25 mm of rain had fallen in an hour. There had also been a flood alarm at Warrubullen Culvert (1,573.575 km, near Silkwood and about 20.5 km south of Innisfail), indicating that the water level had reached 1 m below the rails at 0311.

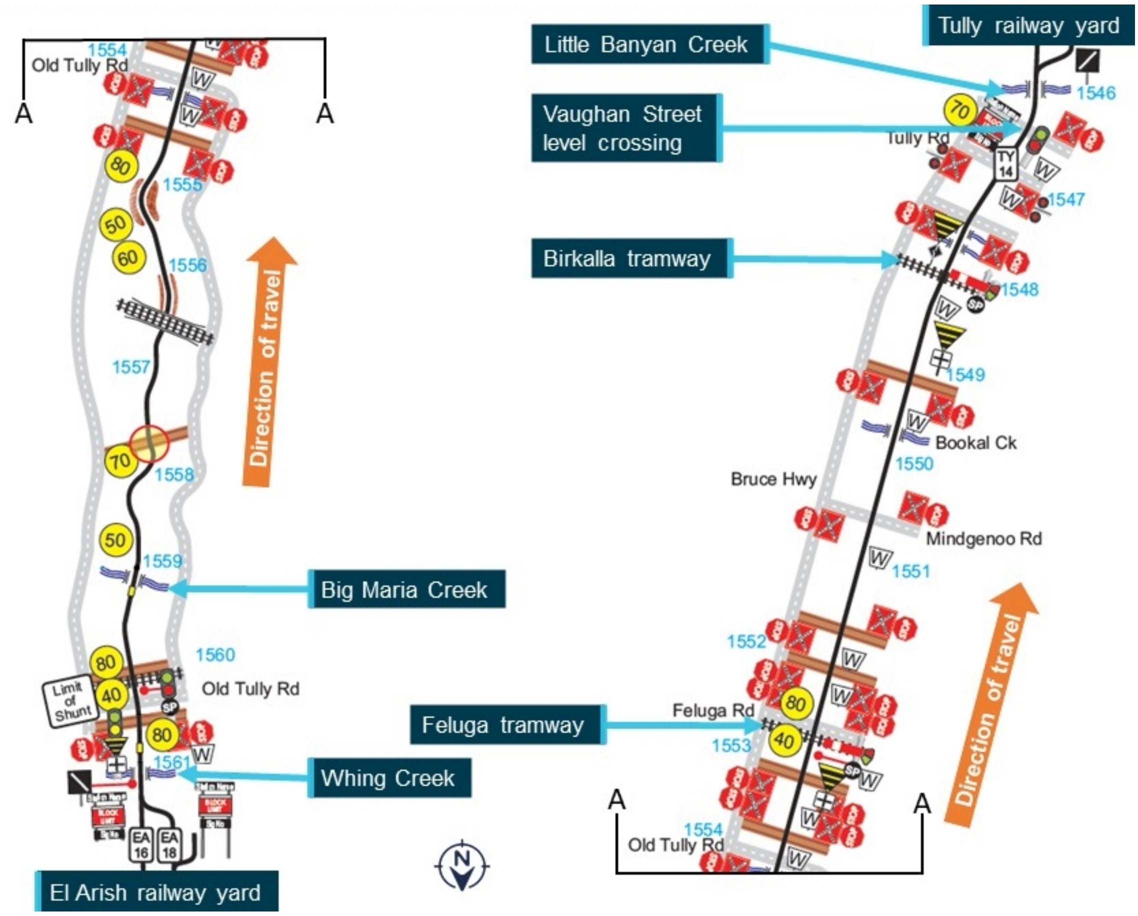
The NCO and TMS agreed that the TMS should conduct a patrol (See *Track inspection procedures*) of the 120 km of track between Babinda and Cardwell (south of Innisfail). The NCO advised the TMS of the current and expected rail traffic on the line. The TMS asked the NCO if the train crews had seen anything, and the NCO replied that they had not reported anything yet. The TMS advised the NCO that he would commence duty at 0600 and would arrive at Babinda at about 0630 to begin the patrol, following trains 6792 and 67P8 south. He noted that his patrol would therefore be conducted before QR's Spirit of Queensland passenger train operated from Cairns to Townsville.

Innisfail to Little Banyan Creek

At 0504, train 6792 departed Innisfail. The driver and the NCO briefly discussed the weather conditions. The driver advised that it was still raining, and the NCO requested that the crew keep providing updates about the conditions.

Train 6792 passed through Boogan and Silkwood and, at about 0552, it passed through El Arish (1,561.48 km). At 0554 the driver phoned the NCO and advised that it was not raining at El Arish, but the water level was 2.5 feet (about 0.75 m) below the rail bridge over Whing Creek and 2 m below the rail bridge over Big Maria Creek (Figure 2). He noted that both creeks were flowing rapidly.

Figure 2: Route map showing features along the North Coast Line between El Arish and Old Tully Road (left) and Old Tully Road to Little Banyan Creek (right)



Note: the diagram is oriented so that the train's direction of travel is upwards (south). Speed limits are shown in yellow circles; distances are shown in blue text.
Source: QR.

At 0610:09, the driver phoned the NCO and reported that all the culverts between Feluga and Birkalla (Figure 2) were full. He also reported that there was a culvert at the Birkalla tramway crossing where the water was about halfway up the ballast (see also *Additional information related to wet weather operations*). He advised the NCO to monitor that location because if the water got any higher it would start flowing through and start scouring out the ballast.

At 0611:18, the driver asked the NCO to stay on the phone so he could report on the water level in Little Banyan Creek (1,546.100 km). He also noted that it would be interesting to see the condition of Murray Flats (1,534.410 km), given the water level in the previous culverts.

At 0611:35, the train rounded the left curve on the approach to the rail bridge over Little Banyan Creek (Figure 3). The train's speed was about 50 km/h, with the maximum permitted speed in normal conditions being 70 km/h. The driver saw floodwater covering the bridge and he immediately attempted to stop the train by applying the emergency brake. The train was unable to stop in the distance available, and it entered the water at 0611:50 (Figure 4).

Figure 3: Train 6792's route on approach to the Little Banyan Creek rail bridge

Source: Google Maps, modified by ATSB.

The distance from brake application to the train stopping was 294 m. After it stopped, the train was on the bridge with the locomotive and first three container wagons partially submerged in about 0.6 m of water (Figure 5). Neither of the train crew were injured.

Figure 4: Train 6792's locomotive passing over the flooded Little Banyan Creek rail bridge

Source: QR.

Figure 5: Empty container wagons behind train 6792's locomotive, standing on the flooded Little Banyan Creek rail bridge

Source: QR.

Post-occurrence events

The driver of 6792 was still on the phone to the NCO as the train entered the floodwater and he immediately notified the NCO of the problem.

The train crew were unable to leave the locomotive due to the surrounding water, and they also believed it was unsafe for them to remain in that position. At 0615, after consulting with their supervisor and the NCO, the driver moved the train forward at low speed through the floodwater and into Tully yard.

After the NCO was notified of the collision with floodwater, the relevant section of track was closed and the following train (67P8) was held at Innisfail.

Train 6792's crew were replaced by a relief crew. Following discussions between train crew and the rollingstock defect coordinator, the coordinator understood that the water ingress to wheel bearings was minimal. On this basis the relief train crew was authorised to continue to the nearest servicing depot at Townsville. At about 1730 on 7 March, the relief train crew restarted the train and continued south. After running 43 km, the locomotive failed and the train was unable to continue any further. Aurizon subsequently reported that, following a detailed inspection of the train, it identified water damage to the traction motors and all wagon wheel bearings that had been submerged in water.

Context

Train and train crew information

Train information

Aurizon train 6792 was an intermodal freight train, servicing customers between Cairns (Portsmith) and Brisbane (Acacia Ridge). On 7 March 2018, train 6792 departed Cairns with one diesel electric locomotive (number 2806) and 28 container wagons. During shunting at Innisfail, three wagons were detached and five other wagons were attached, which resulted in the train having 30 wagons and being 603.5 m long with a gross mass of 1.054 t. Many of the containers on the train were empty, but several were loaded with old road vehicle tyres, bananas and tea.

No problems were identified with the train's braking performance or other relevant systems.

The train was fitted with a data logger and information from the data logger has been included in the report where relevant. All reported speeds have been rounded to the nearest 5 km/h.

Train crew roles and experience

Train 6792 was operated in the two-driver operation configuration, with a planned crew change in Townsville. In this configuration, two qualified locomotive drivers conducted a variety of duties up to a maximum shift length of 12 hours.

Aurizon's *General Operational Safety Manual* stated that, when rail traffic was worked in the two-driver operation configuration, driver duties included:

> Rail Traffic Driver at controls
>
> - take charge of running of the rail traffic
>
> Rail Traffic Driver not at controls to monitor
>
> - other drivers performance
> - signal aspects
> - speed board changes
> - level crossings
> - other safeworking requirements
>
> Note: By agreement with the rail traffic driver at the controls, the other rail traffic driver can take a short break when it is considered safe to do so and when not in or approaching a Safety Critical Zone.

Both drivers of train 6792 on 7 March 2018 were based in Townsville. They advised that they determined their division of duties before the train departed Cairns. Consistent with their normal practice, they intended to swap driving duties at Bilyana, about halfway between Cairns and Townsville. Up until then, one driver would conduct all train driving, safeworking and reporting duties (including all communications with NCOs).

Driver 1 conducted the driving duties up until the time of the occurrence. He confirmed that there were no requirements for drivers to share driving and related duties when operating a train during a condition affecting the network (CAN) or abnormal event, such as in wet weather conditions.

Driver 2 inspected the train prior to departing Cairns, inspected the signals at Garradunga tramway, and handled the shunting duties in Innisfail yard. During the shunting at Innisfail, heavy rain fell and his clothes were saturated. In the period between departing Innisfail and the occurrence, driver 2 put on dry clothes and dried out in the locomotive cab, and conducted monitoring duties.

Both drivers were qualified to work trains between Townsville and Cairns. Driver 1 had a substantial amount of train driving experience, having first qualified as a driver in 1995, and he had a substantial amount of experience on the North Coast Line. In the preceding 12 months, he had worked over the route 65 times. Driver 2 had worked the route 16 times in the preceding 12 months.

Train crew recent history

Over the 4 days prior to the occurrence, driver 1 had worked four duty periods, as shown in Table 1. He conducted no duty periods in the previous 4 days.

Table 1: Actual duty times for driver 1 over previous 5 days

Date	Work activity	Duty start	Duty end	Duty time	Time free (of duty)
3 Mar 2018	Day off				
4 Mar 2018	Townsville–Cairns	0400	1330	9.5 hours	14.5 hours
5 Mar 2018	Cairns–Townsville (road vehicle)	0400	1000	6.0 hours	20.0 hours
6 Mar 2018	Townsville–Cairns (road vehicle)	0600	1150	5.8 hours	13.0 hours
7 Mar 2018	Cairns–Townville (planned)	0050	1250	12.0 hours	

Train 6792 normally departed during the day but, due to the backlog associated with the closure of the North Coast Line associated with planned maintenance, a non-standard start time was required. On 6 March driver 1 and driver 2 drove a road vehicle from Townsville to Cairns to position themselves to operate train 6792 back to Townsville. They signed off duty at 1150 and went to motel accommodation to rest.

Driver 1 reported he had some sleep in the afternoon and woke for dinner. He then returned to sleep for a couple of hours and was woken at midnight by a phone call from the train operator. He stated that at that time he was tired, as was normal for a duty time that commenced in the middle of the night. The driver's planned and actual duty periods met the requirements of the operator's fatigue management system.

Driver 2 worked the same duty periods as driver 1 on 6–7 March, and had the previous 2 days free of duty.

Rail line information

North Coast Line

Queensland Rail's (QR's) North Coast Line extends 339 km from Townsville to Cairns. Most of the line runs along the foot of the coastal ranges or crosses river flood plains, with major rail bridges over the Mulgrave, Russell, Johnstone, Tully, Murray and Herbert Rivers. In several sections, the route crosses hilly terrain where there can be landslips from cutting faces and fallen trees across the line after periods of wet weather. Some sections of the line have relatively poor alignment, with many tight curves, low bridges and level crossings.

Between Gordonvale and Bilyana, there were 10 sections, with a total distance of 134.2 km. Over the 10 sections, there were a significant number of sites that could be associated with potential hazards. These potential hazards included 83 bridges, 56 speed-restricted curves, 20 sugar cane tramway crossings and 79 level crossings (only 14 equipped with active level crossing protection).

There were usually 17 scheduled passenger and freight trains in each direction each week, operated by QR (5), Aurizon (6) and Pacific National (6). These included QR's Spirit of Queensland passenger train, which ran between Cairns and Brisbane.

Little Banyan Creek

Banyan Creek is part of the Tully River catchment. It has a small catchment, bounded by the Walter Hill Range and Mount Mackay. The creek flows south along the foot of the range, and its major tributary, Little Banyan Creek, flows south-west to a point of confluence about 1 km north-east of Tully. Banyan Creek joins the Tully River downstream about 7 km further south.

QR's North Coast Line crossed Little Banyan Creek at 1,546.100 km, about 80 m from the confluence with Banyan Creek. The timber trestle bridge was about 40 m long (Figure 6).

Figure 6: Little Banyan Creek rail bridge

Source: QR.

Approaching Little Banyan Creek and Tully yard from the north, the rail track curved to the left on a 502 m radius curve after the Vaughan Street level crossing and dropped down to the bridge (Figure 3). Trains were permitted to run at a maximum speed of 70 km/h around the left curve and over the bridge. At the southern side of the bridge, the maximum speed limit changed to 60 km/h.

Train crew visibility going around the left curve before the bridge was restricted by large trees beside the track, on the inside of the curve (Figure 3). This meant that a driver in a locomotive could not see the bridge until they were about 60 m away.

Calculations conducted by QR determined that, for a freight train similar to train 6792, a driver would have to be operating at a speed of 15 km/h in order to stop within 60 m.

Track inspection procedures

The QR Civil Engineering Track Standard (CETS), document MD-10-575, specified the safety standards and good practice guidelines for the construction and maintenance of track owned by QR.

The standard provided for the following types of track inspections:

- scheduled patrol
- scheduled general inspection
- scheduled detailed inspection
- unscheduled patrol
- unscheduled general Inspection
- unscheduled detailed Inspection.

Scheduled patrols were required to be conducted at a maximum interval of every 96 hours. Such patrols involved examining the track and related infrastructure. They were usually conducted by a single infrastructure worker driving an on-track (hi-rail) vehicle[5] along the track, at a speed not exceeding 40 km/h. Scheduled general inspections (maximum interval 4 months) and detailed inspections (maximum interval 4 years) were more detailed in nature.

The CETS stated that unscheduled patrols, unscheduled inspections or operational restrictions had to be applied in response to various events. These included 'heavy rainfall / inundation / floods / washaways / ingress of ground water'. The standard also required the rail infrastructure manager to prepare and maintain a hazard location register. The register needed to detail the hazards and the required actions (such as unscheduled patrols or inspections) at hazard locations where defined events might rapidly reduce the capability of the track to safely perform the required function. It stated such locations included track adjacent to an overbridge and track subject to flooding.

The hazard location register for the North Coast Line, from Cains to Cardwell, was last updated in August 2017. It listed 29 locations, with the associated condition or situation of 19 of these locations related to flooding. Some referred to specific locations (such as Banyan Creek) whereas some referred to a distance of up to 14 km of track. Most (14) of the locations were north of Banyan Creek and some (4) were south of Banyan Creek.

Table 2 shows the hazard location entries for Little Banyan Creek (1,546.100 km) and the area immediately north or south. Most of the other entries in the register associated with flooding were similar to the first row in the table.

5 Light vehicle capable of operating on rail tracks and the road network.

Table 2: Selected hazard location register entries for locations near Little Banyan Creek

Location	Activity, process, condition or situation	Defined event	Action if event occurs	Record of event
1530.000 to 1544.300 km	Flooding and washouts	After heavy rain during wet season. Track starts to flood when Murray River reaches 7.6 metres or Tully River reaches 8.1 m at Euramo	Cease traffic until inspected	Yearly during wet season in extreme heavy rain
1545.300 to 1546.300 km	Flooding and washouts	After heavy rain during wet season	Cease traffic until inspected	Yearly during wet season in extreme heavy rain
1546.082 to 1546.130 km Banyan Ck	Flooding and debris on bridge	After heavy rain during wet season	Cease traffic until inspected	Yearly during wet season in extreme heavy rain. Train ran through flooded bridge March 08
1546.900 to 1547.700 km	Flooding and washouts	After heavy rain during wet season	Cease traffic until inspected	Yearly during wet season in extreme heavy rain

Source: QR, modified by the ATSB.

The track maintenance supervisor (TMS) based in Innisfail was responsible for the Babinda to Cardwell section of track. He reported that scheduled patrols were normally done twice a week, once in the northern direction and once in the southern direction. The TMS last conducted a patrol on 6 March (the day before the incident) in a southern direction, which was completed at 1145. After a discussion with the NCO at 0456 on 7 March, he planned to commence another patrol in the southern direction starting at Babinda at about 0630 that morning.

The TMS stated that he was not permitted to conduct patrols at night due to various safety concerns. He said that he had only conducted inspection activities at night in recent years in response to specific incidents at specific locations.

Areas prone to flooding

QR's Townsville network control centre had developed flood hot spot maps for each of its lines. The map for the North Coast Line from Cairns to Townsville, dated 2010, showed 11 flood hot spots between Gordonvale and Bilyana. These included two spots pointing to the area between Tully (1,545.610 km) and Bilyana (1,524.150 km), with an associated table stating these spots included the areas from 1,531.000–1,548.000 km and 1,530.000–1,544.300 km. The location of QR's weather monitoring stations was also marked. However, the labels for the flood hot spots and the weather monitoring stations did not include specific location names.

The TMS based at Innisfail had been working in that or similar roles for more than 10 years. He stated that the main areas prone to flooding of the track between Cairns and Bilyana included Harvey Creek (1,632.310 km), Codfish Creek (1,627.270 km), Babinda Creek (1,621.510 km) and the area between 1,530–1,550 km, which included crossings at Little Banyan Creek (1,546.100 km), Murray River (1,5434.410 km) and Corduroy Creek (1,530.290 km) (Figure 7).

The TMS also advised that Little Banyan Creek could get flooded due to localised rain. That is, on some occasions the creek would be flooded but Tully River and other nearby creeks and rivers the rail line traversed would not be flooded.

Previous occurrences of trains entering floodwater

QR reported that there had only been one previous occurrence during the period from January 2008 to March 2018 when a train had entered floodwater on the North Coast Line. That event occurred at Little Banyan Creek on 14 March 2008.

QR advised that it could not locate an investigation report for the March 2008 occurrence, and therefore the detailed circumstances associated with that occurrence were not able to be determined. The information available to QR indicated that crews of trains that passed over the Little Banyan Creek rail bridge provided reports of the water levels at 2245 on 13 March 2008 (1.5 m below the rails), 2315 (dropping since last report) and 0020 on 14 March 2008 (same as last report). However, at 0145 freight train 6C55 went through water that was about 1.2 m above the rails. A situation update at 0500 indicated that other creeks along the line were at least 1.9 m below the rails but Little Banyan Creek was still 1 m over the rails at 0630.

Meteorological and environmental information

General information

The North Coast Line between Cairns and Townsville experiences a wet season from about November to March each year. According to QR, during this period it was common for the network to be impacted by localised flooding in the numerous rivers and creeks over which the line crossed.

Tully is one of the wettest towns in Australia, with an average annual rainfall of 4,083 mm and an average March rainfall of 756 mm.

Forecasts and warnings

In the first week of March 2018, heavy rain fell in many areas of North Queensland. Rain forecast maps issued by the Bureau of Meteorology (BoM) on the morning 6 March 2018 indicated that the area between Cairns and Tully would receive up to 50 mm of rain on 6 March, up to 100 mm on 7 March and between 100–200 mm on 8 March.

BoM issued an initial flood watch at 1514 on 6 March 2018 for coastal catchments between Cooktown (north of Cairns) and Ingham (between Cardwell and Townsville). It stated:

- Areas of heavy rainfall were expected to develop across the flood watch area later on 7 March and continue into 8 March.
- Minor flood levels were likely across the flood watch area from late on 7 March.
- Heavy rainfall may lead to local flooding.
- Catchments likely to be affected included the Mulgrave, Russell, Johnstone, Tully, Murray and Herbert Rivers.

BoM issued an initial minor flood warning for the Tully and Murray rivers (Figure 7) at 0549 on 7 March. It stated that rainfall totals of 70–300 mm had been recorded across the Tully River catchment since 0900 on 6 March, with the bulk of the rain falling overnight, and further showers then rain were expected. For the Tully River, the warning stated:

> River levels are rising in upper reaches of the Tully River.
>
> The Tully River at Euramo is currently at 5.53 metres and rising. The Tully River at Euramo will exceed the minor flood level[6] (6.00 m) Wednesday morning. Further rises are likely as heavy showers continue. Predictions will be updated as required.

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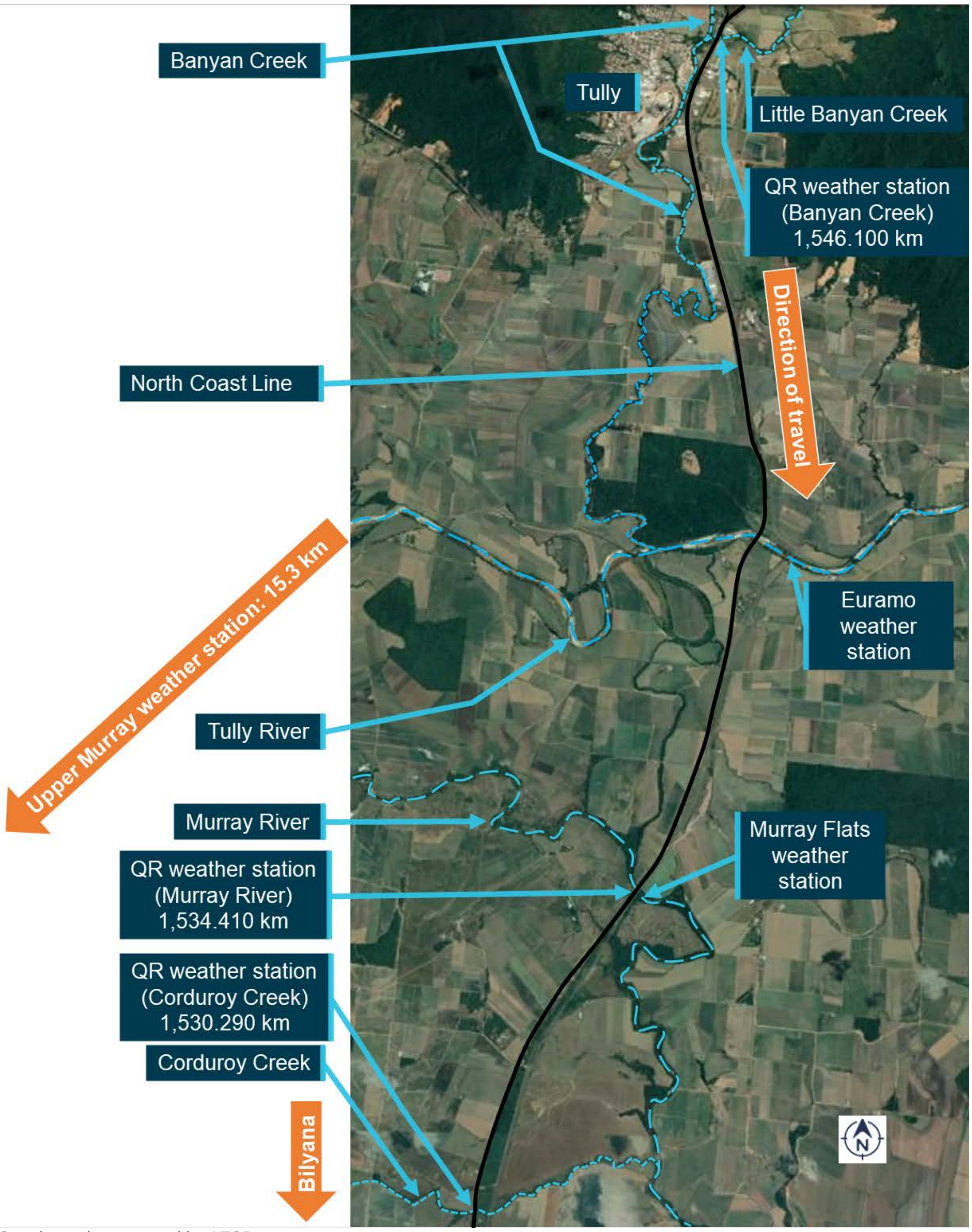
[6] BoM's description of minor flooding included 'Causes inconvenience. Low-lying areas next to watercourses are inundated. Minor roads may be closed and low-level bridges submerged...'

For the Murray River (south of the Tully River), the warning stated:

> River level rises are being recorded in the Murray River catchment.
>
> River levels are expected to remain below minor flood levels at Murray Flats during Wednesday but with further heavy rainfall expected from Wednesday evening rises above the minor flood level are likely during [8 or 9 March].

QR advised that it received the publicly-available weather forecasts and warnings provided by BoM and had processes in place to assess them and their potential impact on its network. It did not have any arrangements in place for BoM to directly contact QR.

Figure 7: Position of rivers, creeks, and weather stations near Tully



Source: Google earth, annotated by ATSB

Rainfall observations

As indicated above, the initial flood watch stated that locations in the Tully River catchment recorded 70–300 mm of rain between 0900 6 March and 0500 on 7 March.

Table 3 shows daily rainfall figures for 6 and 7 March 2018 for the Tully Sugar Mill (1.35 km south-west of the Little Banyan Creek rail bridge) and some other locations close to the North Coast Line in the Tully River catchment (Euramo and Upper Murray) and north of the Tully River catchment (Mulgrave Hill, Deeral and Innisfail).

Table 3: Rainfall for selected locations 6–7 March 2018

Location	24-hour rainfall to 0900 6 March 2018 (mm)	24-hour rainfall to 0900 7 March 2018 (mm)
Mulgrave Hill (Gordonvale)	0.0	88.0
Deeral	0.2	69.0
Innisfail	48.6	151.0
Tully Sugar Mill (near Little Banyan Creek)	71.0	226.5
Euramo (near 1,539.000 km)	55.0	74.0
Upper Murray (11.2 km west of Bilyana)	106.0	70.0

Source: QR, modified by the ATSB.

Water level information

The closest locations to Little Banyan Creek with recorded water level data were:

- Euramo (near a road bridge crossing Tully River, 500 m south-east of the North Coast Line at 1,539.000 km). The water level reached 4.98 m at 0400 on 7 March and was increasing. It reached the minor flood level of 6.00 m at 0712 and the moderate flood level of 8.00 m at 2219. It subsequently reached 8.80 m at 0141 on 9 March, below the major flood level of 9.00 m.
- Murray Flats (near a road bridge crossing Murray River, 50 m from the rail bridge crossing Murray River at 1,534.410 km). The water level reached 5.05 m at 0400 on 7 March and was increasing. It reached the minor flood level of 7.00 m at 2226, the moderate flood level of 7.50 m at 0414 on 8 March, and the major flood level of 8.00 m at 1138.

Queensland Rail weather monitoring stations

General information

QR had weather monitoring stations at 10 locations between Gordonvale and Bilyana, including at Little Banyan Creek. The stations could provide various types of information to the Townsville network control centre, including air temperature, rail temperature, humidity, rainfall and water level. Some parameters were only available for some locations. If a specific value was exceeded, the station would transmit an alarm message.

The weather monitoring station at Little Banyan Creek provided information on air temperature, rail temperature, rainfall and water level.

In October 2017, QR commenced testing of weather monitoring stations on the North Coast Line prior to the wet season. Accordingly, a 6-month service of the Little Banyan Creek station was conducted on 31 October 2017, and the system was found to be fully operational.

Weather monitoring station sensors in North Queensland are exposed to extreme weather conditions and regularly experienced faults. Such faults were allocated a lower priority, relative to other types of equipment faults, as they were deemed to be ‘non-vital’ assets that did not directly impact on the movement of rail traffic. Vital systems, including level crossings and signalling systems, were recognised as essential to the movement of rail traffic and were generally accorded a higher priority.

The QR weather monitoring stations were independent of other weather monitoring stations, such as those used by BoM for rainfall at the Tully Sugar Mill and the water level at Euramo and Murray Flats (see *Meteorological and environmental information*).

Water level monitoring

Nine of the 10 QR weather monitoring stations between Gordonvale and Bilyana, including at Little Banyan Creek, had a water level sensor. These sensors were mounted on rail bridges and measured the vertical distance between the water and the top of the rails.

If the distance reached a certain level, the system would send a flood alarm message. The calibrated levels for a flood alarm were 1.0 m, 0.4 m and 0.1 m below the rails, at rail height, and 0.2 m, 0.5 m and 1.0 m above the rails. All flood alarm messages were sent to the relevant network control officer (NCO) workstation and the regional transit manager (RTM) workstation within the Townsville network control centre.

On 10 January 2018, while working on the Little Banyan Creek rail bridge, a QR maintenance gang damaged a cable running from the water level sensor. A technician attended the site and identified that repairs were required.

On 18 January 2018, a QR engineer, who was monitoring cameras at the site, noted the water level in Little Banyan Creek had risen to the top of the sleepers on the bridge, but the flood alarm had not activated. A new water level sensor was ordered, and a technician attended the site in mid-February to install it. However, the technician was unable to calibrate the sensor. At the time of the occurrence on 7 March 2018, the water level sensor had not been calibrated and it was still offline.

In addition to Little Banyan Creek, QR advised that the water level sensors at two other weather stations between Gordonvale and Bilyana had a 'failed' status during the period between 0000 and 0600 on the morning of 7 March. These were Swann Creek (1,656.500 km) and Murray River (1,534.410 km). The Murray River sensor, located close to the Murray Flats station used by BoM, had a failed status since 9 February.[7]

QR advised that the only flood alarm message sent to the network control centre during the 12-hour period leading up to the occurrence was at 0311 on 7 March from the Warrubullen weather monitoring station (1,573.575 km), which stated that the water level was 1 m below rail height.

Total hourly rainfall monitoring

All 10 of the QR weather monitoring stations between Gordonvale and Bilyana, including at Little Banyan Creek, recorded rainfall. One of the two rainfall parameters that was monitored was total hourly rainfall, or the total amount of rain recorded over the previous 60 minutes (calculated every 5 minutes).

If the total hourly rainfall was over 25 mm the system would generate a warning alarm message, and if it was over 50 mm the system would generate a critical alarm message. Warning and critical alarm messages for total hourly rainfall were sent to the relevant NCO workstation and critical alarm messages were sent to the RTM workstation.

On 7 March 2018 at 0039, a warning message was recorded indicating that the total hourly rainfall at Little Banyan Creek was more than 25 mm (actual value 25 mm).[8] QR advised that this should have generated a warning alarm message, however no message was sent. QR advised that

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7 In addition, the weather monitoring stations at two other locations were temporarily offline (for all parameters) during 7 March, including Harvey Creek (1,632.310 km) during 0108–0245 and 0545–0612 and Corduroy Creek (1,530.290 km) during 0246–0740.

8 The same message was also recorded on 6 March 2018 at 0358.

following the occurrence it identified that the system as delivered by external developers had not been correctly configured, which meant that a higher amount of rainfall (in the order of 30 mm) was required before a warning message was sent from the device to the server. QR also advised that it had commenced an investigation of these types of issues prior to the occurrence.

The only total hourly rainfall alarm message received by the network control centre during the 12-hour period leading up to the occurrence was at 2340 on 6 March from the Babinda weather monitoring station, which stated that the total hourly rainfall over the last hour was more than 25 mm (actual value 27 mm).

Derived rainfall rate of change monitoring

The other monitored rainfall parameter was derived rainfall rate of change, or the estimated rainfall per hour based on the amount of rain measured over a 5-minute period.

If the derived rainfall rate was over 25 mm/h, the system would generate a critical alarm message. These critical alarm messages for derived rainfall rate were sent to RTM workstation but not the relevant NCO workstation.

For Little Banyan Creek, critical alarm messages were recorded:

- 6 March at 1503
- 6 March at 2039
- 7 March at 0015.

All three messages stated that the derived rainfall rate changed to more than 25 mm/h (actual value 28 mm/h).

Closed-circuit television cameras

Some locations along the North Coast Line had a closed-circuit television (CCTV) system that provided images that were able to be viewed by the relevant NCO and the RTM. The systems included an illuminator, which allowed a camera to capture artificially-illuminated images during the hours of darkness.

Between Gordonvale and Bilyana, there were four CCTV systems, located at Swann Creek (1,656.500 km), Babinda (1,621.510 km), Little Banyan Creek (1,546.100 km) and Murray River (1,534.410 km). The CCTV at Little Banyan Creek was installed in September 2015.

The CCTV systems automatically generated a new still image every 2 hours. In addition, network control personnel could generate a new image manually at any other time.

On 22 February 2018, QR's Townsville fault coordination centre received a notification that the camera illuminator at Little Banyan Creek had failed. In its failed state, the images taken by the camera at night were too dark for any detail to be discerned.

A technician was sent to Little Banyan Creek to repair the illuminator, but was not able to access the site due to inclement weather conditions. At the time of the occurrence on 7 March 2018, the camera illuminator had not been repaired.

Morning civil twilight[9] on 7 March 2018 at Tully commenced at 0555. The presence of water over the bridge was discernible on the CCTV footage from about 0550.

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[9] There are three phases of twilight: civil, nautical and astronomical. The sun is below the horizon in each phase, but in civil twilight there is sufficient natural light to carry out most outdoor activities.

Network control information

Townsville control centre

QR's Townsville control centre consisted of seven control boards, one for each line. A separate network control officer (NCO) provided network control services at each board. An NCO was responsible for controlling rail traffic in accordance with safeworking procedures and conducting related duties.

A regional transit manager (RTM) supervised the overall operations of the NCOs on duty, as well as coordinated activities with external parties. A network support officer assisted the RTM.

The Townsville North control board was responsible for the North Coast Line from Purono (1,368.060 km) to Cairns (1,680.580 km). It was also responsible for the Tablelands Branch from Cairns to Croydon. The Townsville North control board's workstation included several monitors for displaying safeworking (train progress) information. There was also a communications monitor and another monitor that was used for a range of other tasks, including ViziRail[10] monitoring, GPS location assurance, weather monitoring, email monitoring, access to procedures and sourcing other operational information.

The RTM's workstation also included a monitor that provided weather-related information.

A large monitor in the control centre displayed current weather radar information for the area from the BoM website.

Network control personnel information

The NCO who commenced duty on the Townsville North control board at 0400 on 7 March 2018 was qualified on five control boards, including the Townsville North board. He had about 3.5 years experience as a controller. He reported that he worked mainly as a relief controller, filling in for others as required, and therefore there could be extended periods where he did not work on the Townsville North control board. He stated that he did not have much experience with far north Queensland wet seasons, and was not aware that Little Banyan Creek was a known location prone to flooding.

During the NCO's shift, the only traffic on the North Coast Line in the area he was responsible for were trains 6792 and 67P8. During the period after civil twilight (0555) he was dealing with some traffic on the Tablelands Branch, including processing a release for one train at 0600 and issuing a warrant for a track vehicle at 0610.

The RTM on duty in the Townsville control centre at the time of the occurrence was normally a network support officer, but acted in the role of an RTM about once per month. He had conducted RTM duties over a 7-year period, and had previously worked as an NCO in the centre for 15 years. He was aware that Little Banyan Creek was a known location prone to flooding.

The RTM signed on at 2100 and was due to sign off at 0630. He stated that the workload during this shift was higher than normal, due to the wet weather and the planned reopening of the North Coast Line after a significant period of closure due to planned maintenance, which affected the Townsville North control board and other control boards.

QR procedures and guidance for managing wet weather events

General rules and procedures

The QR standard MD-12-189 (*Queensland Network Rules and Procedures*), outlined the safety requirements for all persons who were required to access and perform activities in the network rail corridor managed by QR. The standard included rules and procedures for operating rail traffic in

[10] Train scheduling, monitoring and reporting software module.

flood-affected areas (QR 3027). It stated that if an NCO was made aware of flood-affected track, the NCO must stop the rail traffic and arrange inspection by a maintenance representative.

QR 3027 also stated that, when 'the track is affected by flooding', a maintenance representative must arrange for track workers to monitor the height of any water and report damage to the NCO, tell the NCO about any rise or fall of the water level, check the condition of the track before any traffic travels through flood-affected areas, and advise the NCO of operating restrictions on affected track. The standard noted that the height of water could be checked using automatic weather stations (where fitted).

MD-12-189 also included rules and procedures for reporting and responding to a condition affecting the network (QR 2009). It stated:

> Conditions that can or do affect the safety of operations in the Network must be reported promptly to the Network Control Officer responsible for the affected portions of line…
>
> If necessary, the Competent Worker reporting the Condition Affecting the Network must:
>
> - prevent rail traffic from approaching the affected portions of line, and
> - apply protection for rail traffic or a line in an emergency.
>
> If there is any doubt about the safety of rail traffic, any fault must be treated as an emergency and workers must:
>
> - tell the Network Control Officer…

The QR standard MD-10-107 (*General Operational Safety Manual*) outlined the instructions and procedures for rail traffic movements and other matters. With regard to adverse conditions, it stated:

> Where it is required to operate rail traffic in adverse conditions such as:
>
> - heavy rain,
> - high wind, or
> - reduced visibility…
>
> and these conditions affect or have the potential to affect the safe operation of rail traffic and people on the network, the rail traffic crew will operate their rail traffic to suit the current conditions and advise Network Control of the conditions
>
> Network Control should consult with rail traffic crew, Track Maintenance Supervisors and any other resources available and determine other factors which may impact on the running of rail traffic.
>
> Where information is available to Network Control that relates to the condition of the network, the Network Control Officer will advise if it is unsafe for rail traffic to travel.
>
> The Network Control Officer will impose such special conditions as may apply when rail traffic travel under adverse conditions and these include but are not limited to:
>
> - continual monitoring
> - restricted speed
> - increased exchange of information to ensure safety
> - updates on changes in weather conditions

Local guidance information

Supplementary to the QR rules and procedures, the Townsville Regional Safety Committee published a set of 'wet weather protocols' in December 2011 for use by NCOs in the Townsville control centre. These protocols, which were not a formal part of QR's safety management system, included the following guidance:

> - We will stop trains when conditions are uncertain, or until track inspection verifies safe for traffic. For example…

    - Weather monitors alert to a problem
    - Water is in the ballast
    - Visibility is poor
    - There is a report from the last train over the section that indicates a problem…

- We recognise the importance of sharing information and will focus on the quality of our conversations by:-
    - Provide weather report advice to train drivers at the start of their shift when needed.
    - Observe and report on conditions that could stop traffic when travelling across the corridor. For example water levels rising, water entering the ballast and or sever localised storms.
    - Sharing information from Train Control on weather conditions to trains in transit where applicable…

Safety alerts

In December 2015, an Aurizon freight train derailed near Julia Creek on QR's Mount Isa Line, following a flooding event that scoured the ballast and formation of the track. The ATSB investigation[11] identified the following safety issues associated with QR's procedures:

- The Queensland Rail General Operational Safety Manual (MD-10-107) contained insufficient guidance for rail traffic crews to ensure the timely identification and management of a potential hazard (resulting from a weather event) that might affect the safe progress of the train. [RO-2015-028-SI-01]
- The Queensland Rail network rules, procedures and safety manual [MD-12-189] provided insufficient guidance to identify the magnitude of the potential hazard from a weather event, or define the response when encountering water that had previously overtopped the track and receded or was pooled against the track formation or ballast. [RO-2015-028-SI-02]

In January 2016, following the December 2015 derailment, QR issued critical safety alerts to rail traffic crew and network control officers. QR advised the ATSB that the safety alerts were to be trialled over the 2016–2017 wet season and then incorporated into relevant manuals. A subsequent version of the critical safety alert for NCOs was issued in November 2016 and reissued in November 2017.

The 2016/2017 critical safety alert stated:

> If Train Traffic Crew observe flood water (or evidence of recent flood water such as debris on the track) in the ballast (above the formation) they must immediately stop the rail traffic (in a controlled manner) and report to the NCO. The rail traffic must not proceed until authorised (verbally) by the NCO. The NCO must consult with relevant infrastructure personnel prior to providing this authorisation.
>
> - Note: This rule does not apply to puddles, drainage water or small volumes of water that would not impact on the structural integrity of the track.
>
> NCOs may become aware of a wet weather related conditions that affect or potentially affect the network by:
>
> - Reports from the field of
>   - unusually heavy rain;
>   - water pooling against the formation or on land adjacent to the railway;
>   - a washout or scouring of ballast or the formation;
>   - poor visibility;

[11] ATSB Transport Safety Report, Rail Occurrence Investigation RO-2015-028, Derailment of freight train 9T92, near Julia Creek, Queensland, 27 December 2015. Report issued 9 December 2016. Available at www.atsb.gov.au.

> - o high or rising levels in creeks or waterways.
> - Failure of Track Circuits;
> - Remote monitoring station data
> - Meteorological forecasts, observations, warnings and alerts.
>
> NCOs must seek further information from personnel in the field and from Infrastructure personnel if they are unclear on the condition of the network.
>
> NCOs must stop rail traffic if they become aware of a condition that affects or potentially affects the network. The Network should then be inspected…

Network control personnel were required to sign a document to acknowledge they had received and read the alert in November 2017. The NCO and the RTM on duty at the time of the 7 March 2018 occurrence had both signed the document. Both of them recalled in interview that their understanding of the relevant wet weather procedures was that if water was observed to be in the ballast a train should be stopped.

Specific procedures for conditions affecting a network

On 16 January 2018, QR issued version 1.0 of the procedure MD-18-20 (*Supply Chain North – Condition Affecting the Network (CAN) Management*). The document stated:

> This Procedure is intended to provide strategic guidance for Supply Chain North around management of Conditions Affecting the Network (CAN).
>
> The Procedure draws together information from a number of related standards and instructions that guide the Regional Transit Manager (RTM), Network Control Officer (NCO) and/or Asset Maintenance personnel in decision making on receiving reports of "condition affecting the network". This procedure does not replace or contradict related standards; instead it aims to provide a link between each requirement by guiding the actions of the leaders…
>
> This procedure outlines how the Townsville Control Centre will identify and manage CAN's, nominating the functional roles, escalation steps, and integration requirements with other groups of the business and supporting agencies…

In terms of defining a CAN, the document stated:

> A CAN is a situation or condition that affects, or has potential to affect, the safety of the Network... Activities directly associated with a CAN included in this document, but not limited to:
>
> - Track Defect (Rough track-Buckle-Broken Rail- and other Track defects that affect the Network)
> - Extreme Weather (Heat-Wind-Floods-Earthquake's and other Extreme Weather Conditions that affects the Network)
> - Wildfires

In terms of assessing a CAN, MD-18-189 stated that the RTM and NCO were to utilise the resources from various websites (such as BoM and emergency services sites) and information from the field (via train crews, maintenance personnel, members of the public and other sources).

The procedure provided guidance on how to manage various types of conditions. The guidance related to water-related conditions is outlined in Table 4.

Table 4: Procedures for addressing water-related conditions affecting a network

Type	Action	Response
Flood water evident in the ballast above formation level, or recent evidence of flood water in the ballast above formation level or debris on track, or any signs of washouts or scouring of the formation.	Rail traffic reporting CAN to stop immediately. All subsequent rail traffic "STOP" and not allowed over reported location or nominated area until Asset Management Staff Inspect track and track has been certified fit for service.	All rail traffic to Stop in reported location or nominated location from RTM and rail traffic to be restrained with an SW11 if applicable. Any subsequent rail traffic to enter reported location or location nominated by RTM is not allowed entry until Track has been inspected by Asset Management Staff and certified fit for service.
Reports of unusual heavy rain or water pooling against formation or adjacent land, high or rising levels in creeks or waterways or any other condition that may affect or potentially affect the network	NCO if possible to obtain information from any other rail traffic or personal in nominated area to obtain an additional assessment. All rail traffic issued an Instruction (WART) over reported location and instruction remains in place for all rail traffic movement until track has been inspected from Asset Management Staff	All rail traffic is to reduce to "Restricted Speed" over entire section of reported location.
Meteorological forecasts, warnings, alerts and observations, Remote Monitoring Stations, Failure of Track Circuits or advice from Members of the Public or Emergency Services about Wet Weather conditions	Rail traffic issued an Instruction (WART) over reported location and instruction remains in place for all rail traffic movement until track has been inspected from Asset Management Staff	On validation of warnings/alerts and observations all rail traffic is to reduce to "Controlled Speed" over entire section of reported location.

Network control personnel reported the specific CAN procedure (MD-18-20) had been sent to them by email, but there had been no specific training in relation to the document.

Use of weather monitoring station and CCTV information

As noted in *Queensland Rail weather monitoring stations*, the weather monitoring stations were configured to send different types of alarm messages to the NCO's workstation and the RTM's workstation, depending on the parameter. More specifically:

- The NCO's workstation would receive flood alarms and total hourly rainfall warning alarms (more than 25 mm) and critical alarms (more than 50 mm).
- The RTM's workstation would receive flood alarms, total hourly rainfall critical alarms (50 mm) and derived rainfall rate critical alarms (25 mm/h).

All alarm messages were required to be acknowledged by the NCO and/or RTM.

If a weather monitoring station sensor failed, the system would send an alarm message to the RTM's workstation, which was also required to be acknowledged.

In addition to receiving alarms, data from the weather monitoring station (such as rainfall and water level under the rail) could be viewed at the RTM's workstation (if the relevant sensor was online). To view the data, the user had to log into a software program on a computer at their workstation. They could also view weather information via the internet on the BoM website on the same computer.

To view the CCTV images from a location, the NCO or RTM had to open a software program on a computer at their workstation and select the desired location. It the program was left open, the site would generate a new image every 2 hours. If the user refreshed the location, a new image would be displayed, but network control personnel advised it would generally take several minutes to load a new image.

Recorded data indicated that a user had refreshed the Little Banyan Creek CCTV image on the following seven occasions:

- 6 March at 2051 (12 minutes after a derived rainfall rate alarm)
- 6 March at 2139
- 6 March at 2356
- 7 March at 0023 (8 minutes after a derived rainfall rate alarm)
- 7 March at 0033
- 7 March at 0114
- 7 March at 0328 (14 minutes after the NCO had viewed the Babinda Creek CCTV).

Network control personnel reported that in general they would not routinely search for weather information or CCTV information for specific locations unless they had previous advice of problems at those locations. They would typically rely on advice from a track maintenance supervisor (TMS), train crew reports, reports from the public and weather monitoring station alarms to provide information about the extent that weather conditions were affecting the network. They also advised that there were no procedures that required them to proactively monitor weather information or CCTV information ahead of a train's progress during a CAN event.

Awareness of the status of weather monitoring stations and CCTV systems

The Townsville North NCO and the RTM on duty at the time of the occurrence both reported that they were not aware that the water level sensor at Little Banyan Creek was unserviceable at the time of the occurrence. Both of them assumed that, if the water level rose above the threshold level at that location, they would have received a flood alarm message. In addition, both the NCO and the RTM (and other network control personnel) stated they were unaware that the CCTV illuminator at Little Banyan Creek was unserviceable.

Network control personnel stated that there was no formal process in place to ensure that all RTMs and NCOs were aware that weather monitoring equipment or CCTV equipment at specific locations was unserviceable. The handover documentation for both the NCO and the RTM on duty at the time of the occurrence provided no indication to them that either the water level sensor or CCTV illuminator at Little Banyan Creek were unserviceable. Similarly, there were no other formal notices provided to network control personnel advising them of this information.

The TMS based at Innisfail reported that he also was not aware that the water level sensor at Little Banyan Creek and Murray Creek were unserviceable, and he would not normally be provided with such information. QR confirmed that TMSs were not necessarily advised when water level sensors were faulty or offline. If a fault notification was received and a request for repair work issued, then telecommunications personnel rather than the local TMS would receive the work order.

Train operations information

Aurizon procedures and guidance for managing wet weather operations

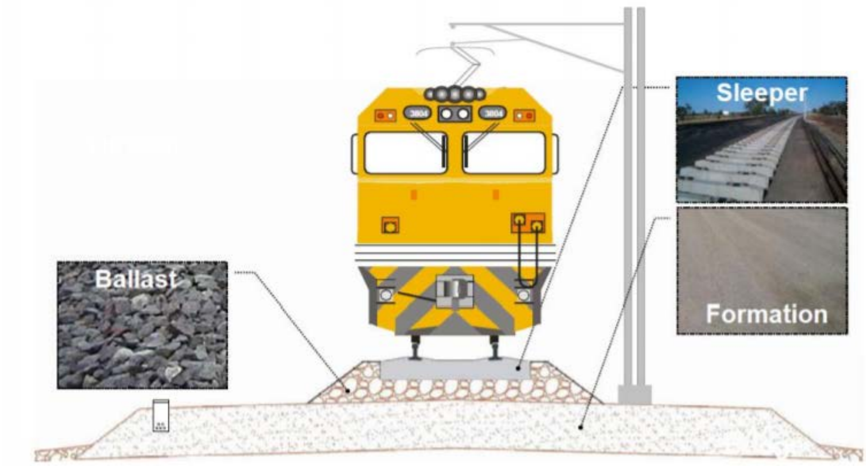
On 6 January 2016, following the December 2015 derailment near Julia Creek, Aurizon issued a critical safety alert to its train crew. Similar to the QR safety alert, it stated:

> Train Traffic Crew must immediately STOP and report to the Network Control Officer:
>
> - water on the formation and near the ballast
> - any potential track or formation deficiencies

- if the track formation and / or supporting ballast cannot be seen
- any signs of washouts or scouring on the side of the ballast or formation…

The safety alert included the following diagram to clarify the difference between the ballast and formation.

Figure 8: Except from Aurizon safety alert showing difference between ballast and formation



Source: Aurizon.

On 21 November 2017, Aurizon issued a safety, health and environment guide titled *Operation of rail traffic in adverse weather conditions*. Its purpose was to provide guidance to train crews operating in severe weather conditions. With regard to wet weather operations, the guide stated:

> When it is necessary to operate rail traffic during fog, heavy rain, unexpected storms and similar circumstances where there is reduced visibility, RTC [rail traffic crew] are to take appropriate steps to protect their safety, the safety of the rail traffic and the track infrastructure by driving to the conditions. RTC should assess the situation and regulate the speed of the rail traffic in accordance with the conditions, and advise the NCO and LRC of their intended action, i.e. they are proceeding at reduced speed because of low visibility.
>
> If operation of rail traffic in heavy rain is required, the Rail Infrastructure Manager (RIM) will normally monitor any flood indicator alarms and/or water levels and to take whatever action is necessary to ensure safe rail traffic operations (e.g. speed restrictions, track closures etc.). RTC operating rail traffic on the affected line(s) are to adhere to any instructions received and take whatever other action is necessary to ensure their own safety and the safety of the rail traffic they are operating.
>
> Occasionally, RTC will encounter storms, flash flooding or similar events where advice is not received from the RIM. In these situations, RTC are to observe any water adjacent to the rail infrastructure. Where the water level is such that the sleepers and the supporting ballast is not visible, or there is signs of washouts or scouring on the side of the ballast and/or in the formation (Refer Figure 1, 2 & 3) the RTC is required to stop the rail traffic and advise the NCO and LRC [live run coordinator].

Additional information related to wet weather operations

Driver 1 of train 6792 recalled that the Aurizon safety alert stated that a train could not proceed if water was observed to be in the ballast. As noted in *The occurrence*, driver 1 advised the NCO that the water in a culvert at the Birkalla tramway crossing was halfway up the ballast. He subsequently reported during interview that the water at Birkalla was level with the bottom of the ballast (and not in the ballast), and that he exaggerated the level of the water in his phone call to the NCO at 0611 to ensure the NCO took notice. He could see that the track was intact and there had been no scouring of the ballast, and he believed the conditions were safe for his train to proceed. However, he was concerned that the conditions would deteriorate prior to the arrival of the following train at this location.

Driver 1 stated that he was aware of the potential flood hazards along the North Coast Line, and that Little Banyan Creek was one of the most likely locations for flooding. However, in the period leading up to the occurrence, he was not concerned about that location as he was aware that it had a flood alarm and a CCTV system that were monitored by network control, and he believed that if there was a problem the NCO would have advised him about it.

Driver 1 reported that the two drivers discussed the potential hazards they could encounter during their journey that day. He also said they were more concerned about other potential flooding locations that were not actively monitored. In particular, they were concerned about Murray Flats (1,534.41 km), located to the south of Tully. Although there was a weather monitoring station at the river crossing, the land for about 2 km to the south of that was also prone to flooding.

Driver 2 stated he was aware that QR had systems in place to monitor water levels at certain bridges, and would advise them if these bridges were affected by water.

Procedures for communicating with network control

The QR standard MD-12-189 (*Queensland Network Rules and Procedures*) included requirements for communications between rail traffic crew and network control personnel. The document MD-14-36 (*General Appendix*) supplemented the MD-12-89 standard, and outlined operational instructions that applied on the QR network.

The general appendix stated that mobile phones were prohibited within rail traffic crew compartments while undertaking rail traffic crew duties. The only permitted exceptions involved the failure of the train control radio, situations where no other means of communication was available (and the train was stationary) or to allow emergency contact/fault reporting (but only to be answered by a co-driver not involved in safety critical duties).

Aurizon confirmed that, when its personnel were conducting operations on the QR network, they were required to comply with QR's network rules and procedures.

Aurizon also had an enterprise-wide guidance document on the use of mobile phones. Its general requirements included:

> Aurizon workers shall not use a mobile phone / other electronic device if that use would interfere with their safety or the safety of others…
>
> The use of personal electronic devices is prohibited while any safety-related duty is being performed, unless in case of an emergency or exceptional circumstances.

In a section covering the operation of locomotives and safety critical tasks, it stated:

> Radios are permitted for use in accordance with radio protocols. If a mobile phone is required to be used in lieu of the radio then applicable radio protocols must be complied with.
>
> Other drivers, workers and passengers traveling spare may use a mobile phone / other electronic devices if it does not interfere with any safety-related duties or distract the driver.

As noted in *The occurrence*, the driver of train 6792 used a mobile phone to initiate some of the communications with network control personnel. The driver reported that when he was using his mobile phone he used it in hands-free mode.

Communications involving train 67P8

Pacific National train 67P8 was operating about 30 minutes behind train 6792. All recorded communications between the train crew of 67P8 and the NCOs were conducted via train control radio.

The Townsville North control board NCOs did not ask the 67P8 train crew to provide any information about weather conditions en route. At 0345, the NCO on duty at the time checked that the train crew of 67P8 was aware of the signal problem at the Garradunga tramway reported by the 6792 driver (which the driver had broadcast on train control radio). However, the NCOs did not ensure that any of the information provided by the driver of 6792 about weather and track conditions was passed on to the crew of 67P8.

Controlled speed

Operational speed restrictions

QR was the owner and manager of most of the rail network in Queensland. The QR standard MD-10-107 (*General Operational Safety Manual*) included two operational speed restrictions that could be used to manage risk in particular circumstances in its network. These were:

- controlled speed – a speed that allows rail traffic to stop short of an obstruction within half the distance of clear line that is visible ahead
- restricted speed – a speed that allows rail traffic to stop short of an obstruction within half the distance of clear line that is visible ahead, but limited to a maximum speed of 25 km/h.

QR did not include any limits or guidance on the duration or distance that a train crew may be required to operate at controlled speed.

In Australia, the Rail Industry Safety and Standards Board (RISSB) and Arc Infrastructure (the owner and manager of the rail network in Western Australia) used similar definitions as QR. They also did not specify any limits on the duration or distance that may be travelled at controlled speed.

For operations in New South Wales, the Australian Rail Track Corporation (ARTC) defined 'restricted speed' as a 'speed that allowed rail traffic to stop short of an obstruction within the distance of clear line that is visible ahead'. The definition did not include a maximum operating speed. Therefore, the ARTC definition of 'restricted speed' was similar to the QR definition of 'controlled speed', although it referred to the distance of line of sight rather than half the distance of line of sight.

In December 2010, a Pacific National grain train collided with the rear of another grain train at Yass Junction, New South Wales. The ATSB investigation[12] into the occurrence identified the following safety issue:

- The current ARTC definition of restricted speed requires considerable judgement on the part of train drivers. [RO-2010-013-SI-01]

The ATSB report also stated that, when using restricted speed:

> Drivers must use their experience to judge a range of factors, in particular the sighting distance and train braking characteristics in the prevailing conditions. That judgement may also vary significantly between different drivers depending on the level of risk perceived and accepted by that driver. While the definition of restricted speed may be a 'clear and concise instruction' its application is not precise and it is something that cannot be measured unless an incident, such as a collision, occurs.

Application of controlled speed on 7 March 2018

Network control had issued the requirement for the train crews of 6792 and 67P8 to operate at controlled speed from Gordonvale to Bilyana. These sections included 134.2 km of track, and the normal sectional running time over these sections (including temporary speed restrictions) was 162 minutes.[13]

As previously discussed (*The occurrence*), recorded data from train 6792's data logger showed that the train was travelling at about 50 km/h rounding the left curve prior to the Little Banyan

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12 ATSB Transport Safety Report, Rail Occurrence Investigation RO-2010-013, *Collision between grain trains 3234N and 8922N at Yass Junction, New South Wales, 9 December 2010*. Available at www.atsb.gov.au.

13 QR published sectional running times for some types of trains to enable rail operators to plan their activities. It also published advice about additional time required for any temporary speed restrictions. Published running times did not include any allowance for starting or stopping, or associated with other traffic.

Creek rail bridge. The maximum permitted speed around the curve was 70 km/h in normal conditions, decreasing to 60 km/h at the southern side of the bridge. Therefore, the train was travelling about 10 km/h below the upcoming maximum speed limit.

Driver 1 advised that he was fully aware of the meaning of 'controlled speed'. He said that network control had issued him with requirements to operate at controlled speed on previous occasions, but he had not previously encountered a situation where he had driven into water or had water over the track. He thought that he was operating the train at about 40 km/h when it rounded the left curve (rather than the recorded 50 km/h). He realised that, in hindsight, he should have been travelling slower to fully comply with the controlled speed restriction. However, he did not expect there would be a hazard at Little Banyan Creek because of the monitoring systems that he thought were in place and working (see *Additional information related to wet weather operations*).

The ATSB reviewed the train's recorded speed in earlier parts of the journey on 7 March 2018 and compared it with sectional running times published by QR, including adjustments for temporary speed restrictions. The key results were:

- Between Gordonvale and Waugh (50.2 km),[14] the adjusted sectional running time was 58 minutes and train 6792's running time was about 71 minutes. The train's average speed (42 km/h) was 18 per cent less than the average adjusted sectional running time speed (52 km/h). There were 38 bridges, 27 speed-restricted corners and numerous other potential hazards in these sections.
- Between Innisfail and Little Banyan Creek (48.0 km),[15] the adjusted sectional running time was 63 minutes and train 9762's running time was about 68 minutes. The train's average speed (42 km/h) was 7 per cent less than the adjusted sectional running time speed (46 km/h). There were 20 bridges, 15 speed-restricted corners and numerous other potential hazards in these sections.

In terms of other locations that had a curved track prior to a bridge, similar to Little Banyan Creek:

- At Harvey Creek (1,632.654 km), the maximum permitted speed in normal conditions was 40 km/h, the train was travelling at about 35 km/h, and there was probably a similar sighting distance of the bridge due to vegetation as at Little Banyan Creek (that is, about 60 m).
- At Frenchman Creek (1,626.218 km), the maximum permitted speed in normal conditions was 40 km/h, the train was travelling at about 30 km/h, and the sighting distance was more than at Little Banyan Creek.

In both cases, the train would not have been able to stop within half the distance of the line of sight, but at Frenchman Creek the train may have been able to stop prior to reaching the bridge. Both locations had a weather monitoring station with a water level sensor.

The ATSB also reviewed the train's recorded speed at a sample of other locations. The speeds ranged from close to the maximum permitted speed to speeds significantly below (by more than 20 km/h) the maximum permitted speed. Locations where the speed was significantly below the maximum permitted speed were on both sides of Innisfail, including Whing Creek, about 15 km north of Little Banyan Creek.

In its investigation report into this occurrence, Aurizon noted that the requirement to operate at controlled speed from Gordonvale to Bilyana (134.2 km of track) was excessive for driver concentration.

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14 The train stopped several minutes after passing Waugh to allow the crew to inspect the Garradunga tramway crossing, so the time between Waugh and Innisfail did not provide a reliable indication of the train's operating speed in that section.

15 The adjusted section running time between Innisfail and Tully was 64 minutes, and 1 minute was deleted for the 600 m between Little Banyan Creek and Tully.

Network control information indicated that train 67P8, following about 30 minutes behind train 6792, was operated at a similar speed to train 6792 between Gordonvale and Waugh.

Implementation of controlled speed on other occasions

QR provided the ATSB with four other recent examples of the application of controlled speed by the Townsville network control centre. These included:

- 29 January 2019, between Orkabie and Dawlish (distance 60.0 km) on the North Coast Line for 19.4 hours. The restriction was prompted by a flood alarm that indicated water was 1 m below the rail level at Ilbilbie. Significant rain fell on the Central Queensland coast during 28–30 January 2019 and the TMS in Mackay expressed concern about the water level in culverts at Dawlish. The restriction was applied to five sections of track, which included 24 rail bridges and a number of other sites with potential hazards.
- 3 February 2019, between Ilbilbie and Koumala (distance 15.9 km) on the North Coast Line for 21.3 hours. A weather monitoring station between Ilbilbie and Koumala was reported to be defective and QR maintenance staff were unable to access the site to make repairs. The restriction was applied to a single section of track with a specific location of concern.
- 16 February 2019, between Jericho and Longreach (distance 193.6 km) on the Central Western Line for 3.5 hours. A report of heavy rainfall and rising water levels in culverts between Alice and Lochnagar prompted network control to apply controlled speed. The restriction was applied to 10 sections of track. Only one train was affected (the westbound Spirit of the Outback passenger service). The train took 3.4 hours to run from Lochnagar to Longreach, but the controlled speed restriction was cancelled at 1808 after it had run under those conditions for 1.5 hours at an average speed of about 50 km/h.
- 29 March 2019, between Pombel and Ingham (distance 13.1 km) on the North Coast Line for 1.1 hours. Water was reported to be about 0.3 m below the Cattle Creek rail bridge. The restriction was applied to a single section of track with a specific location of concern. The controlled speed restriction was applied until it was confirmed that the water level was dropping, and only one train was affected.

Use of restricted speed in the United States

In the United States, the *General Code of Operating Rules* (GCOR) were common to most railroads in North America. The GCOR stated:

> 6.27 Movement at Restricted Speed
>
> When required to move at restricted speed, movement must be made at a speed that allows stopping within half the range of vision short of:
>
> - Train.
> - Engine.
> - Railroad car.
> - Men or equipment fouling the track.
> - Stop signal.
>
> or
>
> - Derail or switch lined improperly.
>
> When a train or engine is required to move at restricted speed, the crew must keep a lookout for broken rail and not exceed 20 MPH [32 km/h]…
>
> 6.28 Movement on Other than Main Track
>
> Except when moving on a main track or on a track where a block system is in effect, trains or engines move at a speed that allows them to stop within half the range of vision short of:
>
> - Train.

- Engine.
- Railroad car.
- Men or equipment fouling the track.
- Stop signal.

or

- Derail or switch lined improperly…

In other words, the GCOR definition of 'restricted speed' was similar to the QR definition, but more explicit about the types of obstructions that were applicable. The equivalent of controlled speed was only applicable off a main track, where only short times or distances would be encountered.[16]

Based on a review of five accidents in 2011, the United States National Transportation Safety Board (NTSB) expressed concern that driver compliance with restricted speed requirements 'may be an issue affecting a broad segment of the U.S. railroad industry'.[17] The NTSB noted that ideally other mitigators would be in place to prevent collisions, but at times it was necessary for two trains occupy the same section of track and therefore collision avoidance relied on driver compliance with restricted speed requirements. It also noted that collisions in the 20 mph range could have catastrophic consequences, particularly if they involve freight trains carrying hazardous materials.

The NTSB stated that restricted speed was not a numerical value, and that to ensure safe operation of following trains the performance portion of the rule (that is, stopping within half the distance of line of sight) needed to be stressed rather than any maximum speed. Based on its review of the five accidents in 2011, the NTSB issued the following recommendation to the Association of American Railroads, the Brotherhood of Locomotive Engineers and Trainmen and the United Transportation Union:

> Through appropriate and expeditious means, such as issuing and posting advisory bulletins on your website, use the occurrences of five recent rear-end collisions of freight trains—(1) Red Oak, Iowa, on April 17, 2011, (2) Low Moor, Virginia, on May 21, 2011, (3) Mineral Springs, North Carolina, on May 24, 2011, (4) DeWitt, New York, on July 6, 2011, and (5) DeKalb, Indiana, on August 19, 2011—to urge your members to undertake a review of their operations to identify the potential for similar occurrences and to take appropriate mitigating actions.

Some research has indicated that restricted speed compliance is the most common operational rule compliance problem in the US (Cohen, 1999). Recent research into US railroad accidents identified that the rate of accidents associated with the appropriate application of restricted speed remained constant during the period 2000–2016 (Zhang and Liu, 2019). In comparison, the rate of some other accident types, and the overall accident rate, decreased.

There is limited published research about the reasons for non-compliance with restricted speed requirements. In some cases trains exceeded the 20 mph limit, and some of these exceedances have been associated with factors such as fatigue and distraction. There has also been some indications that compliance with the sighting distance aspect is more problematic for a driver than the maximum limit of 20 mph, and that a low level of expectancy of particular types of hazards can be problematic (Cohen, 1999).

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16 CSX Transportation differed from other American rail operators in its requirement that a train should not exceed 15 mph under restricted speed. It also included a controlled speed restriction, defined as 'A speed that will permit stopping within one-half the range of vision'.

17 NTSB Accident Report NTSB/RAR-12/2, *Collision of BNSF Coal Train With the Rear End of Standing BNSF Maintenance-of-Way Equipment Train, Red Oak, Iowa, April 17, 2011*. (Available at www.ntsb.gov.)

Safety analysis

Introduction

At 0612 on 7 March 2018, the Little Banyan Creek rail bridge was under 0.6 m of flowing water. The train crew of Aurizon freight train 6792 were unaware of the problem and, after their train rounded the left curve on approach to the bridge, they were unable to prevent the train colliding with the floodwater. The train did not derail and there were no injuries. However, the consequences had the realistic potential to be much worse.

This analysis will first consider the reasons why none of the relevant parties were aware that the bridge was under water before the train arrived. The use of unscheduled patrols, weather monitoring stations, active monitoring of conditions ahead of a train and communication between relevant parties are discussed. The analysis will then discuss potential reasons associated with why the train was travelling in excess of 'controlled speed' on approach to the bridge, and the driver therefore did not have sufficient time to stop prior to the collision.

Use of patrols or inspections

The last patrol of the track from Babinda to Cardwell was conducted on the morning of 6 March, and no trains subsequently used those sections because the line was closed for planned maintenance further south. After the declaration of a condition affecting the network (CAN) due to wet weather, another patrol would ideally have been conducted ahead of the two freight trains (6792 and 67P8) that were planned to depart Cairns early on 7 March.

However, there was no specific requirement to conduct a patrol or inspection, with any decision to be made based on an interpretation of whether specified conditions had been met. Queensland Rail's (QR's) CAN procedures stated that an inspection was required if there were 'reports of unusually heavy rain or water pooling against formation', 'high or rising levels in creeks or waterways', or relevant advice from meteorological warnings, weather monitoring stations or the public about wet weather conditions. Similarly, the hazard location register stated a patrol or inspection was required for particular locations along QR's North Coast Line 'after heavy rain' and at one location (Tully River and Murray Flats) if floodwater had reached a specified level.

In this case, the Bureau of Meteorology (BoM) had issued an initial flood watch for the general area on the afternoon of 6 March, indicating local flooding from late on 7 March. Although rain had fallen in the area overnight, prior to train 6792 departing Cairns, there had been no flood alarms or reports of any water-related problems with the track. The water levels at Tully River and Murray Flats were also well below the levels of concern. However, given the flood watch, the conditions had the potential to deteriorate over the coming days.

If a patrol had been conducted prior to train 6792 departing, it could have only commenced at about 0600 (during daylight), using a hi-rail vehicle with a maximum speed of 40 km/h. This would have further delayed the train by about 6 hours, and potentially longer if the Spirit of Queensland passenger train was then given priority.

In these circumstances, the decision to run trains 6792 and 67P8 without another patrol could be understood. However, the decision meant that train 6792 was in effect being used to prove the integrity of the network following the declaration of the CAN. It also meant that the other controls and processes in place to ensure track conditions were serviceable had to be effective.

Serviceability of weather monitoring stations

Little Banyan Creek was one of several locations on the North Coast Line known to be prone to flooding. In addition, it was a location where the flooding could be localised, and not able to be predicted by the conditions at other nearby locations.

Accordingly, QR had installed a weather monitoring station with a water level sensor, which would provide network control with a flood alarm if the water reached within 1 m of the rails on the Little Banyan Creek rail bridge. It had also installed a closed-circuit television system (CCTV) at the bridge.

However, the water level sensor at Little Banyan Creek had been out of service for 57 days prior to the occurrence. The CCTV's illuminator, which enabled images of the bridge to be viewed in dark conditions, had also been out of service for 14 days. In addition, the water level sensor at Murray Creek, another known flooding location 12 km south of Little Banyan Creek, had been out of action for 28 days.

Given that the region was still in its wet season, it would have been appropriate for relevant weather monitoring systems at known flooding locations to be allocated a relatively high priority for repair. At the time of the occurrence however, other types of systems directly related to the movement of train traffic received a higher priority. Nevertheless, attempts to repair the Little Banyan Creek water level sensor and CCTV illuminator had been undertaken, but the problems had not been able to be resolved.

If the relevant systems could not be repaired, then it was important for network control personnel to be aware of the problems. However, neither the network control officer (NCO) or the regional transit manager (RTM) on duty in the period leading up to the occurrence were aware that the Little Banyan Creek water level sensor or the CCTV illuminator were unserviceable. Had they been aware of the problem with the water level sensor, it is likely they would have advised the 6792 train crew of the situation, and/or taken action to obtain more information about the status of the bridge prior to the train's arrival.

When a weather monitoring station parameter first developed a fault, a message was sent to the RTM's workstation as well as to QR's fault coordination centre. After the message was acknowledged, there was no ongoing process of communicating the status of the system to network control personnel.

More specifically, QR did not have a formal process for ensuring that network control personnel were aware of which relevant weather monitoring systems or CCTV systems were unserviceable or operating in a degraded mode prior to commencing a shift. Although such a process would be useful in all situations, it was particularly important when a CAN due to wet weather was declared.

Processes for actively monitoring conditions ahead of a train

Regardless of the status of relevant weather monitoring systems, it would have been useful for network control personnel to have actively obtained information about track conditions ahead of train 6792. Such a process would have provided more redundancy in the case of problems with the weather monitoring systems, and provided more advance notice of potential problems even if the flood alarms were operational.

However, QR did not have procedures that required network control personnel to actively search for information about track conditions ahead of a train during a CAN associated with wet weather conditions, or in other situations where conditions had the realistic potential to have changed since the last patrol had been conducted or the last train had operated over the section.

It is likely that some network control personnel would actively monitor conditions ahead of a train in some situations, even without specific procedures requiring them to do so. However, there was no indication that this was done in the period immediately leading up to the collision with floodwater. Network control personnel also indicated it was not something that was normally done, and generally they only searched for information if they had already received advice of a problem, such as via a weather monitoring station alarm or a report from an external party. This occurred on the morning of 7 March when the NCO on duty up until 0400 checked the water level at Babinda on the CCTV at 0314, soon after the driver of 6792 had already provided advice about the water level.

Little Banyan Creek was the next location south of Babinda that had a CCTV system. It appeared that one or more network control personnel did attempt to view CCTV images, or at least obtain refreshed images, from the Little Banyan Creek CCTV during the 5 hours prior to train 6792 departing Cairns, and on one occasion after it had departed. This last occasion occurred at 0328, soon after the NCO on duty had checked the CCTV at Babinda. These attempts at viewing the conditions at Little Banyan Creek would have been unsuccessful, given they all occurred at night and the CCTV system's illuminator was not working. There was no attempt to view conditions at the creek after civil twilight (0554) and prior to the train arriving at the creek (0612).

In addition to the CCTV information, network control personnel could also have obtained current information on various parameters from weather monitoring stations at the RTM's workstation. If they had done this, they would have identified that there was no water level information available for Little Banyan Creek or Murray River, which should have generated an increased level of caution. Such a search would have been prudent, given that the RTM's workstation had received derived rainfall rate alarms at 2039 on 6 March and 0015 on 7 March.

To some extent, the ability to actively search for information on conditions ahead of a train will always be dependent on the workload of the network control personnel, and on this occasion the RTMs and NCOs were conducting some other tasks. Nevertheless, a formal process to actively monitor conditions ahead of a train during a CAN or similar situation should ensure that an elevated priority is given to such search tasks, increasing the likelihood that they will be able to be conducted within an appropriate time period.

The active search for information about track conditions would be facilitated if the relevant systems were easy to use and the information was readily available and prominently displayed. From the evidence available, it appeared that obtaining refreshed CCTV images and current weather parameter information from weather monitoring stations was not without some difficulty. Nevertheless, a formal procedure, with appropriate priority for this type of situation, should still ensure that relevant information would be obtained within an appropriate time period.

Communications between operational personnel

During a CAN due to wet weather or similar abnormal situation, it is essential for operational personnel to exchange relevant information to ensure that each of them can effectively perform their roles. During the morning of 7 March, however, there were several aspects of the communications involving network control personnel, trains crews and the track maintenance supervisor (TMS) that were problematic.

Firstly, the Townsville North control board NCOs requested that the 6792 train crew pass on any observations about the weather and track conditions, and the driver of 6792 provided relevant information on several occasions. Unfortunately, the driver of 6792 initiated these communications via mobile phone. The train crew of 67P8 and the TMS (after he commenced duty at 0600), listening to the train control radio, were therefore not directly aware of the reported information. The use of mobile phones is a necessary part of communications on some networks, but they were not permitted for use on the North Coast Line due to associated safety concerns.

Secondly, the NCOs were aware of some weather monitoring station alarms at locations on the North Coast Line, and when the TMS contacted the NCO on duty at 0456, the NCO on duty provided some information about the alarms that had been received. However, this information was not passed on to the train crew of 6792 or the crew of the following train (67P8). In addition, the NCOs did not pass on the relevant information about weather and track conditions provided by the driver of train 6792 (such as the water level at Babinda) to the TMS or the crew of train 67P8.

In normal operations, there would be limitations on the amount of information that needed to be communicated between these parties on the train control radio frequency. However, given a CAN due to wet weather had been declared, a recent track patrol had not been conducted, and only two trains were on the line between Cairns and Townsville at the time, increased sharing of relevant information was warranted.

Although enhanced communications between the relevant parties would have provided more assurance that hazards would be identified and managed, it is unlikely that this would have prevented the occurrence. The more fundamental problem was the absence of known information about the conditions at Little Banyan Creek.

Another communications aspect of note was that the driver of train 6792 advised the NCO at 0610 that there was water halfway up the ballast at the Birkalla tramway. According to the relevant procedures, if a train crew observed water in the ballast they were to immediately stop their train and advise network control. However, the train driver later stated that the water was not in the ballast, and it was not possible for the ATSB to verify the exact status of the water. In addition, the NCO did not have an opportunity to stop the train, as the driver was still providing his report on conditions at the time, and indicated that he had already proceeded through the area of concern.

Train operating speed

Use of controlled speed

In the absence of a recent track patrol, a serviceable water level sensor at Little Banyan Creek and/or active monitoring of the track conditions ahead of the train, the final risk control in place to reduce the risk of a collision with floodwater or a related occurrence was the requirement for the train crew to operate at 'controlled speed'.

In normal operation, a driver may assume the integrity of the network has been proven by a recent track patrol (or rail traffic) and remote monitoring. They can then drive in accordance with the displayed signals and speed limits, with the assumption that they have right of way on the track unless the signals indicate otherwise. When a controlled speed restriction is applied, the driver is required to drive a train in a manner in which it can be stopped short of an obstruction within half the distance of clear track that is visible ahead.

Instead of operating to well-known speed limits, a driver has to estimate target speeds in real time, based on their route knowledge, expectation of potential hazards on the track ahead, perception of the current visibility at the time and judgements about stopping distance in the prevailing conditions. In addition to flooding at known flooding locations, wet weather could also involve a range of other potential hazards to consider, such as signal irregularities or debris on the track. In some cases under controlled speed, a driver may be able to operate at or near the maximum permitted speed limit, whereas in some other cases they may have to operate at speeds well below the maximum speed limit. Overall, the task of estimating controlled speed would vary in complexity during a journey.

Given that the line of sight to the Little Banyan Creek rail bridge was 60 m, and the speed required to stop the train within 60 m was 15 km/h, the driver had to be travelling at much less than 15 km/h to stop within half the distance of line of sight, even if the driver had a rapid response time.

The driver of train 6792 reported that he was operating the train at about 40 km/h, and the data logger indicated the speed was about 50 km/h. Although 50 km/h was conservative relative to the maximum permitted speed of 70 km/h (in normal conditions), it was still far in excess of the controlled speed at that location.

More broadly, during the journey from Cairns, the driver operated the train at a speed that was less than the normal running time speed, indicating that he was applying a level of caution. There was evidence that the train was probably travelling at (or less than) controlled speed at some locations, but there was also evidence that the train's speed was higher than controlled speed at some other locations, including locations similar to Little Banyan Creek.

There is no detailed research that has examined train driver compliance with controlled speed and the reasons why trains have exceeded the controlled speed at particular types of locations. In contrast, a substantial amount of research has determined that road vehicle drivers reduce their speed in reduced visibility or other adverse conditions, but the adaption is not sufficient and speeds are often still inappropriate for the conditions, and a wide range of motivational, perceptual and other factors can be involved (European Commission, 2018).

The ATSB considered a range of potential reasons as to why the driver of train 6792 did not effectively comply with controlled speed on the approach to Little Banyan Creek. These reasons included expectancy, workload and fatigue.

Expectancy

The most obvious reason that the driver was operating the train in excess of controlled speed at Little Banyan Creek was that he did not expect there would be a problem at that location. He was aware that network control had access to a weather monitoring station with a flood warning and CCTV, and he believed that they would advise the train crew if there was any problem at the bridge. The fact that he appeared to be driving more cautiously at some locations that did not have a weather monitoring system, and reported that he was more concerned about locations without a weather monitoring system, is consistent with this explanation.

A person's risk perception of a situation, or expectancy that they will encounter a problem, can decrease after prolonged exposure without any adverse consequences. More specifically, the driver of train 6792 may also have been affected by a low level of expectancy of a problem because he had encountered little evidence of any flooding in the previous 112 km of the journey.

In this regard, the train's average speed was lower (relative to the normal running time speed) in the first half of the journey (Cairns to Waugh) compared to the second half (Innisfail to Little Banyan Creek). However, a range of other factors may account for this difference, including variations in the nature of the track, actual weather conditions at the time and number of perceived hazards given the conditions. The driver also applied a similar approach to approaching other bridges with similar characteristics as Little Banyan Creek (which had weather monitoring stations), prior to reaching Waugh. Overall, there was insufficient evidence to conclude that the driver was operating less cautiously over time during the journey.

Workload and divided attention

Workload is also a relevant consideration. Workload refers to the interaction between a specific individual and the demands associated with the tasks they are performing. High workload leads to a reduction in the number of information sources an individual will search, and the frequency or amount of time these sources are checked (Staal, 2004). It can result in an individual's performance on some tasks degrading, tasks being performed with simpler or less comprehensive strategies, or tasks being shed completely (Wickens and Hollands, 2000).

Driving a freight train in normal conditions involves a high level of expertise managing the mass and energy of the train in sections of track with undulating terrain and a significant number of curves and changes in speed limits, such as on the North Coast Line. In this case, the driver's workload was exacerbated by the requirement to operate at controlled speed and operating at night in weather conditions that included heavy rain. In addition, his workload was increased by passing on reports about the weather and track conditions to network control.

One potential problem with this higher than normal workload was the potential for the driver's attention to be divided at a critical time, resulting in an important task not being conducted in an effective or timely manner. For example, at the time the train was approaching the curve prior to the Little Banyan Creek rail bridge, the driver was engaged in a conversation via mobile phone about the current conditions with the NCO. A substantial amount of research has shown that the use of a mobile phone can adversely affect road vehicle driver performance, particularly in terms of reaction time and stimulus detection, with no difference in effect between handheld or hands-free use (Caird and others, 2018, Horrey and Wickens, 2006).

Given the available sighting distance after rounding the left curve prior to the bridge, the driver could not have prevented the collision, regardless of how promptly he reacted to the situation. Nonetheless, the available evidence indicates he promptly identified the hazard and reacted accordingly. The extent to which the driver’s workload may have influenced other aspects of his performance at the time, such as his consideration of potential hazards and monitoring of the train’s speed, could not be determined based on the available evidence.

Workload and sustained attention

Another aspect of the driver’s tasks and workload was the potential for his sustained attention to be affected. Research has shown that when an individual has to detect specific types of targets or stimuli over an extended period, their performance level will decrease, often typically within the first 30 minutes (Wickens and Hollands 2000). This problem, known as the vigilance decrement, has been demonstrated in a wide range of tasks, and a number of factors can influence its severity. For example, the problem increases as the salience of the targets (or hazards) decrease, the uncertainty about when the targets will occur increases, and the likelihood of encountering a target decreases.

Although there has been no specific research examining the nature of the vigilance decrement on a task such as driving a freight train at controlled speed, there is the realistic potential for a driver’s vigilance to be affected if they are performing the task for an extended period. In this case, the driver of train 6792 was operating with the controlled speed requirement for 68 minutes after departing Innisfail, and had operated with a controlled speed requirement for a longer period between Gordonvale and just passed Waugh. However, as discussed above, there was insufficient evidence to conclude that the driver’s performance changed or deteriorated over time.

Fatigue

Fatigue can have a range of adverse influences on human performance, including slowed reaction time, decreased work efficiency, reduced motivational drive, increased variability in work performance and more lapses or errors of omission (Battelle Memorial Institute, 1998), as well as various effects on decision making (Harrison and Horne, 2000). More specifically, research has shown that fatigue can lead to an increased risk of speed violations in freight train driving (Dorrian and others, 2007), and that fatigued drivers will drive faster and use brakes less in some situations, such as approaching a reduced speed limit on a downhill grade (Dorrian and others, 2006).

Sleep is vital for recovery from fatigue, with both the quantity and quality of sleep being important. Most people need at least 7–8 hours of sleep each day to achieve maximum levels of alertness and performance. Research has shown that obtaining less than 5 hours sleep in the previous 24 hours is inconsistent with a safe system of work (Dawson and McCulloch, 2005), with some research indicating less than 6 hours sleep can increase risk (Thomas and Ferguson, 2010, Williamson and others, 2011). In addition to sleep, a number of other factors can increase fatigue, including time of day, time awake and the nature of work activities.

The driver of train 6792 was woken at midnight after obtaining less than a normal amount of sleep. There is always the potential of reduced sleep and alertness in such situations, even if sufficient rest opportunity has been provided, and this is consistent with many transport activities being conducted overnight. The driver’s sustained workload could also have exacerbated any fatigue.

Overall, there was insufficient evidence to conclude that the driver was experiencing a level of fatigue likely to have a demonstrated influence on performance. It was unclear how much sleep the driver actually obtained and, as discussed above, there was insufficient evidence to indicate that the driver’s response times or other aspects of his performance deteriorated during the journey.

Summary

In summary, a range of factors had the potential to adversely influence the driver's effective use of controlled speed during the 112 km (over 3 hours of driving) from Gordonvale to Little Banyan Creek, including the last 48 km (68 minutes) since departing Innisfail. Based on the available evidence however, the only factor that can be concluded as probably influencing his use of controlled speed at Little Banyan Creek was his expectancy that there was unlikely to be any problems at the bridge, given that he had received no advice from network control about any potential problem.

Requirements to operate at controlled speed

As indicated in the previous section, the application of a controlled speed requirement on a train crew is in effect the final risk control in place to prevent a train from encountering a hazard during a condition affecting a network (CAN) or similar situation. It is undoubtedly also an important risk control to apply in many situations.

However, the effectiveness of controlled speed as a risk control has significant potential to deteriorate if it is required to be used by a train crew for an extended period. As already discussed, its application can significantly increase driver workload, and the potential for problems with divided attention as well as maintaining sustained attention (or vigilance). The workload involved can also increase the potential for driver fatigue. In addition, if the requirement is in place for an extended period and no hazards are encountered, there is the potential for a driver's expectancy of a hazard or risk perception to decrease.

Given these considerations, it would have been appropriate to have any restrictions on time or distance that controlled speed could be used as a mitigation measure for safe train operation in degraded conditions. However, QR had no such restrictions in place, and it did not provide detailed guidance for network control about how controlled speed could be applied to minimise the risk of its use for extended periods by train crews.

Network control personnel generally applied controlled speed as a risk control for specific hazards at specific locations. In such cases, it is relatively easy for drivers to comply with the requirement, particularly if they know the specific types of hazards involved. However, on the 7 March 2018, the requirement was applied for a 134.2 km of track, which involved at least 162 minutes of operation in normal operating speeds (and much longer if controlled speed was applied). As no specific locations or types of hazards were stated in the written authority, the range of potential hazards was also quite large. Network control had also applied a controlled speed requirement for significant distances (193.6 and 60.0 km) associated with wet weather conditions on two other occasions in early 2019.

Alternatives to using controlled speed for extended periods could include using 'restricted speed', with a maximum speed limit, for some or all of the distance involved. Train drivers would find this easier to comply with over extended periods, but the 25 km/h limit would significantly increase running time.

If controlled speed is applied for an extended period, other associated risk controls need to be effective. As already discussed, this includes having serviceable weather monitoring systems, procedures to ensure network control (and other parties) are aware of any relevant weather monitoring systems that are unserviceable, and active monitoring by network control of conditions ahead of the first train.

It could be argued that, if a more appropriate procedure for implementing controlled speed was in place, then the crew of train 6792 would not have had to be using controlled speed for such a distance without other risk control, such a recent track patrol, also being in place. However, based on aspects already discussed, it seems likely that the occurrence would still have resulted even if the requirement for controlled speed had only been applied for a relatively short section of track that included Little Banyan Creek.

Management of train crew workload

The problems with attempting to comply with controlled speed for an extended period for a two-driver operation could be reduced, to some extent, by the drivers effectively sharing their duties.

Aurizon's procedures for two-driver operation required one driver to operate the train and the other driver to conduct monitoring duties. The train crew reported that it was normal practice for the operating driver to handle all communications with external parties, and the drivers would swap roles halfway through the journey. Aurizon had no additional procedures or guidance for a condition affecting the network (CAN) due to wet weather, or similar situation.

The ATSB is aware than this approach to sharing duties in a two-driver crew is common across many routes and many rail operators. However, this traditional approach exacerbates the adverse effects of operating at controlled speed (or restricted speed) for an extended period. The effects could be reduced by the monitoring driver conducting some of the operating driver's duties (such as communications with network control), and/or more frequent swapping of roles between the two drivers. Alternatively, procedures requiring clear verbal nomination and agreement of potential hazards and target speeds could be introduced.

Research in aviation and some other fields has shown the important role that effective teamwork, sharing of duties and use of non-technical skills can play in managing fatigue, or at least making teams more resilient to the effects of fatigue (Dawson and Thomas, 2019). Although efforts to introduce rail resource management in rail operations have been ongoing over many years, further development is needed.

Introducing more effective application of teamwork in two-driver operations in normal situations may be a challenge for many rail operators. Nevertheless, in situations such as a CAN due to wet weather, or other situations likely to increase the normal workload and/or fatigue of the operating driver, having more detailed requirements and guidance about how to share tasks to minimise risk would certainly be beneficial.

Findings

From the evidence available, the following findings are made with respect to the collision with floodwater involving Aurizon freight train 6792 at Little Banyan Creek, Queensland, on 7 March 2018. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

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

Contributing factors

- The Little Banyan Creek rail bridge was under 0.6 m of flowing water, due to heavy rainfall in the Banyan Creek catchment in the hours prior to train 6792 approaching the bridge.
- The Little Banyan Creek weather monitoring station's water level sensor had been out of service for 57 days, and the closed circuit television camera (CCTV) illuminator, which enabled effective operation at night, had been out of service for 14 days.
- The network control officer and regional transit manager on duty in the period leading up to the occurrence were not aware that the Little Banyan Creek water level sensor was out of service. Consequently, they expected to be alerted to any problem by a flood alarm, and did not actively search for additional information about the water level at the bridge prior to train 6792 arriving.
- **Queensland Rail did not have an effective means of ensuring that, during situations such as a condition affecting the network (CAN), network control personnel were aware of the relevant weather monitoring systems that were unserviceable. [Safety issue]**
- **Queensland Rail did not have procedures that required network control personnel to actively search for information about track conditions ahead of a train during situations such as a condition affecting the network (CAN), when conditions had the realistic potential to have deteriorated since the last patrol or train had run over the relevant sections. [Safety issue]**
- The crew of train 6792 expected there were no flooding problems at Little Banyan Creek, based on not receiving any advice of a flood alarm from the network control officer.
- Train 6792 was travelling at about 50 km/h as it rounded the curve prior to the Little Banyan Creek rail bridge. With a sighting distance of about 60 m to the bridge, this speed was significantly in excess of the 'controlled speed', and the driver was unable to stop the train before it entered the floodwater.

Other factors that increased risk

- Although the driver of train 6792 provided regular updates on the operating conditions, he conducted these communications via mobile phone rather than train control radio, limiting the potential for other relevant parties to obtain the information.
- Network control personnel did not pass on all the relevant information they had about the operating conditions during the condition affecting the network (CAN) to the crews of trains 6792 and 67P8 and the track maintenance supervisor.
- During the journey south from Cairns, the driver of train 6792 was experiencing an elevated workload due to operating at night in adverse weather conditions and the requirement to operate at controlled speed. He was also providing reports of the operating conditions to

network control, including providing a report via mobile phone as the train approached Little Banyan Creek.

- **Queensland Rail did not have any restrictions on the distance or time that controlled speed could be used as a risk control for safe train operation in situations such as a condition affecting the network (CAN). The effectiveness of controlled speed has the significant potential to deteriorate over extended time periods due to its effect on driver workload, vigilance, fatigue and risk perception. [Safety issue]**
- **Aurizon's procedures and guidance for two-driver operation during situations such as a condition affecting the network (CAN) did not facilitate the effective sharing of duties and teamwork to minimise the potential effects of degraded conditions on driver workload and fatigue. [Safety issue]**

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.

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

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.

The initial public version of these safety issues and actions are provided separately on the ATSB website to facilitate monitoring by interested parties. Where relevant the safety issues and actions will be updated on the ATSB website as information comes to hand.

Advice of weather monitoring station serviceability

Safety issue number:	RO-2018-007-SI-01
Safety issue owner:	Queensland Rail
Operation affected:	Rail: Operations control
Who it affects:	Network control

Safety issue description

Queensland Rail did not have an effective means of ensuring that, during situations such as a condition affecting the network (CAN), network control personnel were aware of the relevant weather monitoring systems that were unserviceable.

Proactive safety action

Action taken by:	Proactive safety action taken by Queensland Rail
Action number:	RO-2018-007-NSA-030
Action status:	Closed

Safety action taken: In June 2020, in response to the draft ATSB report, Queensland Rail advised:

> Post incident, the Network Control Centre was retrofitted with additional visual display monitors at a prominent location in the centre. On a day to day basis, these monitors are used to provide general information on the network; however, during conditions affecting the network (CANs), the monitors are utilised to provide up to date information on the weather, track and other infrastructure.
>
> These monitors allow workers inside the Control Centre to easily identify issues with the network quickly and efficiently, without having to search through multiple screens and menus on smaller screens at their individual workstations before they can check different systems and alarms.
>
> To mitigate the risk of a network control officer (NCO) being unaware of a fault due to an alarm being silenced by a different network control officer, additional controls have been implemented to ensure applicable weather management station faults and the alarms are detected.

A formal procedure has been implemented for managing Environmental Monitoring Station (EMS) alarms by the Fault Coordination Centre (FCC), with the Control Centre to be notified. Repair of EMS faults has been classified as attendance (high priority) with response occurring as soon as practically possible. The procedure requires:

- All faults to be reported to FCC and Control Centre to be notified.
- FCC to contract local coordinator with fault details.
- If local area staff are unable to attend, Telecoms Management to be notified and Townsville staff will be organised to attend.
- Control Centre to be notified if the fault cannot be repaired.
- If fault cannot be repaired, Telecoms management to be notified and details entered into the long text of work order.

The Control Centre has implemented the following additional controls:

- FCC and Regional Transit Manager to advise either party upon receipt of an alarm indicating a fault with an EMS.
- Responsible NCO to complete a vizirail report and record on handover.
- NCO must proactively monitor resources e.g. BOM sites, Cameras, RMS, RMS, EMS, Rail Traffic Crews or any other means available for the safe management of the Network.
- Rail traffic must be issued a Written Instruction (WART) to travel at “Restricted Speed” over the location of the related disabled device/s. The WART must remain in place until either the device is functioning correctly or there is no indication of any cause for warnings/alerts etc.

In addition, when a CAN event is implemented, the Control Centre now performs a check on the weather management system and if any faults are identified within the system, NCOs provide rail traffic crew with a written instruction to proceed through the impacted area at restricted speed.

Further to this, all new devices and replaced devices are now replaced with generic sensors. The generic sensors being added do not require calibration. Generic sensors do not require specialised skills and have generic spares. This reduces the likelihood of sensor failure and increase the ability to repair failed sensors on the spot.

Status of the safety issue

Issue status: Closed - Adequately addressed

Justification: The ATSB is satisfied that the safety actions taken by Queensland Rail will reduce the risk of this safety issue.

Procedures for actively monitoring conditions ahead of a train

Safety issue description:

Safety issue number: RO-2018-007-SI-02

Safety issue owner: Queensland Rail

Operation affected: Rail: Operations control

Who it affects: Network control

Safety issue description

Queensland Rail did not have procedures that required network control personnel to actively search for information about track conditions ahead of a train during situations such as a condition affecting the network (CAN), when conditions had the realistic potential to have deteriorated since the last patrol or train had run over the relevant sections.

Proactive safety action

Action taken by: Proactive safety action taken by Queensland Rail

Action number: RO-2018-007-NSA-031

Action status: Closed

Safety action taken: Queensland Rail's internal investigation report included the following recommendation (with a due date by end of August 2018) to the manager for freight operations (Townsville):

> Develop and deliver training to Regional Transit Managers and Network Control Officers for Condition Affecting the Network events and the use of weather monitoring systems and proactive train monitoring.

In June 2020, in response to the draft ATSB report, Queensland Rail also advised:

> Queensland Rail's Rail Safety function conducted a risk assessment [of] safeworking rules and procedures to ensure they adequately manage the risk of a CAN.
>
> Linked to this risk assessment, Queensland Rail undertook a complete review of "MD-18-20 Condition affecting the Network (CAN) Management Procedure", ensuring that the documentation was clear in relation to the expectations on NCOs to proactively monitor the Network.
>
> To address the concerns with NCOs actively searching for information about track conditions ahead of a train, a training package was developed and delivered to Regional Transit Managers and NCOs for CAN events and the use of weather monitoring systems for proactive train monitoring. Additionally, as a part of their training packages, including their Maintenance of Competency training, NCOs are now required to complete a scenario which requires them to manage a CAN event.
>
> Queensland Rail has subsequently introduced "MD-20-53 Instruction – Regional Network Operational Status" which further supports the management of a CAN.
>
> This instruction requires Regional Operations North and South to provide Network users with advice and warnings regarding potential impacts to the rail network and utilises a traffic light system (Green – Amber – Red) to help convey changes to network conditions.
>
> It calls for additional controls to be implemented in the case of an increase in status rating, and importantly, these controls must be highly prescriptive in nature.
>
> It includes examples such as heightened communication between NCOs and rail traffic crew, and frequent meetings with asset management teams to obtain local / on the ground knowledge / experience on condition changes. The instruction also clearly points to specific decision makers who act as a central point of contact during a change in status, and related controls that are to be implemented.
>
> This new process provides a heightened level or management attention and focus to marshalling the full range of information sources generally and specifically available to QR when operations are to continue under operating parameters that may have changed due to weather or operational conditions.
>
> Since this process has been rolled out the Regional Network Operational Status has been stepped at least 2 times from condition green for expected weather events on Kuranda Range in the period 22-24 March 2020 and again on the North Coast Line between Cairns and Cardwell for the period 20-25 May 2020, which escalated from condition green to amber for the line from Cairns to Ingham, then to Red for the line from Innisfail to Cardwell and then extending from Cairns to Cardwell in a 7.5 hour period on the 20th May 2020.
>
> Changes introduced in "MD-20-53 Instruction – Regional Network Operational Status" help to ensure that network control personnel pass on relent information to impacted train crews and operators.
>
> Rail operators, including both internal and third party, are informed of changes to the network status via an emailed form. The information in the form is highly prescriptive in nature.
>
> When lifting the network status from either Green to Amber or Amber to Red, the control centre telephones each rail operator's live operational areas to verbally confirm the change in status.
>
> The communication clearly identifies the corridor that is potentially being impacted and the approximate location where there may be an increased risk. It also prescribes any additional controls

> required to be implemented considering the perceived increase in risk of operating during the identified event.
>
> During recent CAN events, feedback has been received from other rail party operators that the enhanced communication process has been highly effective in managing risk and ensuring safe operations during extreme weather events.

Status of the safety issue

Issue status: Closed - Adequately addressed

Justification: The ATSB is satisfied that the safety actions taken by Queensland Rail will reduce the risk of this safety issue.

Application of a controlled speed requirement by network control

Safety issue description:

Safety issue number:	RO-2018-007-SI-03
Safety issue owner:	Queensland Rail
Operation affected:	Rail: Operations control
Who it affects:	Network control

Safety issue description

Queensland Rail did not have any restrictions on the distance or time that controlled speed could be used as a risk control for safe train operation in situations such as a condition affecting the network (CAN). The effectiveness of controlled speed has the significant potential to deteriorate over extended time periods due to its effect on driver workload, vigilance, fatigue and risk perception.

Proactive safety action

Action taken by: Proactive safety action taken by Queensland Rail

Action number: RO-2018-007-NSA-032

Action status: Monitor

Safety action taken: In June 2020, in response to the draft ATSB report, Queensland Rail advised:

> Queensland Rail liaised with other rail traffic operators who use the Queensland Rail network to develop a clear understanding of the requirements of RTCs [rail traffic crews] when receiving instructions to operate at Controlled Speed.
>
> Additionally, the updated "MD-18-20" [Condition affecting the Network (CAN) Management] procedure requires the NCO to confirm with RTC their understanding of "Controlled Speed".
>
> Queensland Rail human factors and technical subject matter experts undertook a detailed review into the application of controlled speed on the Queensland rail network.
>
> The review concluded that due to the complex interactions between a vast number of performance shaping factors, a 'one size fits all' solution such as a blanket ban on the use of controlled speed was is unlikely to be suitable across the many possible operational contexts and conditions experienced on the network. These factors included (but were not limited to):
>
> - The environment (e.g. rainfall, daylight / night-time running, line of sight, gradient etc.)
> - Locomotive and rollingstock characteristics (e.g. braking performance, loco class, weight etc.)
> - Human Factors (route knowledge, experience, workload, risk perception, non-technical skills etc.)
>
> Furthermore (and notwithstanding the significant amount of research on driver behaviour for road vehicles), there is a lack of scientific research that has looked at the reasons for noncompliance and

> speeding related infringements for train drivers operating under controlled speed. This makes an evidence-based decision regarding a specific time or distance restriction difficult to establish, and industry benchmarking does not appear to provide a clear or consistent position supporting the adoption of such restrictions.
>
> Building on the changes introduced by MD-20-53 [Instruction – Regional Network Operational Status], Queensland Rail intends to review MD-18-20 to update and integrate seamlessly with MD-20-53 and following consultation with relevant above rail operators seek to integrate further information that guides the use and conditions around controlled speed vs restricted speed and communication frequency between network control and rail traffic crew including relevant enquiry by network controllers into how the rail traffic crew are managing other human factors issues within the driving cab i.e. rotation and rest breaks.

ATSB comment:

The ATSB appreciates the activities by Queensland Rail (QR) so far to review this issue, and acknowledges that a blanket ban on the use of controlled speed is not necessary. The ATSB notes that QR is undertaking further work to guide the use and conditions around controlled speed and restricted speed, and the ATSB will seek updates on the progress of QR's additional work to address this issue on a regular basis.

Status of the safety issue

Issue status: Open – Safety action pending

Procedures for sharing workload in two-driver operation

Safety issue description:

Safety issue number:	RO-2018-007-SI-04
Safety issue owner:	Aurizon
Operation affected:	Rail: Freight
Who it affects:	The operator's train crew

Safety issue description

Aurizon's procedures and guidance for two-driver operation during situations such as a condition affecting the network (CAN) did not facilitate the effective sharing of duties and teamwork to minimise the potential effects of degraded conditions on driver workload and fatigue.

Proactive safety action

Action taken by:	Proactive safety action taken by Aurizon
Action number:	RO-2018-007-NSA-033
Action status:	Monitor

Safety action taken: In June 2020, in response to the draft report, Aurizon advised:

> Aurizon will review its procedures for the management of workload in two-driver operations in circumstances where Conditions Affecting the Network may impact on driver workload.

ATSB comment: The ATSB acknowledges Aurizon's intent to review its procedures for the management of workload in two-driver operations, and the ATSB will seek updates on the progress of Aurizon's activities to address this issue on a regular basis.

Status of the safety issue

Issue status: Open – Safety action pending

General details

Occurrence details

Date and time:	7 March 2018 - 0612 EST	
Occurrence category:	Incident	
Primary occurrence type:	Collision with floodwater	
Location:	Little Banyan Creek, Queensland	
	Latitude: 17° 55.669' S	Longitude: 145° 56.074' E
Rail infrastructure manager	Queensland Rail	

Train details

Train operator:	Aurizon	
Train number:	6792	
Type of operation:	Freight	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Damage:	Minor	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- Queensland Rail
- Queensland Rail personnel involved in network control and track maintenance
- Aurizon
- the data logger from train 6792
- the driver of train 6792
- the Bureau of Meteorology.

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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 Queensland Rail, the network control officer and regional transit manager on duty at the time, the track maintenance supervisor, Aurizon, the driver of train 6792, and the Office of the National Rail Safety Regulator (ONRSR).

Submissions were received from Queensland Rail (safety action only), Aurizon (safety action only) and the ONRSR. 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 ATSB's 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 operations involving the travelling public.

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.

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, current risk controls and organisational influences.

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, 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 factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: 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.