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WorleyParsons Group

AURIZON

Central Queensland Coal Network (CQCN)

Condition Based Assessment FY 2016

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List of Abbreviations

Term	Definition	Term	Definition
AC	Alternating Current	OTCI	Overall Track Condition Index
ALCAM	Australian Level Crossing Assessment Model	QAL	Queensland Alumina Limited
APCT	Abbot Point Coal Terminal	QCA	Queensland Competition Authority
BPCT	Barney Point Coal Terminal	QR	Queensland Rail
BRTT	Below Rail Transit Time	RCF	Rolling Contact Fatigue
CBA	Condition Based Assessment	RGTCT	RG Tanna Coal Terminal
CBI	Computer Based Interlocking	RIMS	Rail Infrastructure Management System
CCTV	Closed-Circuit Television	SER	Signalling Equipment Room
CQCN	Central Queensland Coal Network	SFC	Static Frequency Converter
CSEE	Compagnie de Signaux et d'Entreprises Electriques	SRT	Section Run Time
DBCT	Dalrymple Bay Coal Terminal	tal	Tonne Axle Load
DC	Direct Current	TCU	Track Condition Unit
DTC	Direct Train Control	TFM	Trackside Functional Modules
FS	Feeder Station	TMS	Traffic Management System
FY	Financial Year	TP	Traction Power
GAPE	Goonyella to Abbot Point Expansion	TRC	Track Recording Car
GIJ	Glued Insulated Joint	TSC	Track Sectioning Cabins
GRS	General Rail Signal	TSR	Temporary Speed Restrictions
HPCT	Hay Point Coal Terminal	UHF	Ultra-High Frequency
KPI	Key Performance Indicator	US&S	Union Switch and Signal
LED	Light Emitting Diode	UT4	2016 Access Undertaking
LHT	Low alloy Heat Treated	UTC	Universal Train Control
mtpa	Million Tonnes per Annum	VPI	Vital Processor Interlocking
NCL	North Coast Line	WICET	Wiggins Island Coal Export Terminal
NTK	Net-Tonne Kilometres	WSRT	Weighted Section Run Time
OHL	Overhead Line	XLPE	Cross-Linked Polyethylene
OPGW	Optical Ground Wire		





Executive Summary

Advisian assesses that the Central Queensland Coal Network (CQCN) generally achieved the operational Key Performance Indicators (KPIs) of Below Rail Transit Time (BRTT) and Overall Track Condition Index (OTCI).

The only exceptions were marginal exceedances in monthly BRTT on the Blackwater and Moura systems for one month each. There was no exceedance of annual BRTTs.

Overall, Advisian assesses that there is no evidence to support that the CQCN has deteriorated in excess of what could be reasonably expected for an operational asset over time. Aurizon Network has adopted good operating practice and prudent and effective maintenance and asset replacement policies and practices.

In terms of the KPIs that Aurizon Network has volunteered to track and report on:

- ***The impact of Temporary Speed Restrictions (TSRs) on a number of systems is higher than the internal Aurizon Network targets***
- ***The Overall Track Condition Index (OTCI) for parts of the Moura system are within an acceptable range but trending downwards.***

The increase in TSRs is worth further comment. At this stage it is not impacting contractual obligations; however it would be prudent for Aurizon Network to investigate this increase in the impact of TSRs.

The throughput of the CQCN has increased by 35.6% from FY 2012 to FY 2016:

- In FY 2012 CQCN moved 166.7 million tonnes of coal
- In FY 2016 CQCN moved 226.0 million tonnes of coal.

This increased throughput causes heavier wear on the infrastructure and in turn increases maintenance workloads and closure times. The risk to Aurizon Network is that under increasing tonnages transported across formations designed to legacy standards and not for these loads, the backlog of sites under TSRs could grow due to lack of access or resources to address these TSRs. This may lead to Aurizon Network being forced into an inefficient reactive maintenance regime.

In the period between this Condition Based Assessment (CBA) and the initial CBA for FY 2012, the considerable efforts Aurizon Network has made in enhancing asset management practice should be acknowledged and commended. These include:

- Increasing organisational emphasis on asset management
- Improving and rationalising asset management systems
- Standardising components (where possible)
- Exploring and trialling innovative and state of the art technology.

Regulation

The CQCN is treated as a natural monopoly and is subject to economic regulation by the Queensland Competition Authority (QCA). Aurizon Network's CQCN rail infrastructure is currently regulated under the 2016 Access Undertaking (UT4). UT4 requires Aurizon Network to procure an assessment of the condition of its rail infrastructure; a Condition Based Assessment.

Aurizon Network and the QCA appointed Evans & Peck (now Advisian) to complete an initial CBA in 2013 based on FY 2012 results and Advisian has now been appointed to conduct the CBA on FY 2016 data.

The CQCN

The CQCN is Australia's largest export coal rail network and one of the largest mineral export heavy haul rail networks in the world. It consists of approximately 2,670 km of heavy haul railway across the following systems and connecting infrastructure:

- Newlands, including Goonyella to Abbot Point Expansion (GAPE)
- Goonyella
- Blackwater
- Moura.

Two of the systems, Goonyella and Blackwater, are electrified.

Each system has a different date of initial construction completion, some as early as the 1920s, and each system has a different history of incremental upgrades, with the most recent major upgrade being the Wiggins Island Rail Project completed in 2015.

The result of this is that the CQCN is not a straightforward system with a standard formation design and consistent track and train control systems. This incremental development of each system has led to a network that is a conglomerate of different asset elements with different capacities, made by different suppliers and installed at different ages under a wide range of planned and actual traffic conditions.

On the CQCN you will find 'state of the art' Voestalpine deep head hardened 60 kg/m rail recently installed in 2013, while in other parts you will find heavily worn 47 kg/m standard carbon rail installed in 1978, being maintained to safely move coal under speed restrictions.



Figure ES.1: State of the art Voestalpine advanced rail steel at Black Mountain



Figure ES.2: Worn standard carbon 47 kg/m rail on contaminated formation at the Moura Loop

On the CQCN you will also find recently constructed prestressed concrete bridges built in 2012 or 2013, while in other parts you will find a heritage listed hand laid spiral culvert or hand placed concrete arches dating from the 1920s.



Figure ES.3: Prestressed concrete bridge, built in 2012, at Euri Creek on the Newlands system



Figure ES.4: Heritage listed hand laid culvert, circa 1920s, on the Blackwater system

Methodology

Advisian generally based the FY 2016 CBA on the same methodology used by Evans & Peck for the FY 2012 CBA. This approach used:

- A high level perspective of operational KPIs as an accurate objective measure of the performance of the asset in terms of contractual commitments
- A detailed analysis and commentary of asset element performance:
  - By the use of objective lagging indicators to map the performance of these elements
  - Complemented by targeted site visits to areas of the network
  - Incorporating a review of leading indicators.

A rating system was developed using colour coding, with amber and red asset categories reflecting the medium and high risk assets and yellow and green reflecting assets with minimal or no risk. Table ES.1 describes the general application of the ratings.

The asset has been divided into the following disciplines:

- Track systems
- Structures
- Train control systems and telecommunications
- Traction distribution and power supply systems.

Advisian, in conjunction with Aurizon Network and the QCA, reviewed and agreed upon lagging and leading indicators to assess the condition of the asset.

Table ES.1: Threshold rating system

Green	Asset performing at or better than specified
Yellow	Minor non-conformance
Amber	Non-conformances with associated risk
Red	Major non-conformance
Grey	Unavailable/insufficient data

The main operational KPI is the BRTT metric. In addition to this indicator, Aurizon Network agreed to track the OTCI and TSRs as operational KPIs. The OTCI is a useful high level indicator of the condition of the top and line of the track and the TSRs are an indirect indication of how the system is handling current traffic and the consequent maintenance load. It is important to note that it is possible, as the results show, to achieve the KPI and not meet internal Aurizon Network speed restriction targets.

Operational KPIs

A summary of operational KPIs for FY 2016 and FY 2012 is shown in Table ES.2 and Table ES.3 below.

Table ES.2: Operational KPIs FY 2016

#	Operational KPI	Newlands	GAPE	Goonyella	Blackwater	Moura
1	Number of months operating above Below Rail Transit Time	0	0	0	1-2	1-2
2	Overall Track Condition Index	Below range		Below range	Below range	Within range trending downward
3	Number of days below Temporary Speed Restrictions target	>98%		<80%	<80%	<80%

Table ES.3: Operational KPIs FY 2012

#	Operational KPI	Newlands	GAPE	Goonyella	Blackwater	Moura
1	Number of months operating above Below Rail Transit Time	3-6		1-2	0	0
2	Overall Track Condition Index	Below range		Below range	Below range	Within range trending upward
3	Number of days below Temporary Speed Restrictions target	90-98%		>98%	<80%	>98%

Aurizon Network has improved on its BRTT performance between FY 2012 and FY 2016. In FY 2012, two systems were green (Blackwater and Moura), one system was amber (Newlands/GAPE) and one system was yellow (Goonyella), compared with FY 2016, where three systems are green (Newlands, GAPE and Goonyella) and two systems are yellow (Blackwater and Moura).

Aurizon Network has generally maintained its OTCI performance between FY 2012 and FY 2016; with a slight improvement in Moura OTCI. In FY 2012 all systems were green except for Moura and this result is repeated for FY 2016.

The impact of TSR has increased from FY 2012 to FY 2016.

A defect that must be addressed, but does not necessarily stop traffic, is managed by placing a TSR on a length of track until the access opportunity and the resources are available to rectify the defect at the site. TSRs may also be placed when construction or maintenance work is occurring on an adjacent track. This is a prudent and safe practice as long as it is sustainable.

A red light rating occurs when the internal Aurizon Network target for section run time (SRT) cannot be achieved 80% of the time or better. The weighted section run time (WSRT) is a calculation based on the expected delay of the length of track under restriction compared to the standard running of actual traffic. It is weighted by the amount of services that travel over that section to encourage maintenance managers to focus on the restrictions that will impact the most services.

The results for FY 2016 were:

- Newlands – achieved a WSRT better than the SRT target 99.7% of the time
- Goonyella – achieved a WSRT better than the SRT target 21.3% of the time
- Blackwater – achieved a WSRT better than the SRT target 12.0% of the time
- Moura – achieved a WSRT better than the SRT target 74.3% of the time.

At first consideration these results look counterintuitive, with the Moura system appearing to perform better than the Blackwater and Goonyella systems. However, under the current high traffic on the Goonyella and Blackwater systems, Aurizon Network is finding it very difficult to impose TSRs on these systems without leading to a significant WSRT impact. The Moura and Newlands systems on the other hand are relatively lightly trafficked and consequently, although TSRs may be common, the WSRT impact is lower. Newlands system also has the advantage of being either new or with sections reconstructed during the GAPE project leading to fewer requirements for the TSRs.

There is a clear link between TSRs, the impact on WSRT and the Queensland wet season from November to April. This indicates that many of the TSRs are driven by issues that are sensitive to wet weather, such as formation quality or ballast contamination. This is not surprising given the early construction and incremental development of much of the network. The WSRT results for the Goonyella system illustrate this wet weather impact as shown in Figure ES.5; other systems, with the exception of Newlands and GAPE, show a similar trend.



Figure ES.5: WSRT against SRT target for the Goonyella system

With the apparent increasing WSRT due to TSRs, the risk to Aurizon Network is that under increasing traffic across legacy formations, which in some places are not designed for these tonnages, the backlog of sites under TSRs could grow due to a lack of access or the resources to address these TSRs. This may lead to Aurizon Network being forced into an inefficient reactive maintenance regime. This situation has not occurred in the 2016 results but it may be prudent for Aurizon Network to investigate this risk and mitigate it.

Asset element performance

Asset element performance FY 2016

The asset element performance for FY 2016 is shown in Table ES.4.

Table ES.4: Asset element performance FY 2016

Element	#	KPI / Lagging Indicator	Newlands	GAPE	Goonyella	Blackwater	Moura
Track systems	4	Delay minutes per billion net tonne kilometres	4,000-6,000		<2,000	<2,000	2,000-4,000
	5	Percentage increase in average number of defects per month per track kilometre since FY 2012 Assessment	10-20%	>20%	10-20%	>20%	>20%
	6	Percentage of sites inspected with serious defects or urgent maintenance requirements	>70%	>70%	>70%	>70%	>70%
Structures	7	Number of cancellations due to structures	<10	<10	<10	<10	<10
	8	Delay minutes for a single service	<360	<360	<360	<360	<360
	9	Percentage of assets with >15 years remaining book life	50%-75%	>75%	25%-50%	50%-75%	25%-50%
	10	Number of days by which inspections of >50% of assets are late	<30	0	0	30-60	<30
	11	Number of days by which maintenance of >50% of assets are late	<30	0	0	0	0
Train control systems	12	Minutes per billion net tonne kilometres	<7,500		<7,500	<7,500	15,000-20,000
	13	Percentage increase in average number of faults per month per track kilometres from FY 2012 Assessment	>20%	0	10-20%	10-20%	10-20%
Telecommunications	14	Minutes per billion net tonne kilometres	<200		<200	200-400	<200
	15	Percentage increase in average number of faults per month from FY 2012 Assessment	>20%		>20%	>20%	>20%
Traction distribution	16	Delay minutes per billion net tonne kilometres	N / A	N / A	<4,500	<4,500	N / A
	17	Number of dewirements	N / A	N / A	<12	<12	N / A
	18	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	<10%	<10%	N / A
Power supply systems	19	Delay minutes per billion net tonne kilometres	N / A	N / A	<4,500	<4,500	N / A
	20	Percentage of feeder transformer oil tests giving exceptions	N / A	N / A	<10%	<10%	N / A
	21	Percentage of auto transformer oil tests giving exceptions	N / A	N / A	10-15%	10-15%	N / A
	22	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	<10%	<10%	N / A

The red ratings for percentage increase in number of defects stands out clearly in lines 5, 13 and 15. This is a measure that could not be assessed in the previous CBA because it is a relative movement between CBAs. This apparent increase in defects is possibly a combination of an actual increase in defects combined with an improvement in reporting systems. Advisian has noted significant improvement in Aurizon Network reporting systems which supports that a large part of these increased reported defects is due to better reporting. Notwithstanding this, increasing defects are likely with an aging asset and Aurizon Network should monitor this.

Asset element performance FY 2012

The asset element performance for FY 2012 is shown in Table ES.5 below.

Table ES.5: Asset element performance FY 2012

Element	#	KPI / Lagging Indicator	Newlands	GAPE	Goonyella	Blackwater	Moura
Track systems	4	Delay minutes per billion net tonne kilometres	2,000-4,000	<2,000	2,000-4,000	2,000-4,000	<2,000
	5	Percentage increase in average number of defects per month per track kilometre since previous assessment	N / A	N / A	N / A	N / A	N / A
	6	Percentage of sites inspected with serious defects or urgent maintenance requirements	>70%	N / A	>70%	>70%	>70%
Structures	7	Number of cancellations due to structures	<10	<10	<10	<10	<10
	8	Delay minutes for a single service	<360	<360	480-600	<360	<360
	9	Percentage of assets with >15 years remaining book life	>75%	>75%	>75%	25%-50%	25%-50%
	10	Number of days by which inspections of >50% of assets are late	<30	30-60	30-60	30-60	0
	11	Number of days by which maintenance of >50% of assets are late	<30	N / A	0	N / A	N / A
Train control systems	12	Minutes per billion net tonne kilometres	15,000-20,000	<7,500	7,500-15,000	<7,500	<7,500
	13	Percentage increase in average number of faults per month per track kilometres from previous assessment	N / A	N / A	N / A	N / A	N / A
Telecommunications	14	Minutes per billion net tonne kilometres	<200	<200	200-400	N / A	<200
	15	Percentage increase in average number of faults per month from previous assessment	N / A	N / A	N / A	N / A	N / A
Traction distribution	16	Delay minutes per billion net tonne kilometres	N / A	N / A	<4,500	<4,500	N / A
	17	Number of dewirements	N / A	N / A	<12	<12	N / A
	18	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	<10%	<10%	N / A
Power supply systems	19	Delay minutes per billion net tonne kilometres	N / A	N / A	4,500-6,750	<4,500	N / A
	20	Percentage of feeder transformer oil tests giving exceptions	N / A	N / A	<10%	10-15%	N / A
	21	Percentage of auto transformer oil tests giving exceptions	N / A	N / A	10-15%	<10%	N / A
	22	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	10-15%	<10%	N / A

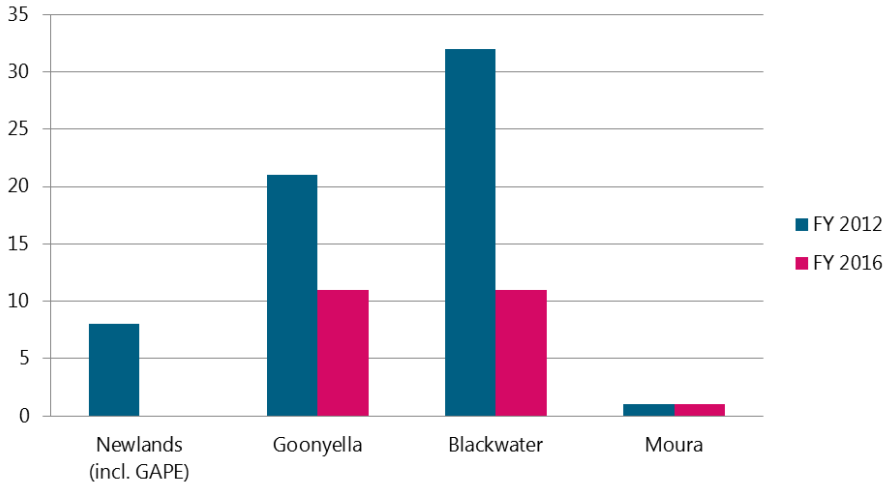


Figure ES.6: Number of derailments in FY 2012 and FY 2016

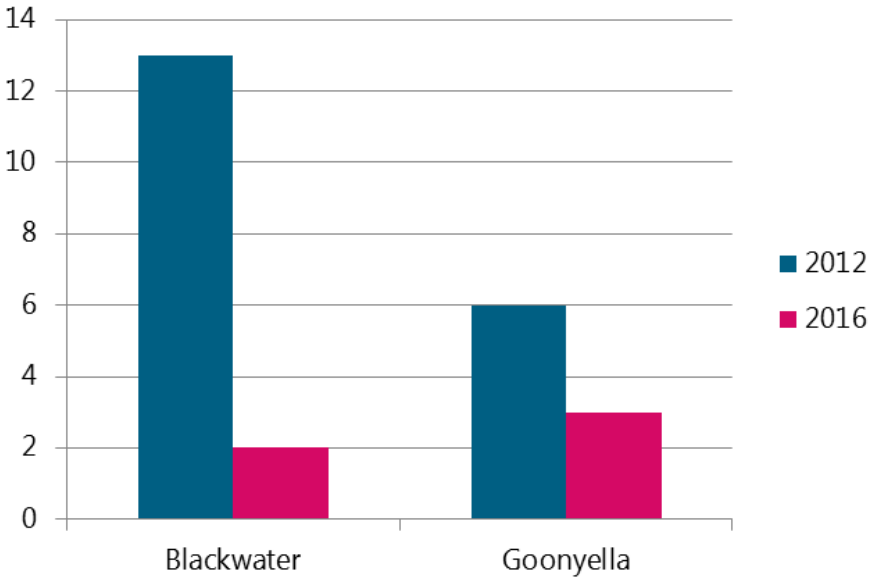


Figure ES.7: Number of dewirements in FY 2012 and FY 2016

Other relative improvements from FY 2012 to FY 2016 include:

- Significant decrease in derailments (Figure ES.6) and dewirements (Figure ES.7)
- Performance of structures on all systems
- Reliability of traction distribution and power supply systems on the Goonyella system
- Decrease in delays due to signalling on the Newlands system
- Minimal delays due to telecommunications.

There have been increases in delays on the Newlands system due to track issues and on Moura due to signalling.

Track systems

Rail

Aurizon Network has the following types of rail on the network:

- 60 kg/m Voestalpine advanced rail steel (370 LHT)
- 60 kg/m head hardened steel
- 60 kg/m standard carbon steel
- 53 kg/m standard carbon steel
- 50 kg/m standard carbon steel
- 47 kg/m standard carbon steel
- 41 kg/m standard carbon steel.

The 60 kg/m head hardened steel is becoming the standard on the network; the longer life of this rail compared to 60 kg/m standard carbon steel makes it a better option from a whole of life perspective despite its higher initial cost. The 53 kg/m and 47 kg/m rail can be found in older sections of the track but are gradually being replaced by 60 kg/m rail as they wear out. The 41 kg/m rail is rare and only found in bad order sidings and on the Nogoa-Wurba junction main line. The 60 kg/m Voestalpine advanced rail steel has been installed at all re-rail sites throughout the network.

The types of defects identified on the rails during the site inspection included:

- Rolling contact fatigue (RCF)
- Squats
- Gauge and head corner checking (leading to head shelling)
- Wheel burns
- Plastic flow.

These are normal defects for a heavy haul rail system and are being controlled by Aurizon Network through a rail grinding and, where required, rail replacement programs. These programs are informed by track recording car (TRC) data and ultrasonic testing. Aurizon Network does appear to have a specific issue with plastic flow on the low rail of curves. This appears to be because trains are travelling slower than the design cant; Aurizon Network has a program in place to address this.

Sleepers and fasteners

Aurizon Network has the following types of sleepers and fasteners on the network:

- 28.5 tal sleepers and Pandrol E clips
- 28.5 tal sleepers and Pandrol FAST clips
- 28.5 tal FIST clip sleepers and fasteners
- 22.5 tal FIST clip sleepers and fasteners
- Various size steel sleepers and appropriate fasteners
- Timber sleepers and dog spikes or screws.

The current policy is to move towards the 28.5 tal concrete sleepers with Pandrol clips as standard. However there is a great deal of the other types of configurations in the network. The FIST sleepers and fasteners, South African manufactured from the 1980s and early 1990s, are particularly problematic from a maintenance perspective as corrosion and failure of the bolt through the sleeper under the ballast is not easily observed. Aurizon Network is gradually replacing these sleepers with sleepers suitable for Pandrol fasteners. Advisian observed some sleepers with derailment damage installed and operational on the Moura system; these sleepers were serviceable and it was appropriate for Aurizon Network to leave them in place.

Advisian assesses that Aurizon Network has a reasonable and effective approach to sleeper and fastener management.

Ballast

Maintaining ballast quality is a major challenge for Aurizon Network. This challenge comes from:

- Contamination by coal fines
- Contamination by poor formation
- Mechanical and chemical degradation.

Contamination by coal fines was observed at a number of locations during the site inspection. It was particularly evident at locations where the track configuration had potential to shake off coal on various parts of the wagons external to the bin. The amount fugitive coal can increased by poor loading practices. Coal fines are weak and there is a contamination limit, approximately 25% coal dust by volume, where the ballast is rendered ineffective and the track cannot maintain top and line.

Although most of the system appeared to have this contamination managed, a number of locations observed during the site inspection were badly contaminated and Advisian assumes that these locations would potentially require TSRs in wet weather.

Formation

The CQCN has formations that range from recently constructed well-engineered formations and drainage to legacy formations with little engineering and constructed with material adjacent or near the site. The older formations were constructed to lighter axle loads than the existing formations. The CQCN formations must also be suitably constructed to handle extreme weather events.



Figure ES.8: Formation scour repair on the Moura system

In general terms the formations appear to be performing adequately, although the impact of wet weather can be seen in the TSR analysis, indicating some formations do not perform well after prolonged periods of rain; the notable exception here was the Newlands system, including GAPE, which performed consistently regardless of rainfall. Figure ES.8 shows an example of formation repair where there has been scouring due to wet weather on the Moura system.

Aurizon Network is exploring some in situ localised cost effective options to increase formation performance such trench drains and shear keys; these trials are not complete at the time of this report.

Structures

The structures for the four systems were generally in good condition. The following issues were commonly identified:

- Propping/bracing concrete culverts
- Corrosion of galvanised steel culverts
- Blocked culverts with poor up and down stream drainage
- Concrete cracking in bridge beam girders
- Bearing pads on bridges.

The age of culverts on the Moura and Blackwater systems reflect that the majority of culverts have between three and 15 years remaining book life. The condition of culverts did not result in any delays or cancellations. A number of these culverts have been propped to extend their service life. Although this is an effective short term solution for maintaining structural capacity of the culverts, propping restricts water flow and in many instances significant levels of debris had accumulated. Alternatives to consider are lining with smaller diameter pipes, repairs and local strengthening or worst case replacement with a new culvert or small bridge. Aurizon Network is employing all these various options. Aurizon Network has employed some ingenious methods of retrofitting some bridges designed for lighter axle loads to be able to carry heavier loads, as shown in Figure ES.9 below.



Figure ES.9: Overflow bridge with retrofitted reinforcing chords to increase capacity

Some culvert invert levels were also too low, resulting in water pooling in and around the track. This leads to sediment build up and increased corrosion rates where galvanised steel lined culverts are present.

Minor cracks and some issues with bearings were found on some bridges in the Newlands system and these should be investigated further as they could impact long term. Potential causes of the cracks are overstressing of the concrete at transfer or in service, shrinkage cracks from the frame anchor bolts. Some girders may need to be jacked and have the bearings reset.

Train control systems and telecommunications

Signalling and telecommunications assessment results for FY 2016 generally indicate improved results across the CQCN relative to FY 2012.

Since FY 2012 there has been a significant increase in the number of faults recorded against both signalling and telecommunication, however this has not resulted in increased operational delays. This suggests that reporting practices have become more stringent, potentially aiding the improved delay results seen in the Newlands and Goonyella systems.

During site visits there was an inconsistent use of air conditioning units in signalling equipment rooms (SERs), indicating that across the network there may not be a well-established requirement regarding the use of SER air conditioning units. Ideally air conditioning units should automatically turn on once a threshold temperature is reached to ensure equipment does not fail before its design life.

One of the major issues with train detection on the network is the coal dust ballast contamination that occurs in certain locations. This is most evident on the exit road from the various coal unloading locations, likely due to loose dust lodging on the hopper door mechanisms and wagon running gear and being shaken off at points crossings and bad rail joints. Contaminated ballast impacts upon the rail to rail impedance to which track circuits settings are adjusted. If the impedance varies greatly, more frequent inspection may be required to check and correct the track circuit adjustment. Site visits also indicated that there were high levels of contamination around point machines, raising concerns around longevity of point machine and turnout life.

The base standard for the Aurizon Network is relay interlockings using British Rail Specification 930 relays. Controls and indications are wired out to the trackside equipment using copper cables. Aurizon Network also use Computer Based Interlockings (CBI). The three main CBI used on the Aurizon Network are:

- VPI – developed by GRS (now an Alstom product)
- Microlok – developed by US&S (now an Ansaldo product)
- Westrace – developed by Westinghouse (now a Siemens product).

The deployment of these interlocking types is shown in Figure ES.10 below.

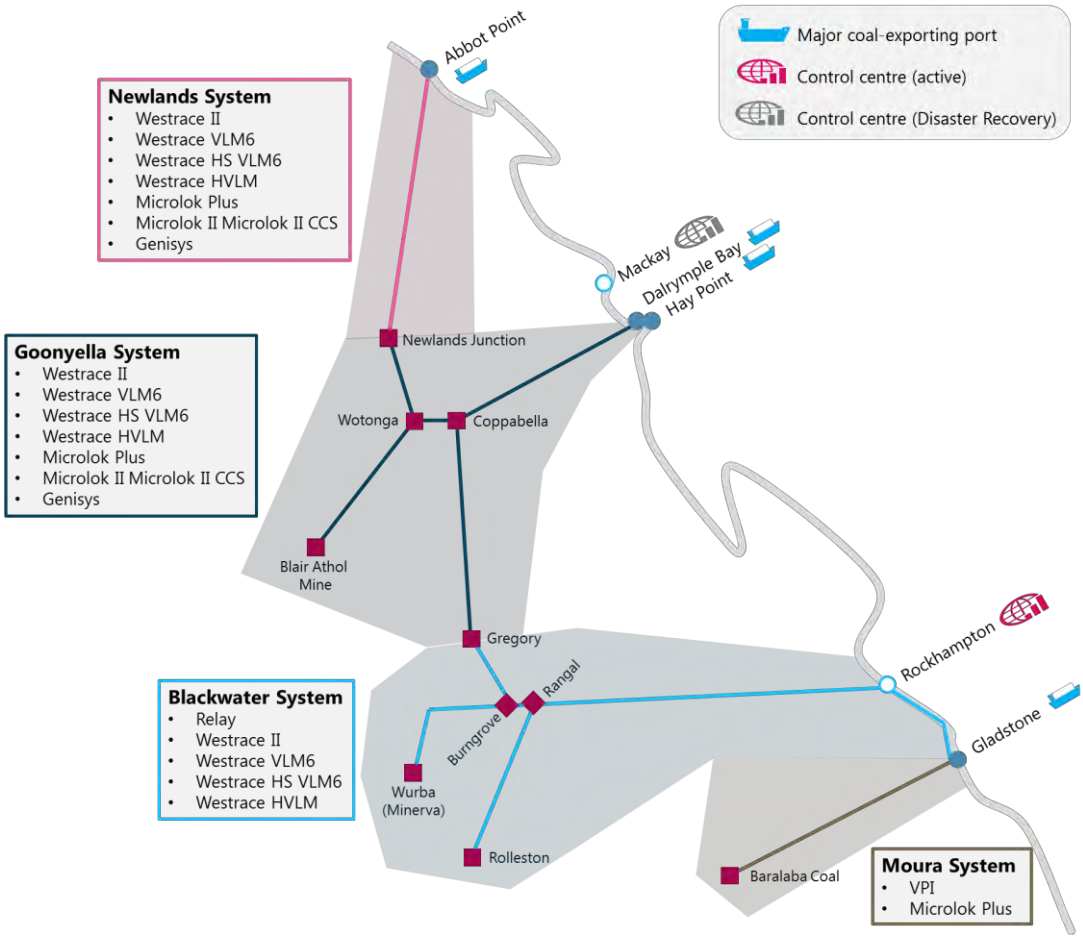


Figure ES.10: CQCN interlocking types

This approach avoids Aurizon Network being constrained to a single supplier. The disposition of interlocking types, with each system within the network being predominantly fitted with one interlocking type, minimises spare holdings in each area maximises the skills of staff.

The telecommunications framework is shown in Figure ES.11 below.

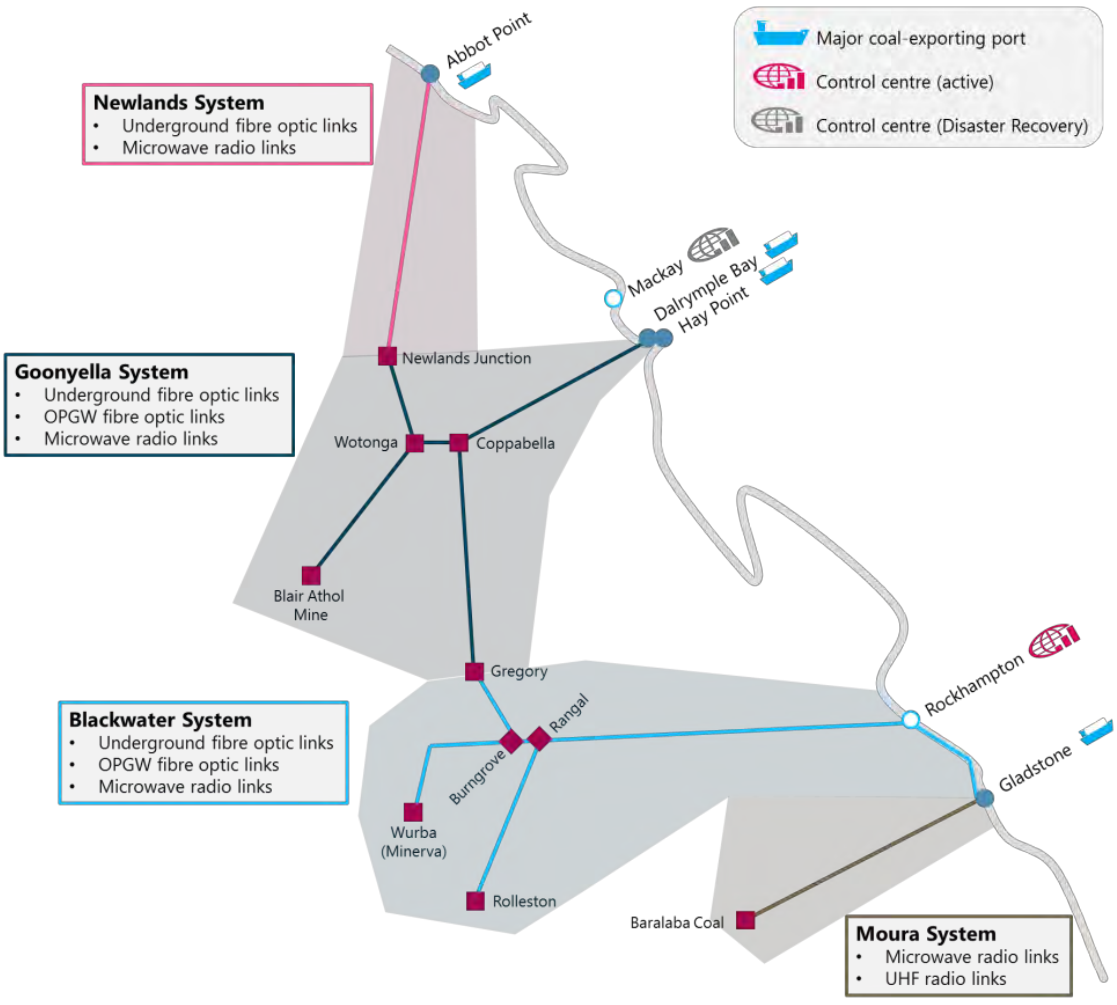


Figure ES.11: CQCN telecommunications framework

Traction distribution and power supply systems

There has been a significant improvement in the traction distribution and power supply systems from FY 2012 to FY 2016. The results see a drop in delay minutes in the Blackwater and Goonyella systems. This shows Aurizon Network's maintenance effort has been well focused.



Figure ES.12: Traction distribution system at a turnout on the Blackwater system

Traction power fault delays are significantly lower than the overhead contact system as the faults can be quickly isolated resulting in resumed operations and there is some redundancy in the power supply system.

The site inspections carried out on autotransformer and feeder stations in the Goonyella and Blackwater systems, coupled with the Aurizon Network's oil analysis data, indicate the systems are being maintained to a serviceable standard. However, some units within the Blackwater system have returned a poor oil condition test result.

The only significant issue with the feeder stations in this system was at Dalrymple Bay. This was attributable to failures on the harmonic filter. Advisian recommends further investigation of this by Aurizon Network.

The upgrade program to the Blackwater system means many of the autotransformers are relatively new. This replacement and refurbishment of the autotransformers aligns to Aurizon Network's renewal program described in the CBA for FY 2012. There is a significant improvement in feeder stations in these sections compared to the previous analysis.

Integrated system view

The delays on the CQCN for below rail impacts are shown below in Figure ES.13 for FY 2016.

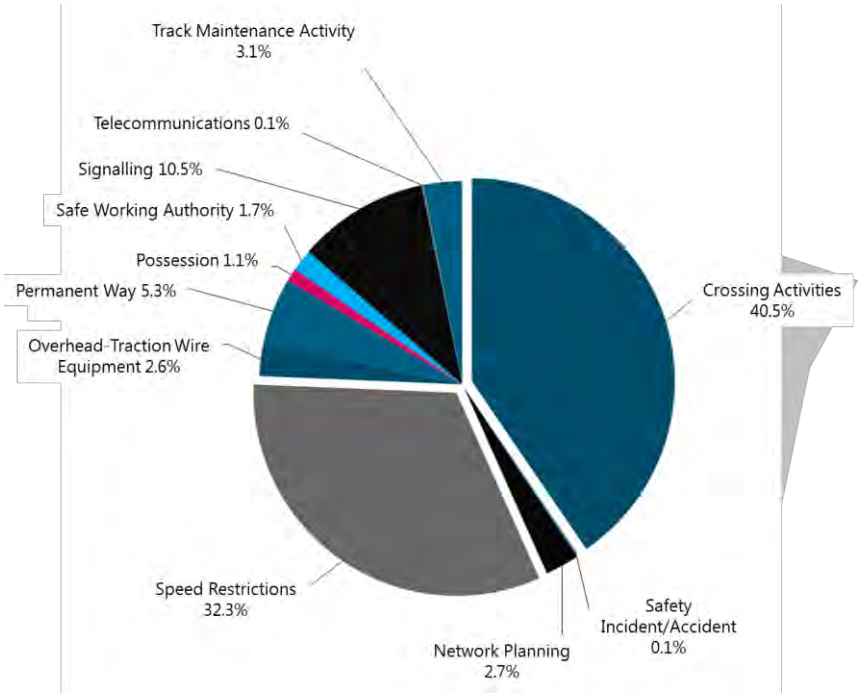
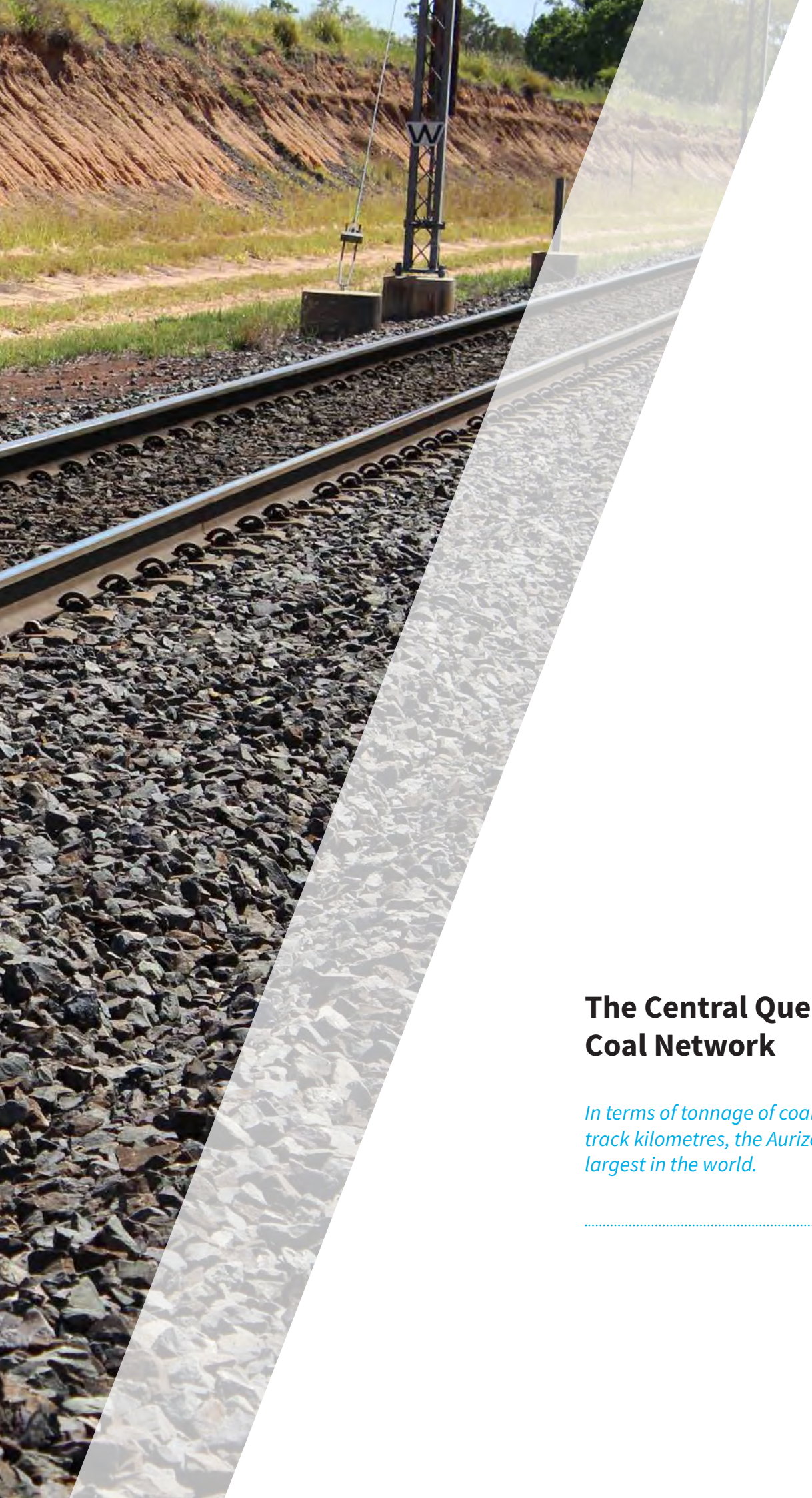


Figure ES.13: Total reported delays for FY 2016

The biggest delays are due to the impacts of speed restrictions and crossing activities. The large portion of delays attributed to speed restrictions is indicative of the extent to which degraded and underperforming infrastructure is impacting on above rail travelling speeds. The crossing activity delays represent trains waiting for a path at yards or passing loops. This may indicate that the current infrastructure may be approaching capacity.





1

The Central Queensland Coal Network

In terms of tonnage of coal transported and track kilometres, the Aurizon CQCN is one of the largest in the world.

1.1 Overview

Haulage and size of the CQCN is compared against other international rail networks in Figure 1.1 below.

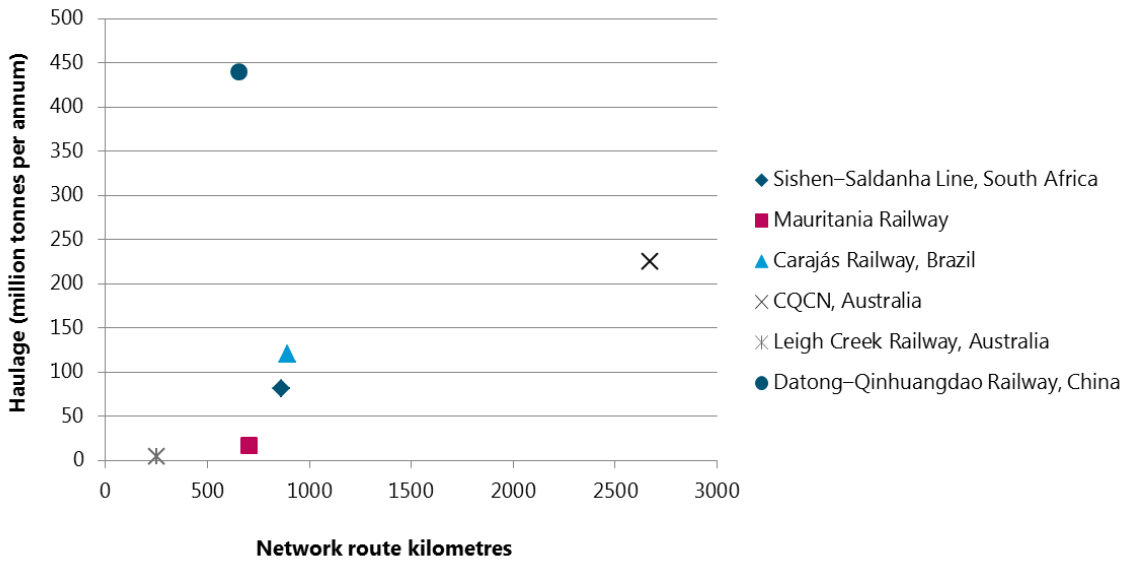


Figure 1.1: CQCN compared with other international rail networks

The tonnage transported on the CQCN has increased steadily and has more than doubled since the late 1990s, as shown Figure 1.2 below.

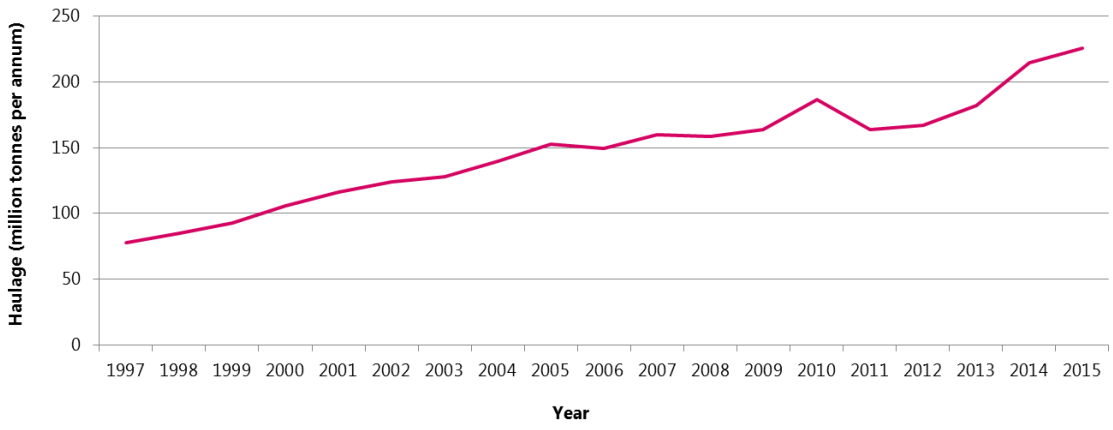


Figure 1.2: Historical tonnages of the CQCN

1.2 Newlands system

Track length	193 kilometres (not electrified)
Rail weight	53 kg/m and 60 kg/m
Sleepers	Concrete
Axle load	26.5 tal
Max design speed	80 km/hr
FY 2016 tonnage	12.1 million tonnes

The Newlands system is located at the northern end of the Bowen Basin. It incorporates part of the North Coast Line (NCL) between Durroburra and Kaili and connects to the Abbot Point Coal Terminal (APCT).

The system is single line with passing loops, duplicated at Briaba. It is non-electrified and services mine balloon loops at the Newlands, Sonoma and McNaughton mines. The system connects to terminals at APCT.

The system operates an H82 reference train with 82 wagons of 26.5 tal. During the 2012 GAPE project some sections of the original track, Euri Creek and Briaba, were maintained at 20 tal to minimise cost and constrained operationally to unloaded traffic.

1.3 Goonyella to Abbot Point Expansion (GAPE)

Track length	81 kilometres (not electrified)
Rail weight	60 kg/m
Sleepers	Concrete
Axle load	26.5 tal
Max design speed	80 km/hr
FY 2016 tonnage	16.0 million tonnes

The GAPE was commissioned on 19 December 2011. It connects the Goonyella system to the Newlands system. It has been designed to increase capacity on the combined GAPE and Newlands connection to the APCT to 50 mtpa.

Following the GAPE expansion, there has been an increase in the maximum axle loading from 20 tal to 26.5 tal, with a 30 tal design provision.

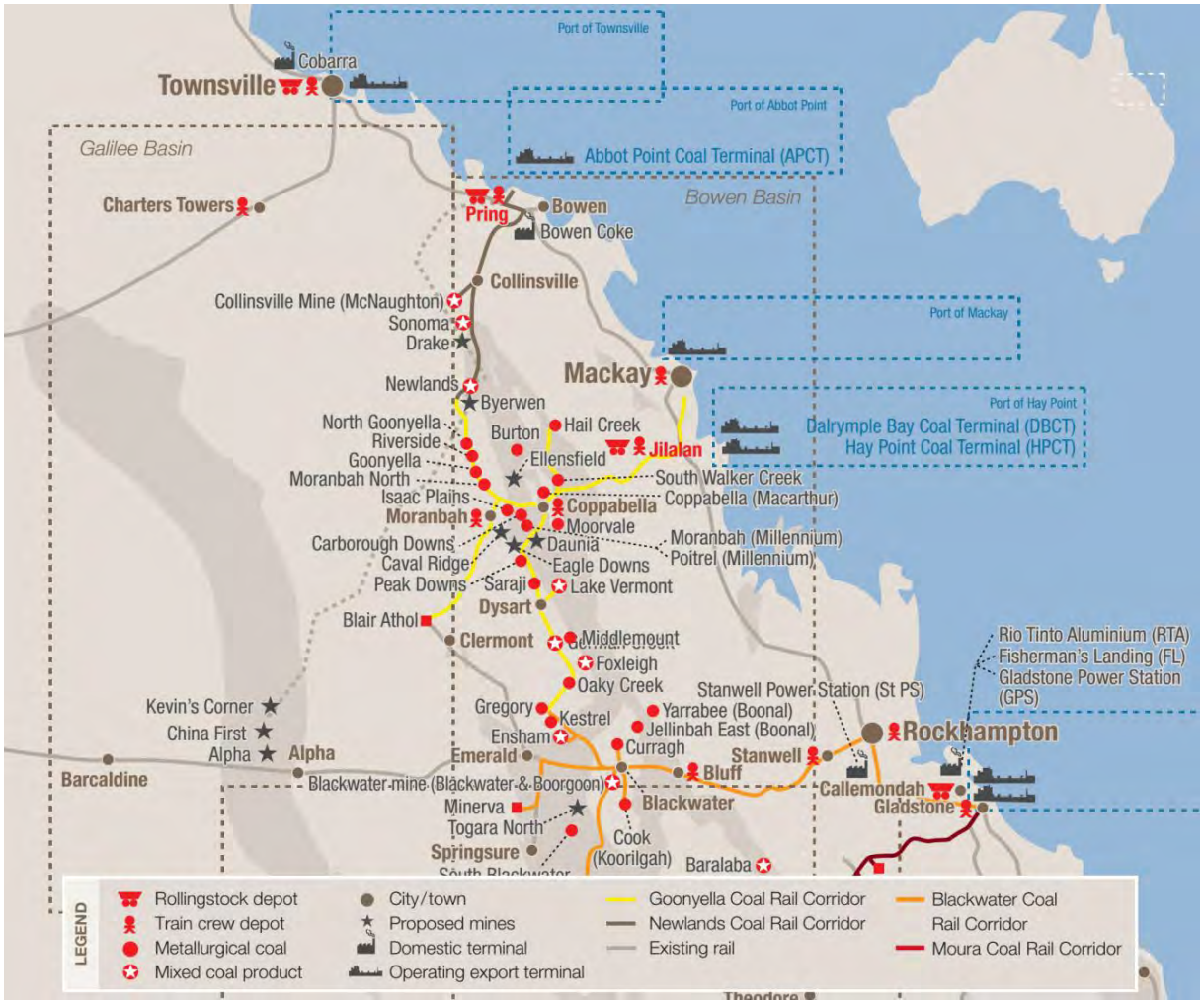


Figure 1.3: Newlands system and GAPE

1.4 Goonyella system

Track length	978 kilometres (electrified)
Rail weight	47 kg/m, 53 kg/m and 60 kg/m (main line) 41 kg/m (some bad order sidings)
Sleepers	Concrete (main line) Timber (some balloon loops)
Axle load	26.5 tal
Max design speed	80 km/hr (generally)
FY 2016 tonnage	121.5 million tonnes

The Goonyella system is located in Central Queensland and services the Bowen Basin. Coal is transported to Hay Point Coal Terminal (HPCT) and Dalrymple Bay Coal Terminal (DBCT).

The system is mainly comprised of bi-directional duplicated track with crossovers between Dalrymple Junction and Wotonga. The remainder of the track consists of duplication between Coppabella and Ingsdon. A single line connection links the Goonyella system with the Blackwater system via Oaky Creek to Gregory. The line is electrified by an autotransformer system with the overhead line (OHL) equipment at 25,000 volts, 50 Hz, alternating supply.

The system services balloon loops at many mines including Goonyella, Riverside, North Goonyella, Moorvale, Millennium, Carborough Downs, Isaac Plains, Blair Athol, South Walker and Hail Creek. In addition, the line services dual unloading balloons at HPCT and triple unloading balloons at DBCT.

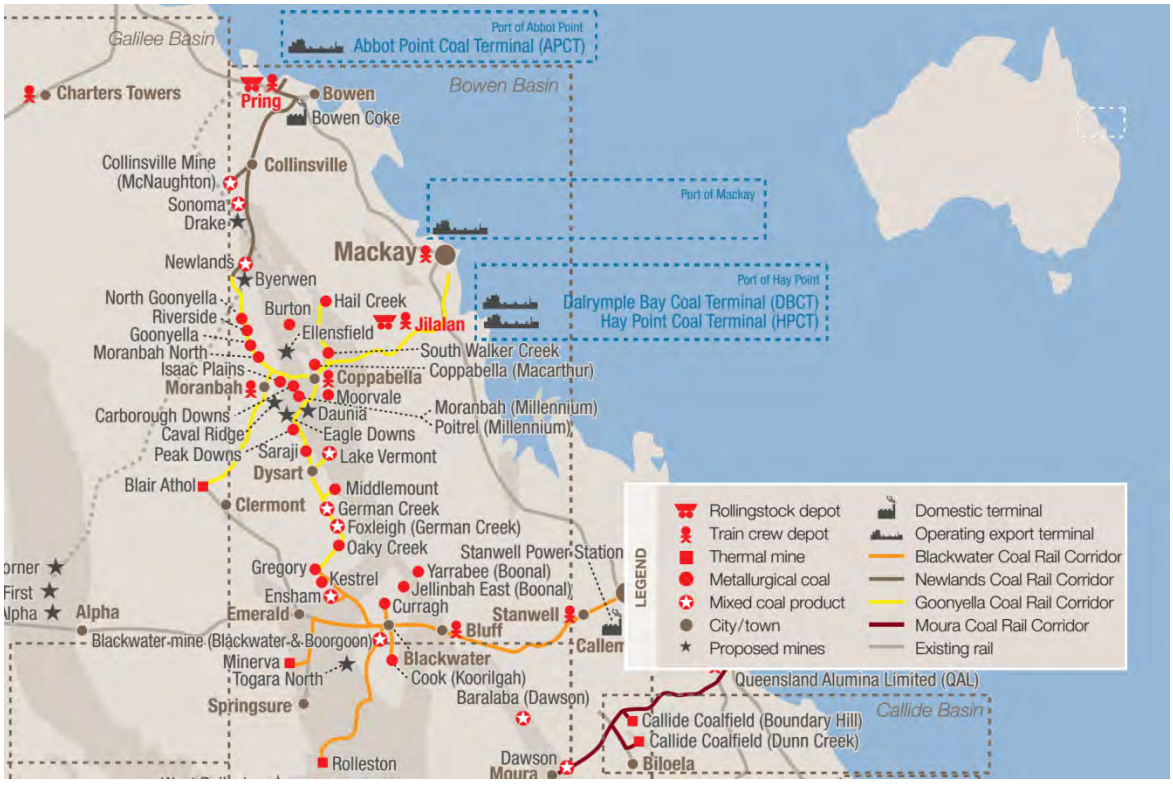


Figure 1.4: Goonyella system

1.5 Blackwater system

Track length	1,082 kilometres (electrified)
Rail weight	41 kg/m, 47 kg/m, 50 kg/m, 53 kg/m and 60 kg/m (main line)
Sleepers	Concrete, steel and timber
Axle load	26.5 tal
Max design speed	80 km/hr (generally)
FY 2016 tonnage	64.4 million tonnes

The Blackwater system services coal mines off the Central Line. It transports coal to the Stanwell Power Station, Gladstone Power Station and the Port of Gladstone via the NCL to the export facilities at RG Tanna Coal Terminal (RGTCT) and Barney Point Coal Terminal[1] (BPCT).

The system mainly comprises of bi-directional duplicated track with crossovers between Callemondah and Rocklands, Stanwell and Dingo and Bluff and Rangal. The Wiggins Island Rail Project completed the duplication of the eastern end of the Blackwater system.

The line is electrified with the OHL equipment operating at 25,000 volts, 50 Hz, alternating supply. It services loading balloon loops at East End, Boonal, Koorilgah, Curragh, Boorgoon, Kinrola, Ensham, Gordonstone, Rolleston, Minerva and Gregory with a spur line at Fairhill for Yongala. In addition, it services triple unloading balloons located at Golding, as well as unloading balloons at Stanwell Powerhouse, Fishermans Landing, Gladstone Powerhouse, BPCT and Comalco. There is also a section of non-electrified track from Nogoa to Minerva mine.

The Blackwater system also provides access for bulk commodities above rail traffic to the balloon loops at Auckland Point, which are managed and owned by Queensland Rail (QR).



Figure 1.5: Blackwater system

[1] Services to BPCT ceased during FY 2016.

1.6 Moura system

Track length	234 kilometres (12.9 kilometres is electrified)
Rail weight	47 kg/m, 53 kg/m and 60 kg/m (main line)
Sleepers	Concrete (main line) Timber (some balloon loops/sidings)
Axle load	26.5 tal
Max design speed	80 km/hr (generally)
FY 2016 tonnage	11.9 million tonnes

The Moura system services the industrial and rural communities of the Dawson and Callide Valleys. The transported goods are hauled by diesel electric locomotives to the export facilities at RGTCT, Auckland Point, BPCT and Queensland Alumina Limited (QAL) and to intrastate destinations via the NCL.

The system is comprised of single line railway with passing loops.

The Callemondah Yard, Powerhouse and RGTCT balloon loops are electrified with the OHL equipment operating at 25,000 volts, 50 Hz, alternating supply; however currently only diesel locomotives operate on the Moura system. Other balloon loops are located at Boundary Hill, Callide Coalfields and Moura mine.

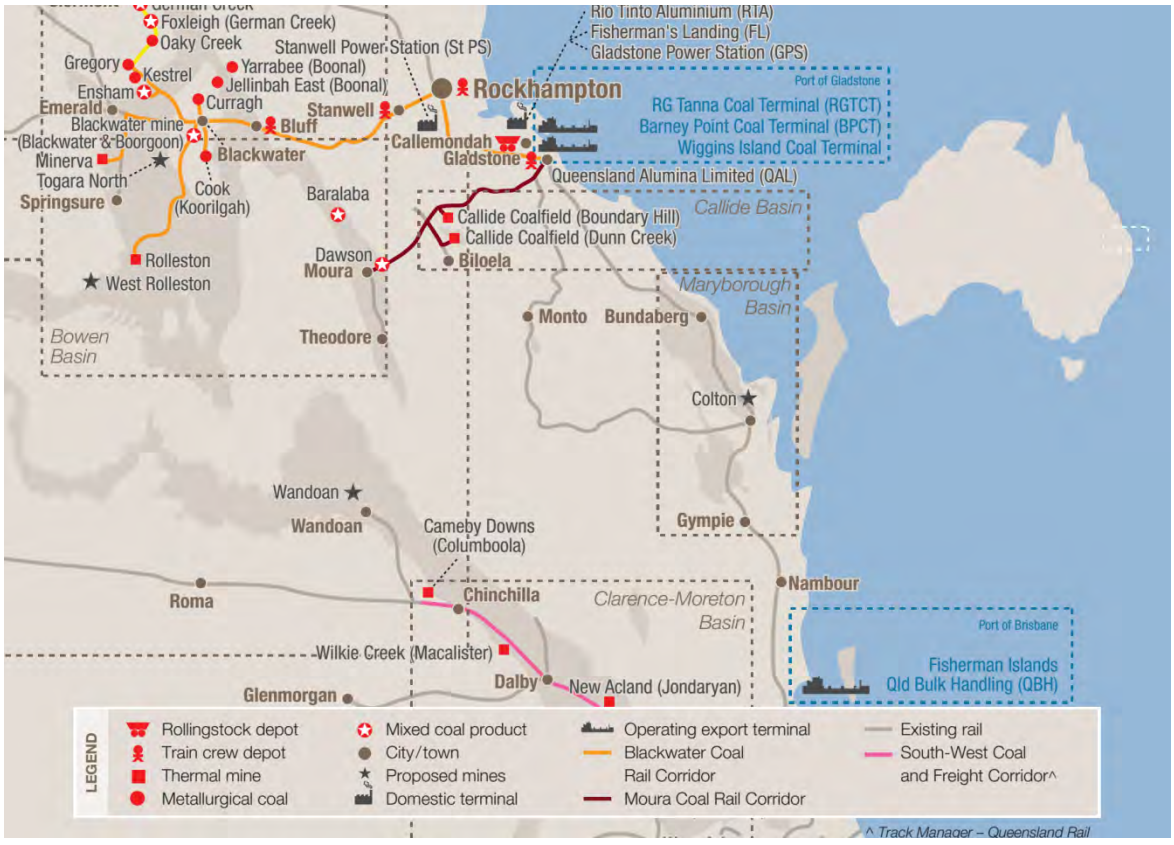


Figure 1.6: Moura system


CAUTION
CAUTION

2



CQCN Rail Infrastructure

This CBA assesses the rail infrastructure in terms of track systems, structures, train control systems, telecommunications, traction distribution and power supply systems.

2.1 Track systems

Aurizon Network constructs and maintains track systems and formation in accordance with Aurizon Network Civil Engineering Track Standards and AZN.NA.POL.03.6120.001 Asset Maintenance and Renewal Policy, Version 2.0 June 2014. These documents combined provided detailed guidance based on track theory and many years of experience operating the CQCN.

The track structure consists from the top down of:

- Rail
- Sleepers and fasteners
- Ballast
- Capping
- Subgrade.

This is illustrated in Figure 2.1. This figure is from a standard rail reference and included as a guide only. In practice for Aurizon Network the gravel layer is called a capping layer and can be as deep as 600 mm, not the 10 cm shown in this diagram.

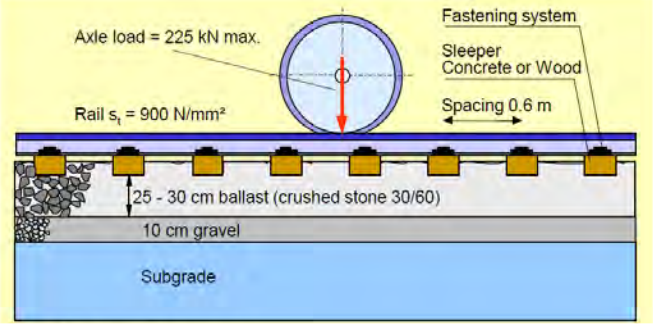


Figure 2.1: Conventional track structure[2]

The structure is designed to transmit the point loads at the wheel rail interface through to the subgrade. As the load is transmitted the bearing area is increased and consequently less strong, and cheaper materials, can be utilised. This is illustrated in Figure 2.2.

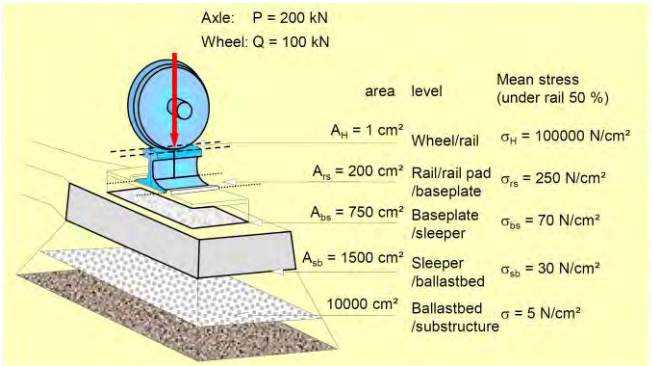


Figure 2.2: Principle of load transfer

[2] Esveld, Modern Railway Track, 2014

2.1.1 Rail

Aurizon Network has the following types of rail on the network:

- 60 kg/m Voestalpine advanced rail steel (370 LHT)
- 60 kg/m head hardened steel
- 60 kg/m standard carbon steel
- 53 kg/m standard carbon steel
- 50 kg/m standard carbon steel
- 47 kg/m standard carbon steel
- 41 kg/m standard carbon steel.

The 60 kg/m Voestalpine advanced rail steel has been installed at all re-rail sites throughout the network. 60 kg/m head hardened steel is becoming the standard on the network; the longer life of this rail compared to 60 kg/m standard carbon steel makes it a better option from a whole of life perspective despite its higher initial cost. The 53 kg/m and 47 kg/m rail can be found in older sections of the track but are gradually being replaced by 60 kg/m rail.

2.1.2 Sleepers and fasteners

Aurizon Network has the following types of sleepers and fasteners on the network:

- 28.5 tal sleepers and Pandrol E Clips
- 28.5 tal sleepers and Pandrol FAST Clips
- 28.5 tal FIST clip sleepers and fasteners
- 22.5 tal FIST clip sleepers and fasteners
- Various size steel sleepers and appropriate fasteners
- Timber sleepers and dog spikes or screws.

The current policy is to move towards the 28.5 tal concrete sleepers with Pandrol clips as standard. However there is a great deal of the other types of configurations in the network. The FIST sleepers and fasteners, South African manufacture from the 1980s and early 1990s, are particularly problematic from a maintenance perspective as corrosion and failure of the bolt through the sleeper under the ballast is not easily observed. Aurizon Network is gradually replacing these sleepers with sleepers suitable for Pandrol fasteners. Advisian observed some sleepers with derailment damage installed and operational on the Moura system; these sleepers were serviceable and it was appropriate for Aurizon Network to leave them in place.

2.2 Structures

The term structure used in the Aurizon Network relates to any bridge, culvert, or other construction.

2.2.1 Bridges

Numerous bridges with varying construction and material types are found throughout the Aurizon Network. Figure 2.3 provides a breakdown of items which make up a typical bridge structure.

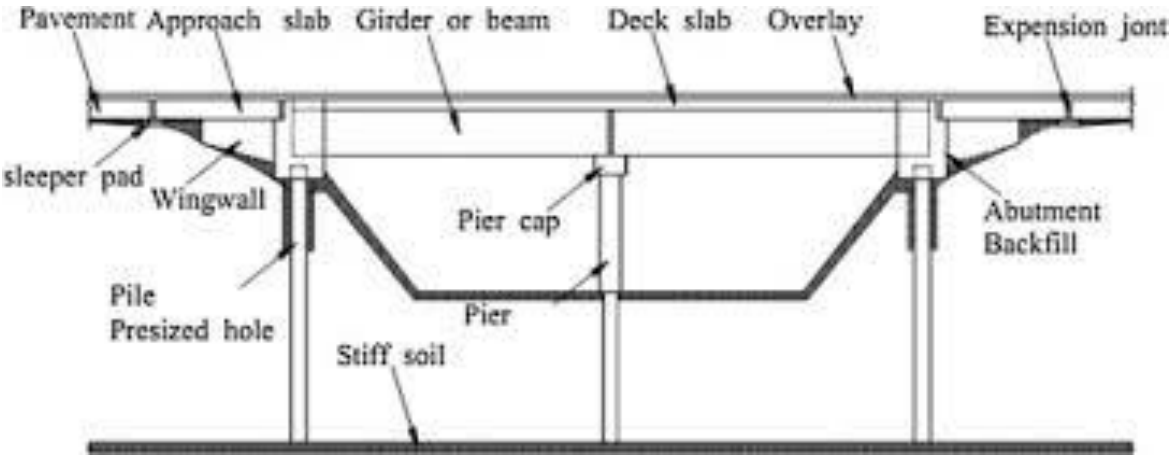


Figure 2.3: Standard bridge structure

Abutment and wing wall structure

The abutment acts as a retaining wall and interface point between the first span and approach slab formed on ground. These structures are mainly constructed of robust concrete to provide a durable low maintenance item. The main focus is to retain soil but allow free draining to relieve pressure build up behind the wall; weep holes are installed to accommodate this. Most repairs and maintenance to abutments focus on ensuring weeps holes are draining and are not blocked.

Piles and piers

The piers provide mid-span supports for the deck and associated rail infrastructure above. Pier types found within the Aurizon Network include cast in situ concrete, steel columns cast in concrete bases and timber columns cast in fibreglass lined concrete bases. The most common type is the cast in situ concrete pier as this is the cheapest and most durable.

Pier caps and expansion joints

Pier caps are designed to accommodate the bearing interface of the deck units and piers allowing the transfer of forces. Expansion joints between deck units and the approach slabs are created using bearing pads and sliding joint pads.

Deck units

Types of deck units commonly used within the network include:

- **Pre-cast concrete deck units**

  This is the most commonly applied solution for bridges across the network. Precast concrete deck units can be cast in varying lengths for a specific crossing. As the axle tonnages have increased over the lifetime of the rail network, standard deck units have also been amended to reflect new requirements:

  – 10 m span QR/QR National/Aurizon Network standard deck unit
  – 15 m span QR/QR National/Aurizon Network standard deck unit
  – 20 m span QR/QR National/Aurizon Network standard deck unit
  – 25 m span QR/QR National/Aurizon Network standard deck unit
  – 30 m span QR/QR National/Aurizon Network standard deck unit.

  Units are cast offsite and are either pre-stressed to their intended capacity or post-tensioned. Once placed in position on site, standard deck units are transported and dropped in place on bearing pads.

  In recent years, Aurizon Network has moved away from standard girders due to changes in Australian Standards as well as using contractors under in-house design.

- **Steel trusses, transoms and girders**

  Steel truss bridges are evident across the network where these provide the most cost effective solution, such as larger spans, and those constructed prior to advances in concrete deck techniques. Durable steel structures require increased maintenance to protect from corrosion of steel and mechanical joints (i.e. bolts) by regular painting and galvanising, as opposed to concrete structures.

  Standard girder lengths used by Aurizon Network include:

  – 15m span QR/QR National/Aurizon Network standard steel I-beam girder
  – 25m span QR/QR National/Aurizon Network standard steel I-beam girder.

- **Timber transom beam/girders and corbels**

  Timber bridges were a cost effective and suitable solution when the rail network was originally developed in remote areas for spur and balloon loops. As the least durable material used across the network, Aurizon Network has made a conscious decision not to use timber for any new structures. Significant maintenance of timber structures has become even more important than other structures as each individual defect is harder to quantify in both cost and labour implications, which directly impacts the overall structural capacity of the bridge structure. The Nogoa to Minerva mine section of track has five timber bridges still in operational use.

Approach/relieving slabs

Approach slabs are required to create a smooth transition between flexible and stiff track, from the rigid abutment to the ground bearing pavement either side of a bridge. Poor or non-existent relieving slabs create unnecessary pounding and friction on the bridge and rail infrastructure.

2.2.2 Culverts

Typically, a culvert is defined as any structure conveying water under the railway or providing access for property owners. The types of culverts found in the Aurizon Network include:

- **Reinforced concrete box culvert and reinforced concrete circular culvert**

  The most common form of culvert within the network, reinforced concrete culverts are the most suitable culvert as they are easily sourced, cast offsite which allows reduced construction time and are durable providing long service life.
- **Concrete lined corrugated metal pipe**

  These are commonly used throughout the network as a cheap construction alternative as the steel lining acts as formwork during construction, while the smooth lining aids water flow. This culvert type requires additional maintenance of the corrugated steel to mitigate corrosion.
- **Spiral sandstone block culvert**

  Rarely used, these remaining culverts are now heritage listed and have been superseded by cheaper construction and require additional maintenance.

All culvert types listed above require regular maintenance of associated up and down stream drainage channels and vegetation.

2.3 Train control systems

The train control system provides the means for monitoring and controlling train movements in a safe, efficient and effective manner.

The system grants movement authorities to trains to permit movement along sections of line ensuring:

- The section of line is secured (points set and locked in correct positions)
- Conflicting train movements are locked
- The section of line is proved to be clear of other traffic.

The key components of a train control system are:

- The traffic management system (TMS) acts as the interface between the train controllers/signallers and the train control system. The system will display train position and train ID to the operators and allow them to route the trains through the network in accordance with train plans and live situational information.
- The signalling interlocking provides the safety logic to determine if routing commands issued by the TMS are safe to execute. It interprets the route commands to issue point setting and locking controls, checks for conflicting routes and ensures the line section is clear of other trains before issuing a movement authority, usually by clearing the relevant lineside signal.
- Telemetry systems to convey commands from the TMS and the interlocking and signalling status information from the interlocking to the TMS. As the safety integrity of the train control system lies mainly within the signalling interlocking, this can be via non-vital communications channels.

- The lineside signalling equipment:
  - Point machines to move and lock detect turnout switches and then detect their position and status
  - Track circuits or axle counter that determine the occupancy of a particular track section
  - Signals to convey movement authorities to train drivers
  - Level crossing protection to manage the interface between rail traffic and road users
  - Other signalling infrastructure that supports the operations of the lineside equipment and connects the lineside equipment to the interlocking:
    - Equipment rooms, huts and cupboards
    - Power supplies and power distribution systems
    - Trackside cabling and cable routes.

The Aurizon Network train control system is built upon a base of legacy systems inherited from QR. Signalling in some areas has been upgraded since the privatisation in 2010, although the basic signalling principles remain aligned to the existing QR principles.

2.3.1 Traffic management system

The Rockhampton Control Centre is based around a bespoke QR system designed in house in the early 1990s. The system is known as Universal Train Control (UTC) in signalled territory and Direct Train Control (DTC) in dark territory. UTC/DTC provides basic screen based train and allows for through setting of routes within a control area, as well as pre-setting of conflicting routes. The Aurizon Network is covered by 15 workstations, comprising of four DTC workstations and 11 UTC workstations.

In mid-2016 Aurizon Network and GE Transportation successfully implemented the first phase of GE's Movement Planner into the control centre. This is a real time traffic planning and management system that provides a complete view of all assets on the network relative to each other and identifies conflicts in the network out to twelve hours. This enables the train controllers to make earlier proactive routing decisions. Future phases of this project will deliver a more automated and optimised solution.

The UTC/DTC system has been regularly upgraded since installation and is to be ported from Windows XP to Windows 10 later this year. Given that the train plan is regularly optimised and updated, it may be worth considering a replacement system in the future that could enable automatic route setting and potentially allow staff savings on the control floor, although it would require a task analysis and workload study to determine the viability of the savings. Automated route setting is still an emerging technology, however, that few railways have yet to successfully implement.

The control centre is backed up by a disaster recovery centre in Mackay. This was originally the control centre for the northern part of the network, before control was consolidated into the Rockhampton centre. Given the tonnages and traffic densities on the network, the remoteness of some of the locations, the length of communication links and the risk of cyclones in this part of Queensland, the retention of the disaster recovery centre is a prudent initiative.

2.3.2 Signalling interlocking

A schematic of the signalling interlocking systems across the CQCN is shown in Figure 2.4.

The base standard for the Aurizon Network is relay interlockings using British Rail Spec 930 relays. Controls and indications are wired out to the trackside equipment using copper cables.

Westinghouse style S2 telemetry systems are exclusively used as the remote control system linking the signalling interlockings to the control centre via the communications fixed bearer network. It is understood that Aurizon Network is investigating the use of an internet protocol telemetry system in the future.

As signalling has been upgraded due to asset condition or layout alterations, relay interlockings have been progressively replaced by Computer Based Interlockings (CBIs). Where major layout changes are involved replacement of the relay interlocking by a CBI is a most cost effective way of implementing the changes, as locking alterations can be carried out and testing off site in a factory environment. The only on-site testing required is correspondence testing to the lineside equipment.

Three main CBIs have been used within the Aurizon Network:

- VPI, developed by GRS (now an Alstom product)
- Microlok, developed by US&S (now an Ansaldo product)
- Westrace, developed by Westinghouse (now a Siemens product).

This approach allows Aurizon Network to avoid being locked into a single supplier and is a prudent approach to the disposition of interlocking types, with each system within the network being predominantly fitted with one interlocking type, minimises spare holdings in each area a maximises the skills of staff.

A solitary Westlock interlocking has been installed at Jilalan, unusually configured with several Westraces used as the input/output interface.

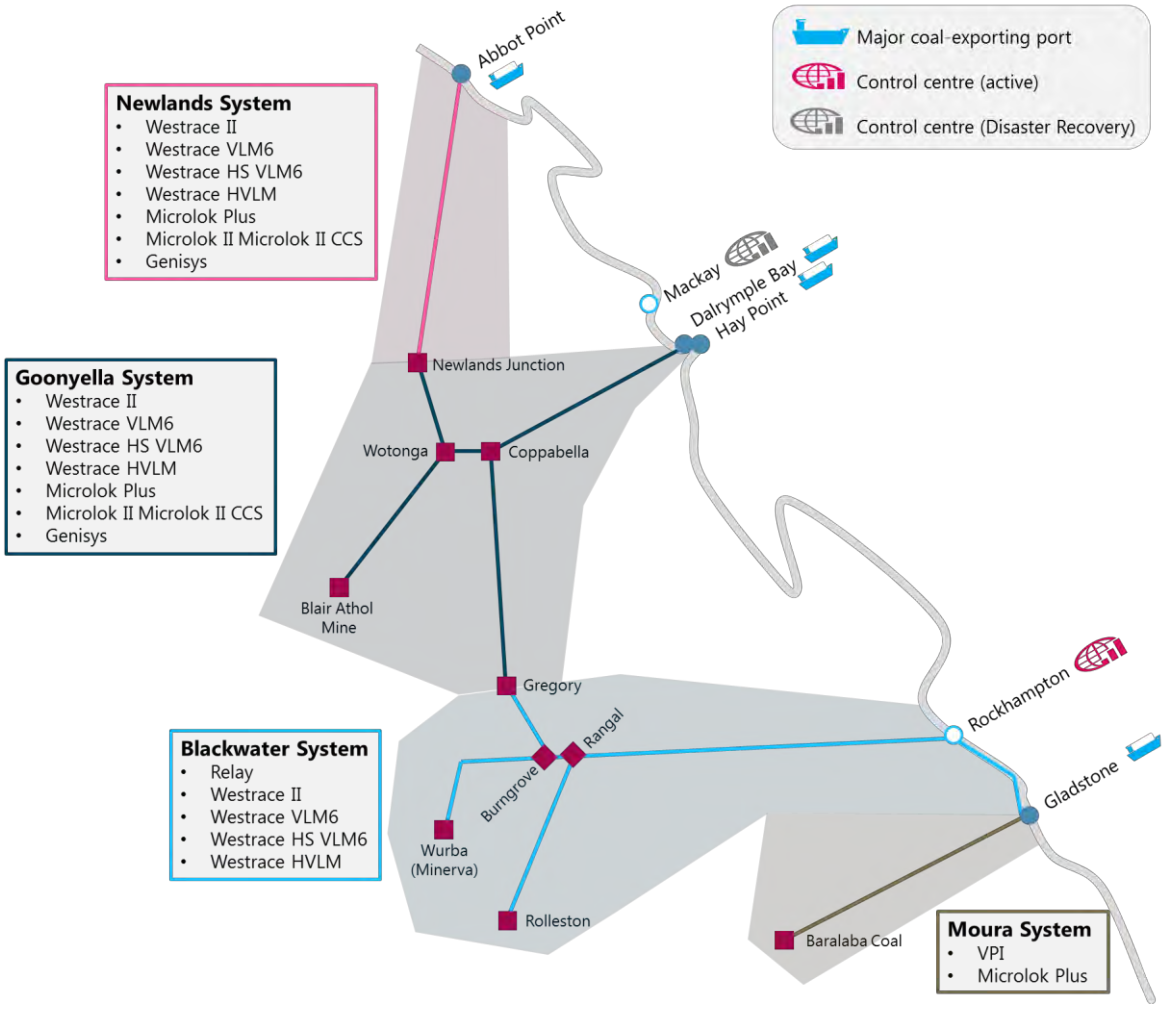


Figure 2.4: Interlocking devices used throughout CQCN

2.3.3 Points operation

A wide variety of point machines are in use throughout the network, of both sleeper mounted with hand thrown lever for manual operation and in-bearer types. An overview of point machines used across CQCN is shown in Figure 2.5.

It has been a beneficial initiative to replace the majority of main line point crossings with swing nose crossings. Although the quantity signalling equipment is increased, the reduction in wear and tear on both the track components and rail vehicles is significant. Given the potential for coal dust contamination, the smoother passage though the swing nose is a major benefit.

Point Machine Type	Newlands	Goonyella	Blackwater	Moura	Total
Automatic Switch Stand Points		8	2		10
Civil Points (Detected)	1		1		2
Cooper HV4 Electro-Hydraulic Points		10	44		54
D84M Points	3	81	109	2	195
Dual Controlled E-H In-sleeper Points	3	8			11
Dual Controlled Electro-Hydraulic Points	11	134	132	37	314
M23A MK1 Points		25	7		32
M23A MK2 Points	96	197	257	2	552
M70 MK1 Points			19		19
M70 MK3 Points			13		13
Mechanical Lever Frame (Electric)	6	41	56	15	118
Mechanical Lever Frame (Non-Electric)			3		3
Nippon KA1401C TFP Points		25			25
Nippon KA1401E TFP Points			11		11
Siemens S700K Points	2	27			29
Siemens S700V Points		191	79		270
Trailable Facing Points (Detected)			2	3	5
Trailable Facing Points (Non-Detected)		2	10	5	17
VAE Ecostar Points		2			2

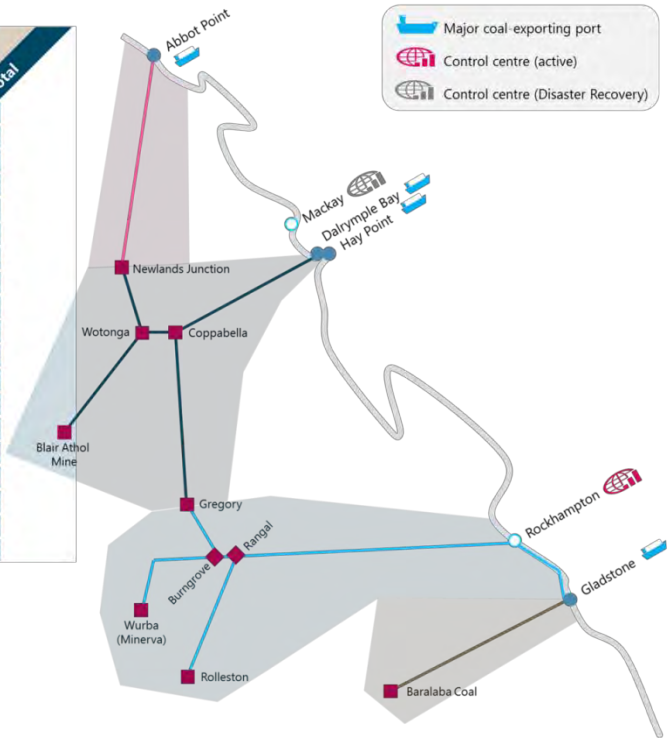


Figure 2.5: Overview of point machines used across CQCN

Examples of different point machine types are shown in Figure 2.6.



Figure 2.6: Examples of different point machine types used throughout the CQCN

At Wandoo on the Goonyella line, a trial installation of the Voestalpine Ecostar point machine is in place. The machine drives the points via a Voestalpine Spherolock mechanism. This is a patented system developed by Voestalpine comprising a fully encapsulated and long-time lubricated locking system with a revolutionary locking principle, designed to minimise maintenance costs. The inside locking jaws and cylindrical surface are designed so that the closed switch is reliably locked in a manner similar to a clamp lock. The design guarantees that no lock leasing forces are generated by uncontrolled movement of the switch.



Figure 2.7: Voestalpine pneumatics switch machine at Wandoo

In Coppabella yard, a previously unpowered set of points has been fitted with a point machine to improve the safety of operations. To keep down costs, a capacitor bank has been provided to store energy to drive the points, avoiding am expensive upgrade to power supplies in the area.

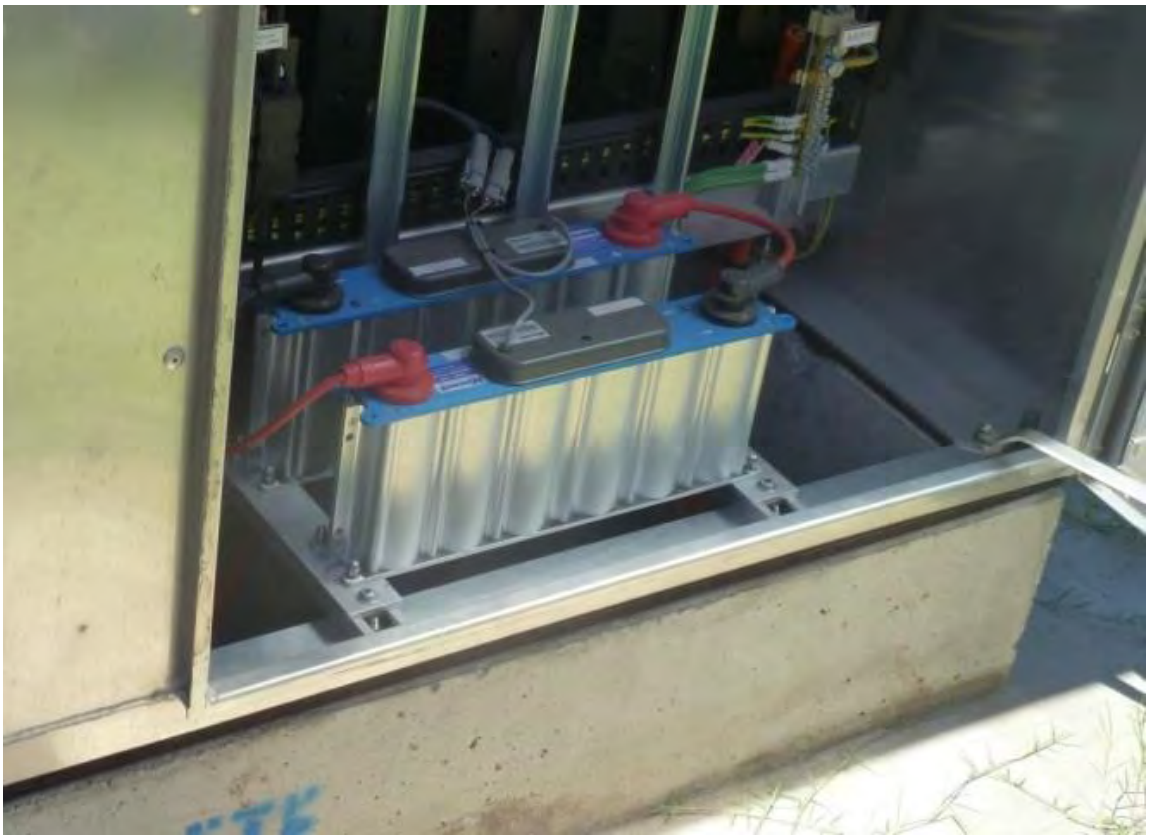


Figure 2.8: Coppabella capacitor bank

At a number of locations point monitoring equipment has been installed to enable certain parameters such as point drive current and operating time to be viewed remotely.

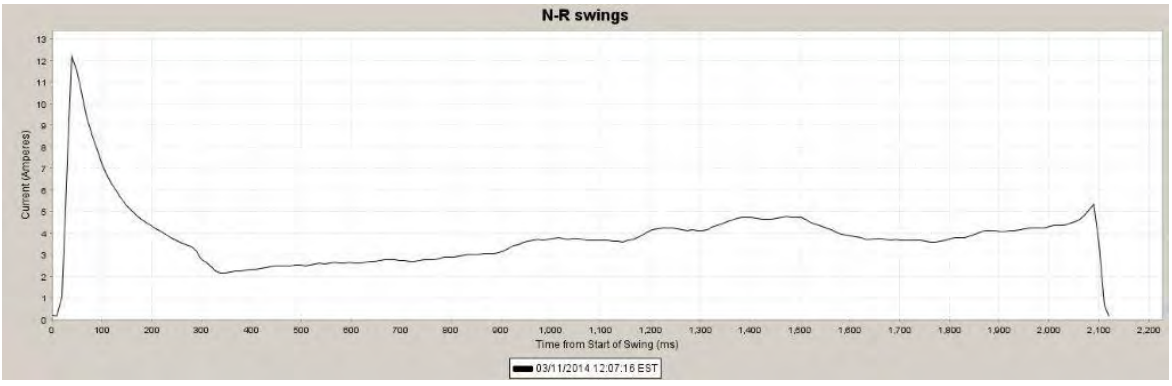


Figure 2.9: Typical point monitor output showing operating current

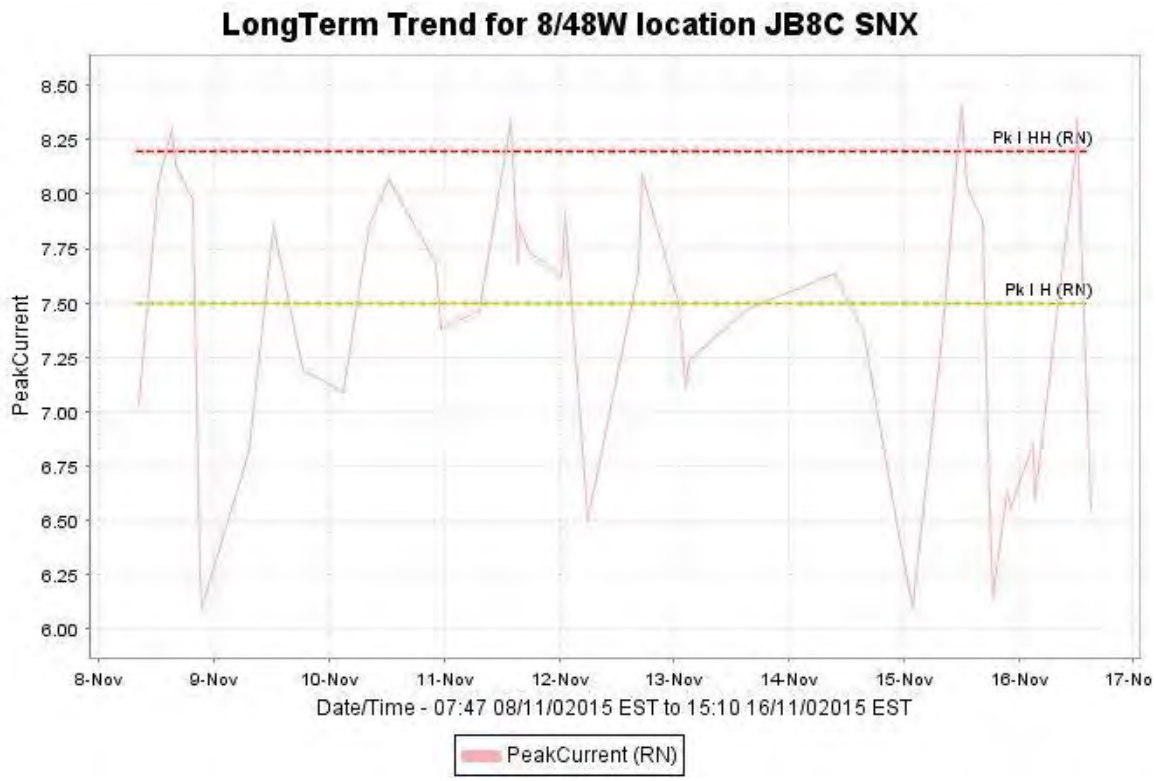


Figure 2.10: Typical point monitor output showing peak operating current over time

Currently point inspections and gauging is carried out on an eight weekly cycle. There have been proposals recently to reduce the number of site visits required by signal electricians. Turnout switch movement and locking is probably the most safety critical element of the signalling system. Whilst remotely monitoring point operating parameters can provide an indication of the correct functioning of the points, it cannot guarantee that the switches are correctly locked and set to the required tolerances. Any move to reduce the frequency of point inspection and gauging would need very careful analysis and significant risk assessment to validate the safety.

2.3.4 Train detection

Other than in DTC areas, train detection is performed either with track circuits or axle counters.

Older block section signalling generally employs audio frequency (jointless) track circuits through the block and direct current (DC) or impulse type track circuits in interlocking areas through turnouts. The limitation on audio frequency track circuits of a maximum length of 700 m in the alternating current (AC) electrified area requires a considerable number of cut sections through the block. The 50 V DC line circuits conveying track circuit status to the interlockings are also limited to 700 m in AC electrified territory, requiring frequent repeater circuit through the block section. Block sections in the network are typically between 10 and 15 kilometres, which necessitates more than 20 individual track circuits per track in some sections. The need to repeat track sections and line circuits every 700 m leads to numerous equipment housings, all requiring power supplies and often with difficult access for maintenance staff.

Lines signalled more recently employ axle counters through the block section and track circuits only in interlocking areas. This simplifies the block section signalling as axle counter readers are only required where the signalling arrangements dictate (i.e. at signals and overlaps etc.) and no additional cut sections are necessary. This can result in a significant benefit for maintenance and fault finding.

The distribution of track circuit types is broadly on a line segment basis, with CSEE track circuits generally used in the south maintenance area and ML TI21 track circuits generally used in the north maintenance area. DC track circuits, AC/DC track circuits or Jeumont Schneider track circuits are used in interlocking areas through turnouts. At Raglan on the Coast Line there is a trial installation of a new version of the CSEE track circuit, style UM2000.

The earliest axle counters to be installed were Seimens type, but as new sections are equipped, Thales axle counter are now preferred and a few Frauscher axle counters have been introduced.

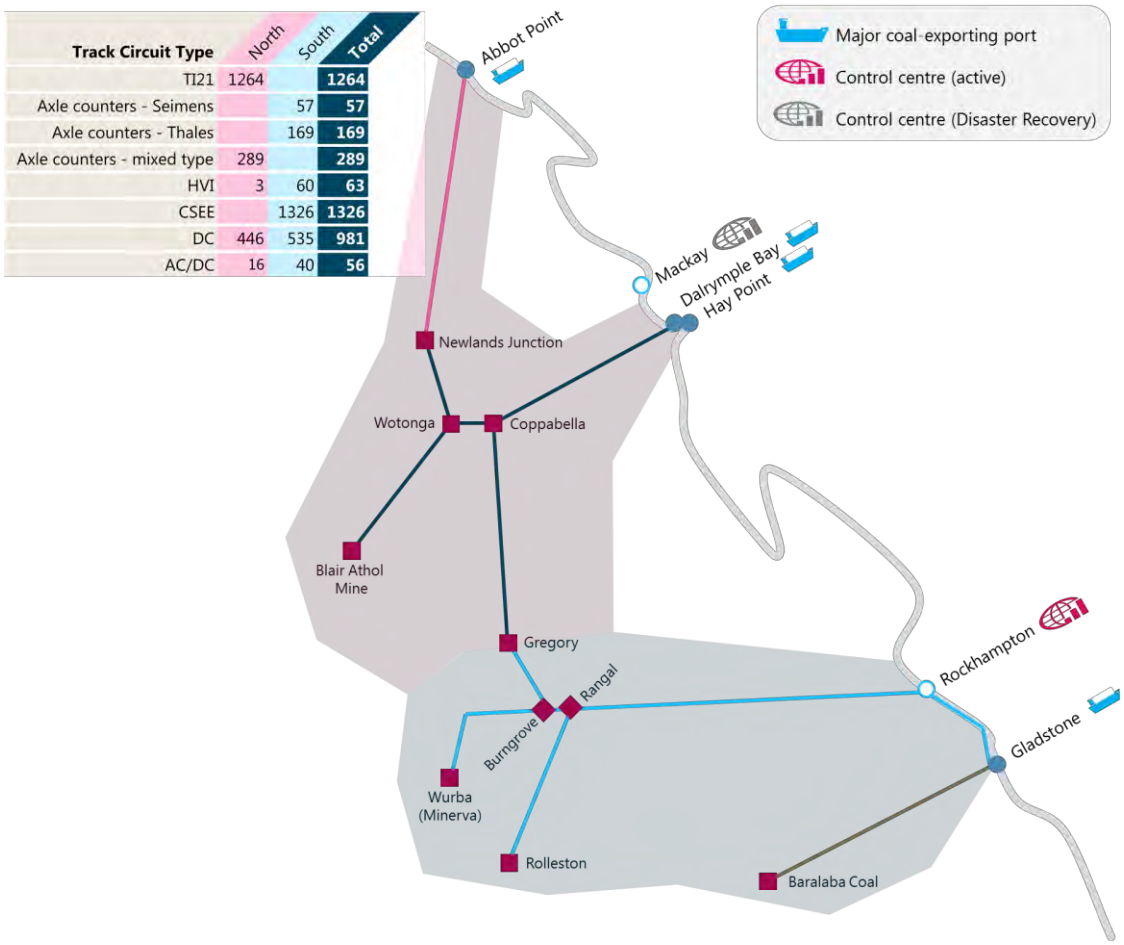


Figure 2.11: Overview of track circuits and axle counter used across CQCN

One of the major issues with train detection on the network is the coal dust ballast contamination that occurs in certain locations. This is most evident on the exit road from the various coal unloading locations, likely due to loose dust lodging on the hopper door mechanisms and wagon running gear and being shaken off at points crossings and bad rail joints etc. Contaminated ballast impacts upon the rail to rail impedance to which track circuits settings are adjusted. If the impedance varies greatly, more frequent inspection may be required to check and correct the track circuit adjustment.

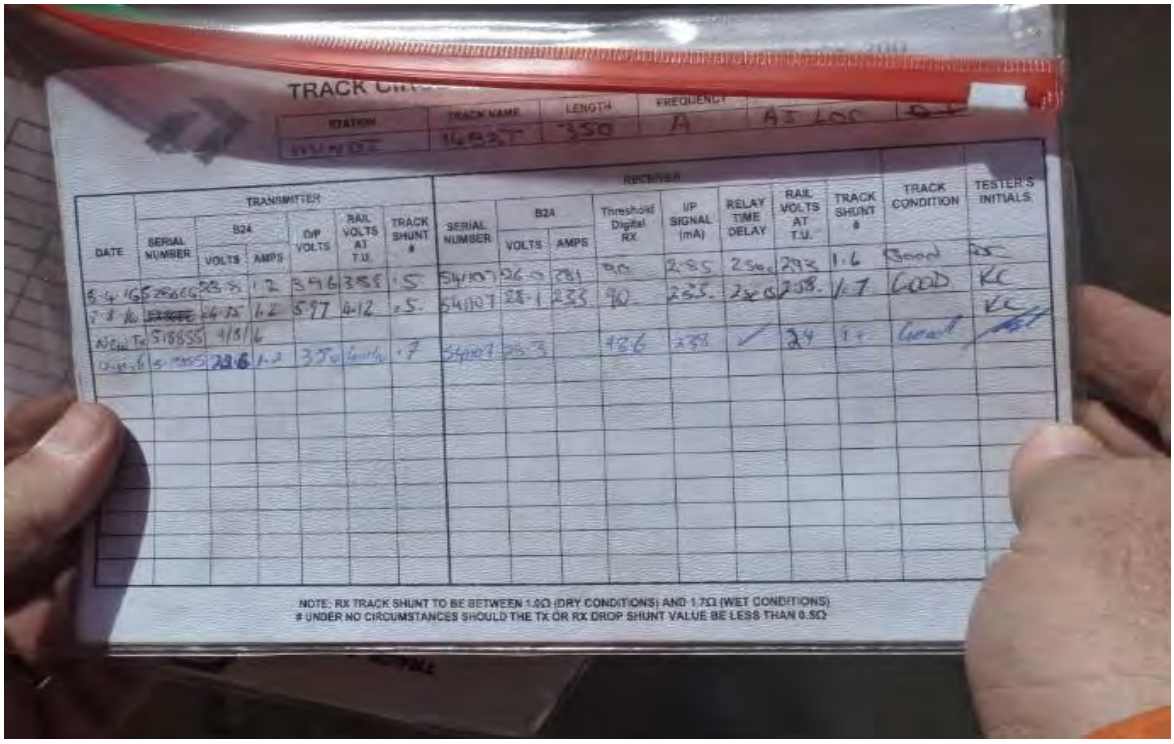


Figure 2.12: Track circuit test results at Mindi

Bonding plans show most of the key bonds for correct signalling operation, but it appears that not all bonds are necessarily shown on the signalling bonding plans. In particular the pig tail bonds for continuity through crossings/swing nose frogs and bonds from impedance bond centre tap to OHL earth wire are not shown. The preferred method of connecting bonds and track circuit leads to the rail is to use Cembre AR style connectors. At some locations cadwelds are still in use, although they are being replaced as changes or repairs occur.

2.3.5 Signals

Colour light signals in the Aurizon Network conform basically to QR signalling practice. Multi-light three aspect signals are the norm, with five light route indicators designating a divergent route. Most signals are now fitted with LED lamps, although some incandescent lamps remain. There are also a number of optic fibres until used as speed indicators.

As an ingenious initiative, pivoting signal posts have been installed in recent years. These were collaboratively developed with Westinghouse (now Siemens). They allow the post to be pivoted to the horizontal, permitting work to be carried out on the signal unit without climbing ladders and minimising the dangers of contacting the OHL.



Figure 2.13: Westinghouse pivoting signal post

2.3.6 Level crossings

Level crossings are a key point of risk exposure on any rail network, being the interface between rail and road traffic. Most level crossings on the network are either single boom gates with flashing lights or unprotected crossings relying on the road user to check for trains before crossing. Level crossing standards are designed on a risk basis and are assessed using the Australian Level Crossing Assessment Model (ALCAM). Level crossing operation is tested twice weekly by the signal electricians.

Aurizon Network has pursued a number of initiatives to improve level crossing safety.



Figure 2.14: Over height control at Dingo level crossing

CCTV has been installed at several crossings, and at Dingo and Arduarad Road on the Blackwater line, over height detectors have been fitted. Normanby Street forms the main road between the Capricorn Highway from Rockhampton, Middlemount and Coppabella. There is a significant flow of oversize vehicles along this road, making the crossing at Dingo a prime site for OHL strikes. The over height detectors are positioned about 80 m from the crossing and illuminate a large LED warning sign at the crossing if it is triggered.

2.3.7 Other signalling infrastructure

Most signal cables are direct buried, including tail cables. Track circuits leads are surface run from the tuning units (audio frequency track circuits) or disconnection boxes (DC, AC/DC and impulse track circuits). We do not routinely perform insulation/continuity testing on signalling cables. Signalling cables are not routinely Megger tested. Testing occurs on installation or commissioning and would be retested after jointing or repair. Testing may also occur as an aid to fault finding.

Signal location cases power supplies are routinely tested for earth faults. This would potentially reveal a fault on a cable.

Signalling equipment rooms (SERs) are a mixture of metal clad huts, stainless steel cupboard and brick or blockwork built rooms and the most computer based interlockings have been installed in demountable building, allowing most testing to take place under factory conditions, before transporting to site.

Some SERs are fitted with air conditioners, although it is unclear if there is a consistent policy for this. The air conditioners do not appear to be monitored and at two sites visited they were not working.



Figure 2.15: Signal location power supply case

2.4 Telecommunications

The telecommunications system and network provides the communications channels necessary to support the operation of the railway. These systems include data transmission, signalling and electrification control systems, radio systems, lineside communications, level crossing CCTV, customer information systems as well as more general IT and business telephony needs.

The fixed bearer network is at the core of railway communications and is thus vital to the operation of the railway. The fixed bearer network infrastructure comprises transmission systems and telephone exchanges linked by a fibre optic, microwave and copper cable networks. The network architecture will usually provide a diversity of communication links, to ensure the reliability and integrity in the system.

2.4.1 CQCN application

Across CQCN there are two levels of redundancy in the design of communication systems:

- Fibre optic links (underground or optical ground wire (OPGW))
- Microwave links.

In some instances where both underground and OPGW fibre optic wires are installed there are three levels of redundancy available.

Underground fibre optic wires were installed in the mid to late 1980s and are the primary communication link throughout CQCN (except in the Moura system where microwave and sub-rate links are used). Underground fibre optic wires have a life between 30 and 50 years, indicating that they are coming towards the end of their lifespan. In areas where underground optical fibre wires have severely deteriorated, it has been replaced with OPGW (installed within earth return wire on the side of traction masts). Approximately 85% of the network relies on underground optical fibre wire while the other 15% is OPGW. There are very few instances where OPGW and underground fibre optic wires are in actively used. In the case that a fibre optic link is broken, communication logic paths allow messages to be re-routed in the opposite direction to the broken link, and transmitted either entirely via the fibre optic network or a microwave tower. Fibre optic nodes (approximately 850 CQCN-wide) are tested remotely every three months, with each test taking about 10 to 20 minutes.

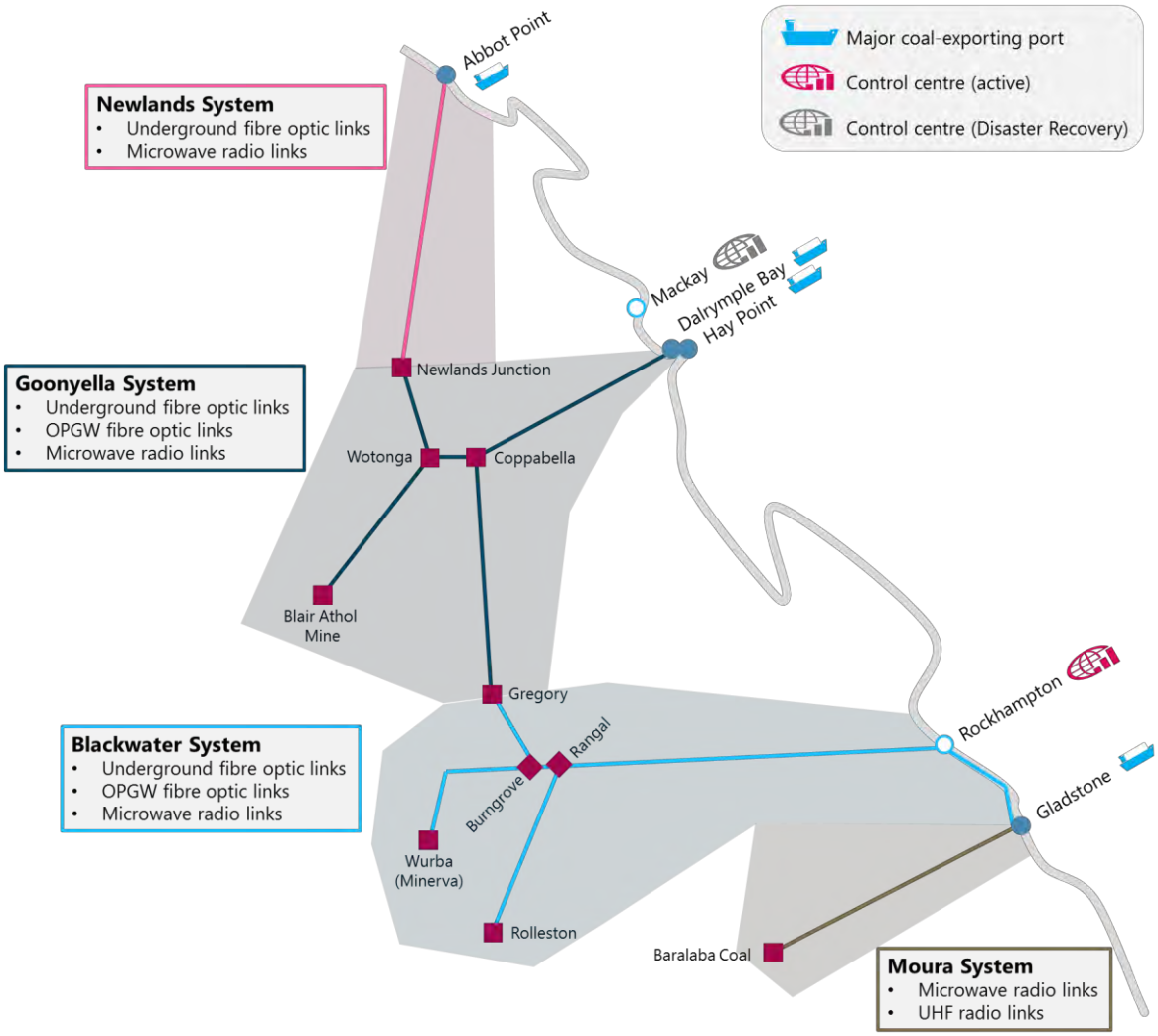


Figure 2.16: Outline of CQCN system telecommunications links

Microwave towers allow messages to be transmitted long distances. If a section of track has issues with its fibre optic links and can no longer communicate to the control centre, microwave towers allow messages to bypass the broken links. This enables the rest of the network to function normally without interruption from a broken link upstream. In some instances physical barriers prevent the use of microwave towers. This has happened at ports (stacked containers blocking path) and near mines (spoil piles blocking path).

Three levels of redundancy are present where OPGW has been installed.

2.4.2 Fixed bearer network

Underground fibre optic cables were installed in the mid to late 1980s and constitute the primary communication links throughout CQCN (except in the Moura system where microwave and sub-radio links are used). Underground fibre optic wires have a life between 30 and 50 years, indicating that they are coming towards the end of their lifespan. In areas where underground optical fibre cables have severely deteriorated, they have been replaced with OPGW (a composite optic fibre earth return wire) usually mounted on the side of traction masts.

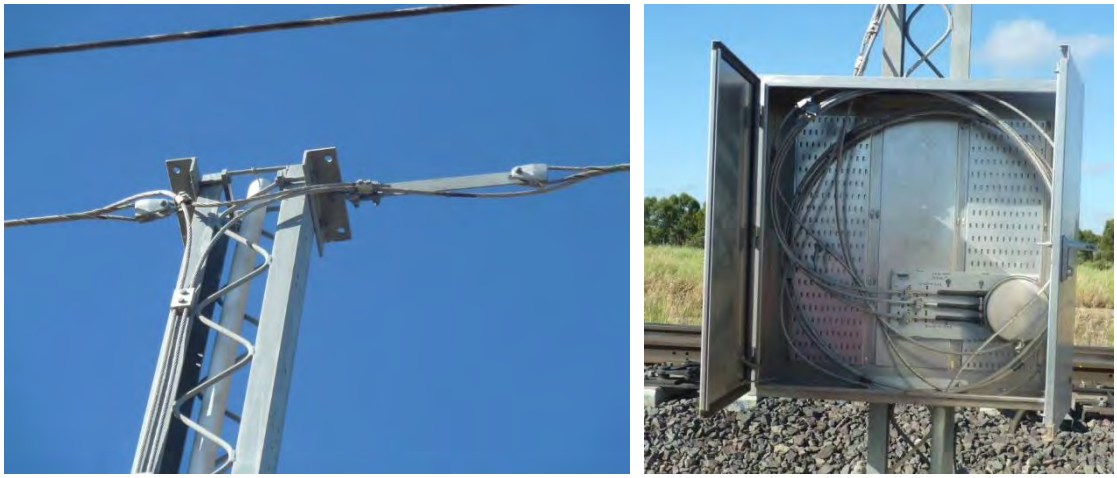


Figure 2.17: OPGW cable and fibre termination box

OPGW cables have a lower installation cost than buried optic fibre cables and are better protected from damage and vandalism. Installation requires careful planning as it is impractical to splice cables mid span, requiring cable lengths supplied to be carefully coordinated with OHL span design.

Redundancy is built into the transmission network by the provision of microwave links, consisting of pairs of tower mounted antennae transmitting a beam of radio waves in the microwave frequency range between them.

Microwave links are cost effective and quick to install as they only require communications infrastructure at the two transmitter sites. Microwaves are usually able to contend with most climatic conditions, although, flat terrain can create undesirable reflections and precipitation can absorb or scatter some of the microwave energy. The main limitation is that there must be a clear path between the towers. At some locations, microwave links have been blocked by physical barriers erected in the line of sight between the towers. This has happened at ports (stacked containers blocking path) and near mines (spoil piles blocking path).



Figure 2.18: Microwave tower

2.4.3 Radio systems

Train to control centre communications occurs via UHF radio. CQCN radio network was built in 1996 and has an expected life of 20 years. Each radio base is serviced bi-annually and the CQCN has the following radio systems:

- Train Control Radio – approximately 51 radio bases in CQCN
- Maintenance Service Radio
- Multiple yard systems for different geographical locations.

On the Moura section, there are no optic fibre cables and UHF radio links are provided as a back path for the microwave links.

In January 2017 a contract was awarded to Radlink Communications to install a Tetra radio system throughout all CQCN. This will overcome any of the equipment condition and obsolescence issues that were identified in previous CBAs.

2.5 Traction distribution and power supply systems

The Blackwater and Goonyella systems is a large heavy-haul electrified railway, powered by a 50/2x25 kV autotransformer fed traction supply system. There are presently 22 50 kV feeder stations which supply the rail system from the Central Queensland 132 kV and 275 kV transmission network. The traction power and distribution system was originally designed and built in the early to mid-1980s to accommodate phase controlled DC traction electric locomotives. However there has been substantial electrical infrastructure upgrades which have been driven by rail corridor capacity increases. In the Blackwater system track duplications from 2009 to 2014 drove the increase in the number of feeder stations from six in FY 2012 to 11 at present. Traction power innovation is evident in the Blackwater system with the new feeder station at Raglan being the first to be fed from the 275 kV Powerlink network and new static frequency converter (SFC) technology introduced on the Rolleston line at Struan Road feeder station. Goonyella has also received electrical system upgrades with feeder station additions to the original network at Mindi, Bollingbroke, Wotonga and Dalrymple Bay.

Due to the railway load being single phase some of the feeder stations are equipped with static var compensators to prevent power quality impacts on the electrical supply network. These static var compensators are owned and operated by Powerlink and not part of the asset base. The feeder stations in the main consist of two 132/50 kV single phase transformers with a rating of 30 to 40 mVA. Due to the distorted current waveform that the older DC traction locomotives draw from the power network many of the feeders stations are equipped with harmonic filters. These reduce the harmonic currents associated with the distorted waveforms flowing in the outside network where they can be troublesome to the other customers. Newer AC traction rollingstock has significantly less harmonic current and the harmonic filters may be reduced or possibly removed. Aurizon Network is currently reviewing the harmonic filter requirement since the DC traction locomotives are likely to be phased out over the next five years.

The electrified system is almost entirely dual track with power being fed radially in both directions from the feeder station. A neutral section is located at each feeder station and provides isolation of the two electrical sections from each transformer. The neutral sections are 'dead' areas which are grounded to remove the risk of bridging the separation between supplies. This is mandatory since the two sections are normally fed from differing power phases to assist in balancing the load on the utilities supply network.

The electrical sections are terminated at a distance of typically 15 to 30 km by track sectioning cabins (TSCs) where additional neutral sections are located. These also isolate electrical sections from each other. Switching stations are located at the feeder stations and TSCs which contain circuit breakers which protect the electrical overhead system from short circuits and allow full segments of it to be isolated. In the case of a feeder transformer or supply point failure (contingency event) the switching stations can be configured to feed through from the adjacent section.

The system is further segmented with section insulators which allow smaller areas to be isolated in the case of failures allowing the remainder of the track to operate. To enable these isolation points, mast mounted track switches are employed.

The autotransformer system transmits the 50 kV voltage along the track on a back of mast mounted feeder cable. The return path is an earth cable which is also mounted back of mast in parallel with the rails and the 'massive' earth. At approximately 10 km intervals single winding autotransformers convert the 50 kV to 25 kV which is applied to the contact wire. The 25 kV is also referenced to the rails and by which the vehicle currents return to the autotransformers. The contact wire is mechanically supported by a catenary wire system. This assembly is supported by cantilever masts with insulators and portal structures in some areas. The use of a 50 kV electricity transmission system reduces the voltage drop due to the high traction load associated with a heavy haul railway.

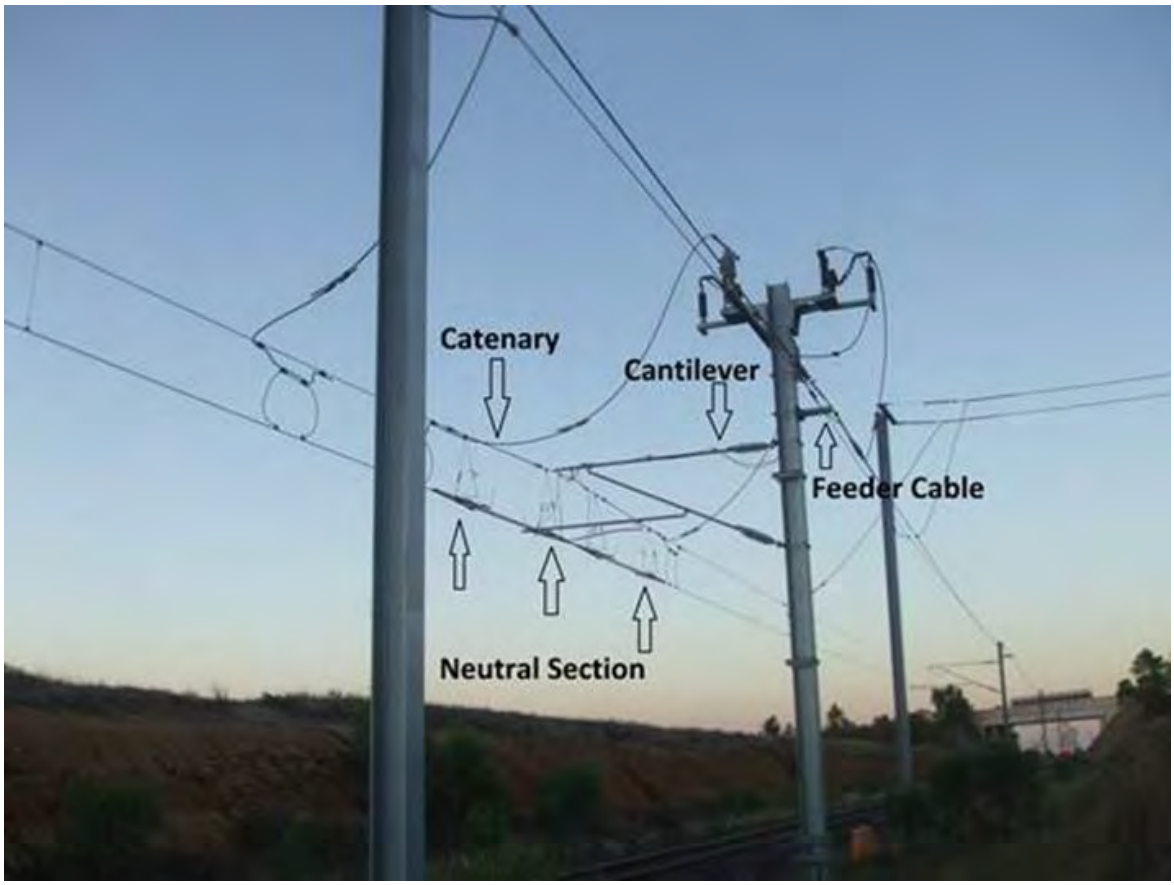


Figure 2.19: Overhead wiring components

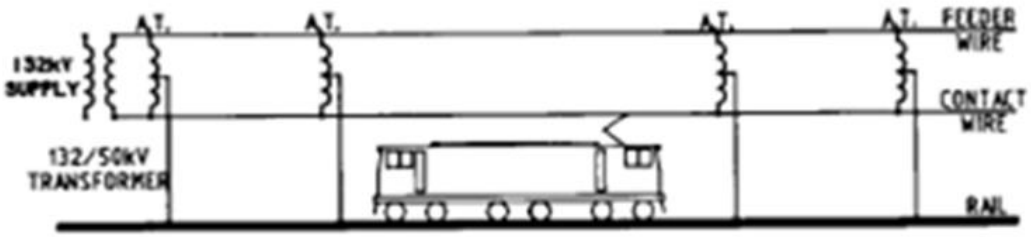


Figure 2.20: The 50/25 kV autotransformer system



Figure 2.21: Feeder transformer



Figure 2.22: Harmonic filters


WD 25
WD 22



3

Asset Management Policy

Aurizon's Asset Maintenance and Renewal Policy is a comprehensive and detailed document that covers a range of disciplines.

The current asset management policy document is AZN.NA.POL.03.6120.001 Version 2.0 dated June 2014.

This is a comprehensive and detailed policy document. Disciplines covered include:



- Mechanised track maintenance
- General track maintenance
- Structures and facilities maintenance
- Signalling maintenance
- Traction power system maintenance
- Telecommunications maintenance
- Facilities maintenance
- Civil track asset renewal
- Civil structural asset renewal
- Civil right of way asset renewal
- Signal equipment asset renewal
- Traction power equipment asset renewal
- Telecommunications asset renewal.

3.1 Track systems

Track systems are maintained according to a combination of:

- Regular time based inspections
- Utilisation based inspections
- Condition monitoring.

Track systems are constructed, maintained and inspected to the Policy and in accordance with Aurizon Network's Civil Engineering Track Standards.

3.2 Structures

Structures are maintained and inspected to Department of Transport and Main Roads guidelines and in accordance with the Aurizon Network's Civil Engineering Structural Standards.

3.3 Train control systems

Typical inspection and testing cycles of some of the key items of signalling equipment are shown in Table 3.1.

Table 3.1: Signalling and telecommunications equipment inspection and testing

Equipment Type	Frequency	Unit
Signal Heads and Mounting Structures (Including posts, gantries and folding posts)	3, 6 and 12 monthly services Fix on Failure	Posts or gantries per year
Points and Point Machines	2, 3, 6 and 12 monthly services	Point machines per year
Track Circuit Equipment	Yearly tests Fix on Failure	Track circuits per year
Axle Counters and Evaluators	6 monthly tests Fix on Failure	Counter head pairs per year
Level Crossing Warning Controls Level Crossing operation	1, 3 and 12 monthly services Tested twice weekly	Crossings per year
Signalling Cables	Yearly	100 Route km per year
Fixed Radio Systems	3 and 6 monthly services Fix on Failure	Base stations per year
Network Switches	2 weekly, 1, 3, 6 and 12 monthly services	Units per year
Microwave Sites	3 and 6 monthly services	Sites per year

3.4 Telecommunications

Typical inspection and testing cycles of some of the key items of telecommunications equipment are shown in Table 3.2.

Table 3.2: Fixed radio system maintenance intervals

Equipment Type	Maintenance	Maintenance Intervals
Fixed Shunt Radio Station	Visual checks, Function Tests, Measure inputs/outputs, Cleaning	13 and 26 weeks
Fixed Wayside Radio Stations (Weighbridges, Hot Box Detector, Derailment Detectors, Pan Up Alarm)	Visual checks, Function Tests, Measure inputs/outputs, Cleaning	26 weeks
Fixed Automatic Train Protection Field Site Radio Stations	Visual checks, Function Tests, Measure inputs/outputs, Cleaning	26 weeks
Fixed Rollingstock Defect Coordinator Radio Stations	Visual checks, Function Tests, Measure inputs/outputs, Cleaning	13 and 26 weeks
Fixed Dragging Equipment Detection Link Radio Station	Visual checks, Function Tests, Measure inputs/outputs, Cleaning	26 weeks

3.5 Traction distribution and power supply systems

Overhead contact system faults

When overhead contact system faults occur, there will be delays which impact the network's ability to meet annual tonnage commitments. Whilst the delay minutes attributed to the overhead contact system is potentially much less than those caused by other assets it is an important performance indicator in terms of measuring the organisation's efficiency in responding to and rectifying overhead contact system failures. This is very important since even one event, if not dealt with quickly, can accumulate substantial delay minutes.

Contact wire and catenary wire replacement policy

Aurizon Network has historically assumed the contact wire to have a 60-year estimated lifetime. This is based on a condemning limit where the cross-sectional area is reduced by 33% and nominal wear rates are based on industry knowledge.

Transformer oil analysis

The vast majority of the traction transformers and autotransformers undergo at least annual oil sampling and chemical analysis. All the transformers were sampled in November 2016. Table 3.3 summarises the key criteria which are examined together with the exception limits used by Aurizon Network.

Table 3.3: Oil analysis criteria and exceptions

Description	Exception Limit	Units
Water Content	>35	ppm (mg/kg)
Dielectric Strength	<30	kV
Acidity (Neutralisation Number)	>0.3	mgKOH/g
Interfacial Tension	<20	Dynes/cm
Total Dissolved Combustible Gas Level	>10k	ppm (mg/kg)
Dissolved Hydrogen (H2)	>200	ppm (mg/kg)
Dissolved Carbon Monoxide(CO)	>750	ppm (mg/kg)
Dissolved Methane (CH4)	>150	ppm (mg/kg)
Dissolved Acetylene (C2H2)	>20	ppm (mg/kg)
Dissolved Ethylene (C2H4)	>100	ppm (mg/kg)
Dissolved Ethane (C2H6)	>150	ppm (mg/kg)
Dissolved Nitrogen (N2)	50k to 100k	ppm (mg/kg)





4

Summary of Findings

An assessment of operational KPIs and asset element indicators found that the performance of the CQCN generally met agreed targets.

4.1 Methodology

The following forms the basis of this assessment:

- Operational key performance indicators (KPIs) and asset element lagging indicators – assessed to the extent of data provided by Aurizon Network, based on performance measures during FY 2016
- Site visits – assessed to the extent of sites inspected during the preparation of this report, based on the condition at the time of inspection
- Leading indicators – identification of potential future performance based on a combination of all inputs and observations throughout the assessment.

The ratings thresholds for each KPI and lagging indicator are shown in Table 4.1.

Table 4.1: Rating thresholds

Element	#	KPI / Lagging Indicator	Green *Asset performing at or better than specified*	Yellow *Minor non-conformance*	Amber *Non-conformances with associated risk*	Red *Major non-conformance*
Operational KPI	1	Number of months operating above Below Rail Transit Time	0	1-2	3-6	>6
	2	Overall Track Condition Index	Below range	Within range trending downward	Within range trending upward	Above range
	3	Number of days below Temporary Speed Restrictions target	>98%	90-98%	80-90%	<80%
Track Systems	4	Delay minutes per billion net tonne kilometres	<2,000	2,000-4,000	4,000-6,000	>6,000
	5	Percentage increase in average number of defects per month per track kilometre since 2012 Assessment	0%	<10%	10-20%	>20%
	6	Percentage of sites inspected with serious defects or urgent maintenance requirements	>70%	50-70%	30-50%	<30%
Structures	7	Number of cancellations due to structures	<10	10-15	15-20	>20
	8	Delay minutes for a single service	<360	360-480	480-600	>600
	9	Percentage of assets with >15 years remaining book life	>75%	50%-75%	25%-50%	<25%
	10	Number of days by which inspections of >50% of assets are late	0	<30	30-60	>60
	11	Number of days by which maintenance of >50% of assets are late	0	<30	30-60	>60
Train Control Systems	12	Minutes per billion net tonne kilometres	<7,500	7,500-15,000	15,000-20,000	>20,000
	13	Percentage increase in average number of faults per month per track kilometres from 2012 Assessment	0%	<10%	10-20%	>20%
Telecommunications	14	Minutes per billion net tonne kilometres	<200	200-400	400-600	>600
	15	Percentage increase in average number of faults per month from 2012 Assessment	0%	<10%	10-20%	>20%
Traction distribution	16	Delay minutes per billion net tonne kilometres	<4,500	4,500-6,750	6,750-9,000	>9,000
	17	Number of dewirements	<12	13-15	16-20	>20
	18	Percentage of sites inspected with serious defects or urgent maintenance requirements	<10%	10-15%	15-25%	>25%
Power supply systems	19	Delay minutes per billion net tonne kilometres	<4,500	4,500-6,750	6,750-9,000	>9,000
	20	Percentage of feeder transformer oil tests giving exceptions	<10%	10-15%	15-25%	>25%
	21	Percentage of auto transformer oil tests giving exceptions	<10%	10-15%	15-25%	>25%
	22	Percentage of sites inspected with serious defects or urgent maintenance requirements	<10%	10-15%	15-20%	>20%

4.2 Operational KPIs

A summary of operational KPIs for FY 2016 and FY 2012 is shown in Table 4.2 and Table 4.3 respectively.

Table 4.2: Operational KPIs FY 2016

#	Operational KPI	Newlands	GAPE	Goonyella	Blackwater	Moura
1	Number of months operating above Below Rail Transit Time	0	0	0	1-2	1-2
2	Overall Track Condition Index	Below range		Below range	Below range	Within range trending downward
3	Number of days below Temporary Speed Restrictions target	>98%		<80%	<80%	<80%

Table 4.3: Operational KPIs FY 2012

#	Operational KPI	Newlands	GAPE	Goonyella	Blackwater	Moura
1	Number of months operating above Below Rail Transit Time	3-6		1-2	0	0
2	Overall Track Condition Index	Below range		Below range	Below range	Within range trending upward
3	Number of days below Temporary Speed Restrictions target	90-98%		>98%	<80%	>98%

Aurizon Network has improved on its Below Rail Transit Time (BRTT) performance between FY 2012 and FY 2016.

In FY 2012, two systems were green (Blackwater and Moura), one system was amber (Newlands/GAPE) and one system was yellow (Goonyella), compared with FY 2016, where three systems are green (Newlands, GAPE and Goonyella) and two systems are yellow (Blackwater and Moura).

Aurizon Network has generally maintained its Overall Track Condition Index (OTCI) performance between FY 2012 and FY 2016.

In FY 2012 all systems were green except for Moura and this result is repeated for FY 2016.

The amount and impact of Temporary Speed Restrictions (TSRs) has increased from FY 2012 to FY 2016.

A defect that must be addressed, but does not necessarily stop traffic, is managed by placing a TSR on a length of track until the access opportunity and the resources are available to rectify the defect at the site. TSRs may also be placed when construction or maintenance work is occurring on an adjacent track. This is a prudent and safe practice as long as it is sustainable.

A red light rating occurs when the internal Aurizon Network target for section run time (SRT) cannot be achieved 80% of the time or better. The weighted section run time (WSRT) is a calculation based on the expected delay of the length of track under restriction compared to the standard running of actual traffic. It is weighted by the amount of services that travel over that section to encourage maintenance managers to focus on the restrictions that will impact the most services.

The results for FY 2016 were:

- Newlands – achieved a WSRT better than the SRT target 99.7% of the time
- Goonyella – achieved a WSRT better than the SRT target 21.3% of the time
- Blackwater – achieved a WSRT better than the SRT target 12.0% of the time
- Moura – achieved a WSRT better than the SRT target 74.3% of the time.

4.3 Asset elements

Asset element performance FY 2016

The asset elements performance for FY 2016 is shown in Table 4.4 below.

Table 4.4: Asset element performance FY 2016

Element	#	KPI / Lagging Indicator	Newlands	GAPE	Goonyella	Blackwater	Moura
Track systems	4	Delay minutes per billion net tonne kilometres	4,000-6,000		<2,000	<2,000	2,000-4,000
	5	Percentage increase in average number of defects per month per track kilometre since FY 2012 Assessment	10-20%	>20%	10-20%	>20%	>20%
	6	Percentage of sites inspected with serious defects or urgent maintenance requirements	>70%	>70%	>70%	>70%	>70%
Structures	7	Number of cancellations due to structures	<10	<10	<10	<10	<10
	8	Delay minutes for a single service	<360	<360	<360	<360	<360
	9	Percentage of assets with >15 years remaining book life	50%-75%	>75%	25%-50%	50%-75%	25%-50%
	10	Number of days by which inspections of >50% of assets are late	<30	0	0	30-60	<30
	11	Number of days by which maintenance of >50% of assets are late	<30	0	0	0	0
Train control systems	12	Minutes per billion net tonne kilometres	<7,500		<7,500	<7,500	15,000-20,000
	13	Percentage increase in average number of faults per month per track kilometres from FY 2012 Assessment	>20%	0	10-20%	10-20%	10-20%
Telecommunications	14	Minutes per billion net tonne kilometres	<200		<200	200-400	<200
	15	Percentage increase in average number of faults per month from FY 2012 Assessment	>20%		>20%	>20%	>20%
Traction distribution	16	Delay minutes per billion net tonne kilometres	N / A	N / A	<4,500	<4,500	N / A
	17	Number of dewirements	N / A	N / A	<12	<12	N / A
	18	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	<10%	<10%	N / A
Power supply systems	19	Delay minutes per billion net tonne kilometres	N / A	N / A	<4,500	<4,500	N / A
	20	Percentage of feeder transformer oil tests giving exceptions	N / A	N / A	<10%	<10%	N / A
	21	Percentage of auto transformer oil tests giving exceptions	N / A	N / A	10-15%	10-15%	N / A
	22	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	<10%	<10%	N / A

The red ratings for percentage increase in number of defects stands out clearly in lines 5, 13 and 15. This is a measure that could not be assessed in the previous CBA because it is a relative movement between CBAs. This apparent increase in defects is possibly a combination of an actual increase in defects combined with an improvement in reporting systems. Advisian has noted significant improvement in Aurizon Network reporting systems which supports that a large part of these increased reported defects is due to better reporting. Notwithstanding this, increasing defects are likely with an aging asset and Aurizon Network should monitor this.

Asset element performance FY 2012

The asset elements performance for FY 2012 is shown in Table 4.5 below.

Table 4.5: Asset element performance FY 2012

Element	#	KPI / Lagging Indicator	Newlands	GAPE	Goonyella	Blackwater	Moura
Track systems	4	Delay minutes per billion net tonne kilometres	2,000-4,000	<2,000	2,000-4,000	2,000-4,000	<2,000
	5	Percentage increase in average number of defects per month per track kilometre since previous assessment	N / A	N / A	N / A	N / A	N / A
	6	Percentage of sites inspected with serious defects or urgent maintenance requirements	>70%	N / A	>70%	>70%	>70%
Structures	7	Number of cancellations due to structures	<10	<10	<10	<10	<10
	8	Delay minutes for a single service	<360	<360	480-600	<360	<360
	9	Percentage of assets with >15 years remaining book life	>75%	>75%	>75%	25%-50%	25%-50%
	10	Number of days by which inspections of >50% of assets are late	<30	30-60	30-60	30-60	0
	11	Number of days by which maintenance of >50% of assets are late	<30	N / A	0	N / A	N / A
Train control systems	12	Minutes per billion net tonne kilometres	15,000-20,000	<7,500	7,500-15,000	<7,500	<7,500
	13	Percentage increase in average number of faults per month per track kilometres from previous assessment	N / A	N / A	N / A	N / A	N / A
Telecommunications	14	Minutes per billion net tonne kilometres	<200	<200	200-400	N / A	<200
	15	Percentage increase in average number of faults per month from previous assessment	N / A	N / A	N / A	N / A	N / A
Traction distribution	16	Delay minutes per billion net tonne kilometres	N / A	N / A	<4,500	<4,500	N / A
	17	Number of dewirements	N / A	N / A	<12	<12	N / A
	18	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	<10%	<10%	N / A
Power supply systems	19	Delay minutes per billion net tonne kilometres	N / A	N / A	4,500-6,750	<4,500	N / A
	20	Percentage of feeder transformer oil tests giving exceptions	N / A	N / A	<10%	10-15%	N / A
	21	Percentage of auto transformer oil tests giving exceptions	N / A	N / A	10-15%	<10%	N / A
	22	Percentage of sites inspected with serious defects or urgent maintenance requirements	N / A	N / A	10-15%	<10%	N / A

Other relative improvements from FY 2012 to FY 2016 include:

- Significant decrease in derailments and dewirements
- Performance of structures on all systems
- Reliability of traction distribution and power supply systems on the Goonyella system
- Decrease in delays due to signalling on the Newlands system
- Minimal delays due to telecommunications.

There have been increases in delays on the Newlands system due to track issues and on Moura due to signalling.





5

Newlands system

This 193 kilometres of non electrified track connects the northern end of the Bowen Basin to the Abbot Point Coal Terminal.

5.1 Operational KPIs

Below Rail Transit Time (BRTT)

The Newlands system has achieved BRTT targets consistently in FY 2016. The results are shown in Figure 5.1 below.



Figure 5.1: Newlands system – BRTT

Overall Track Condition Index (OTCI)

The Newlands system (including GAPE) has achieved OTCI targets consistently in FY 2016. The results are shown in Figure 5.2 below.



Figure 5.2: Newlands system (including GAPE) – OTCI

The results in Figure 5.1 and Figure 5.2 indicate a well maintained track.

Speed restrictions

In the Newlands system (including GAPE) in FY 2016, 99.7% of days were recorded to have a weighted section run time (WSRT) performing better than section run time (SRT) targets, as shown in Figure 5.3.

Of particular note is that in this system, WSRT is consistent regardless of the rainfall, indicating that for the Newlands system and GAPE the formation and ballast are in good condition and not sensitive to wet weather.

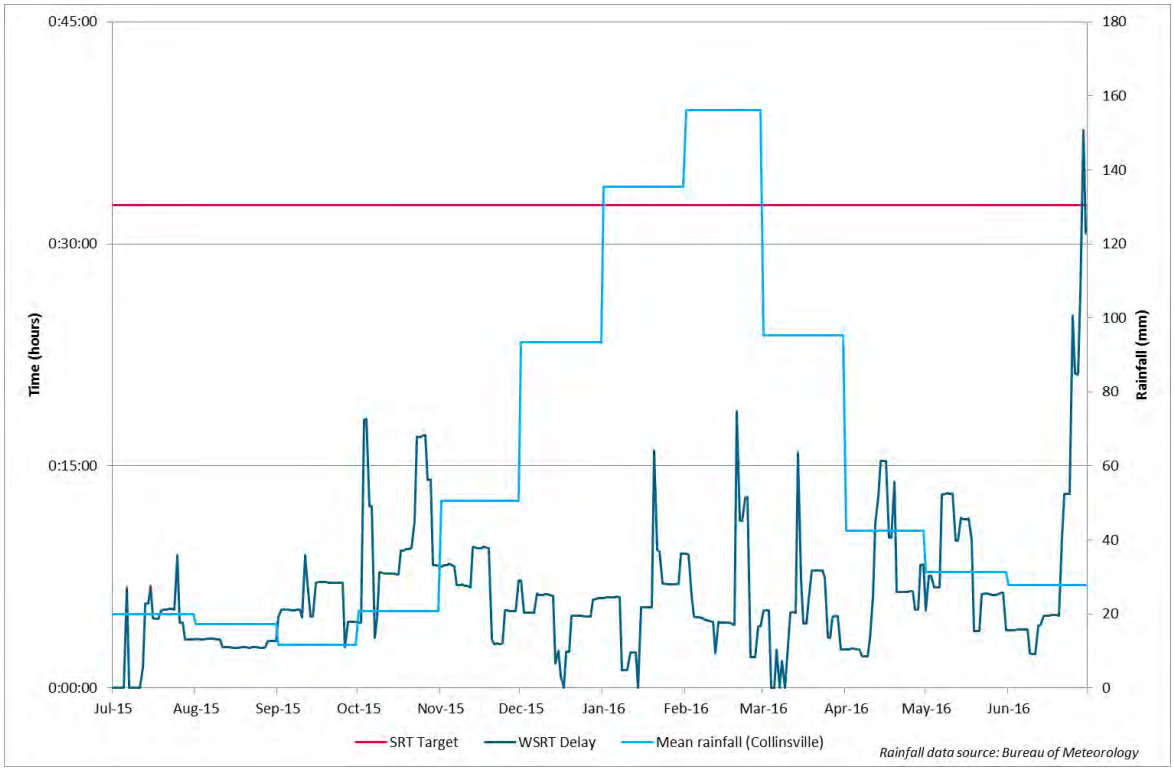


Figure 5.3: Newlands system (including GAPE) – WSRT

Delays

The detailed causes of below rail delays in Newlands (including GAPE) are shown in Figure 5.4 below.

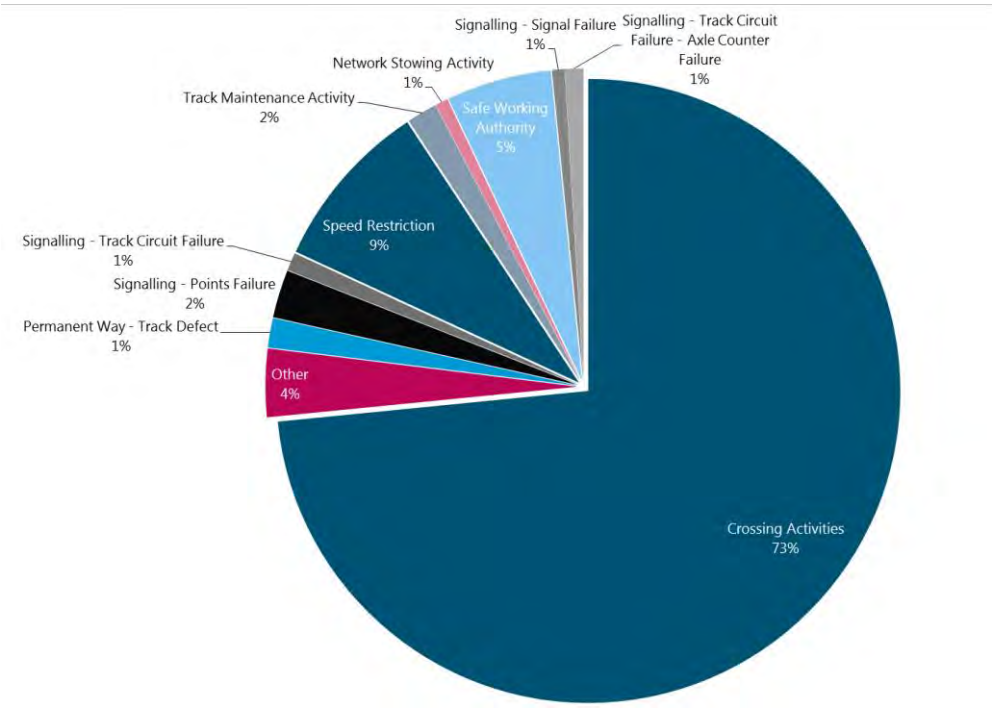


Figure 5.4: Newlands system (including GAPE) – specific causes of rail delays

5.2 Track systems

5.2.1 Lagging indicators

Delays

The delays attributed to the permanent way on the Newlands system (including GAPE) are shown in Table 5.1 below.

Table 5.1: Newlands system (including GAPE) – permanent way delays

Permanent way delays	Delay (minutes)	Normalised delay (min/billion NTK)
Delays due to track maintenance and defects	7,807	4,720

These delays can be broken down into two categories:

- 4,118 minutes per billion NTK attributable to track defects
- 602 minutes per billion NTK attributable to track maintenance and repair.

Due to Aurizon Network reporting systems, GAPE cannot be separated out from the Newlands system and is reported in these figures as well.

Derailments

In FY 2016 there were no derailments in the Newlands system. There was a derailment which damaged a large number of sleepers at Havilah in September 2016 outside the period of this CBA.

Defects

The percentage increase in average number of monthly track and formation defects per track kilometre is 20.4% since the FY 2012 assessment. This is shown in Figure 5.5 and Figure 5.6 below.

It is worth noting the increase in defects reported between FY 2012 and FY 2016. Advisian suggests this is a combination of the impact of the heavier 26.5 tal traffic on the original 20 tal alignment and more rigorous reporting processes by Aurizon Network implemented over the last four years.



Figure 5.5: Newlands system – track and formation defects for FY 2012 and FY 2016

Figure 5.6 shows that in relative terms track defects are more common than bridges, culverts or level crossings.

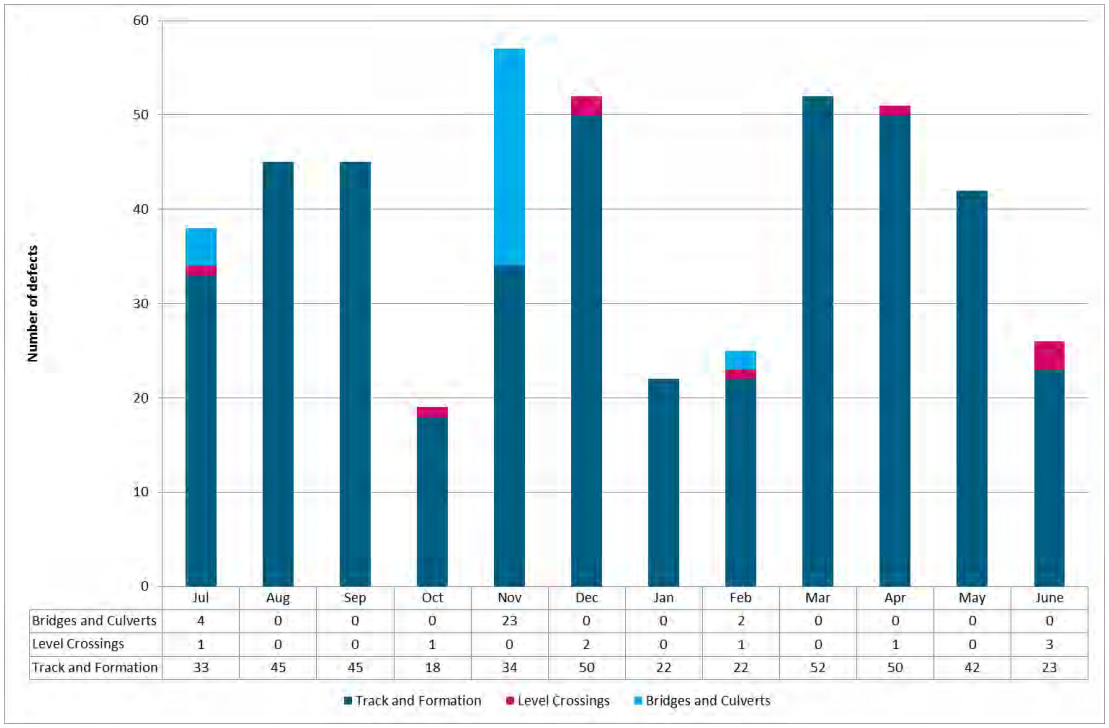


Figure 5.6: Newlands system– monthly track and structures defects

5.2.2 Site visits

The track on the Newlands system was generally in good condition. Of particular note is how well some the original 53 kg/m standard carbon rail is performing when installed on well drained straight track even under the new 26.5 tal loads on the Newlands system.

There were a number of sites to note:

- Ballast contamination at the Abbot Point Coal Terminal (APCT) unloading loop
- Rolling contact fatigue (RCF) in the low rail of an R440 curve constructed in 2012 at Briaba
- Damaged vee at a set of points at Collinsville
- Use of trench drains to improve embankments
- A bad order siding at Collinsville with a set of points due to be removed
- A formation failure west of Pring.

The APCT unloading loop was inspected and significant ballast contamination was noticed on the exit roads, shown in Figure 5.7.



Figure 5.7: Contaminated ballast on the APCT unloading loop exit roads.

This type of coal dust contamination was observed at all unloading loops and requires regular maintenance, either by removal using vacuum trucks or small plant. Although the traffic is moving slowly at these locations maintenance is required to ensure no loss of top and line, particularly in wet weather.

The curve in Figure 5.8 below shows a section of track comprising new track and a recently reballasted original track at Briaba north of Collinsville. The new track is designed for 26.5 tal loads and the original track for 20 tal. The decision to not upgrade the original track saved cost during construction but leads to an operational constraint where loaded trains must use the new track. The rail is 60 kg/m head hardened.



Figure 5.8: R440 curve at Briaba constructed with GAPE

The wear on the rails of the new track is relatively even with 6 mm and 5 mm table wear on the low and high rails respectively after approximately four years of service, at 25 to 30 million net tonnes per year. There is minimal table wear.

There is some evidence of RCF on the lower rail, shown in Figure 5.9, below. There was no evidence of RCF on the high rail. The RCF on the low rail can be removed with grinding.



Figure 5.9: RCF on the low rail of the R440 curve at Briaba

The wear on the Briaba curve is normal for a heavy haul rail system. The earlier the RCF is addressed on the low rail the less steel has to be removed and consequently the longer the service life of the rail. That aside the wear on the rails indicates that the design of this curve is well matched to its design traffic in terms of speed and cant.

At Collinsville a damaged vee at a set of points was inspected. These points clearly show the type of damage fixed vees receive on heavily trafficked systems, as seen in Figure 5.10. Aurizon Network has scheduled a replacement of this fixed vee with a swing nose vee within the next 12 months.



Figure 5.10: Damaged vee on points at Collinsville

At sites that may have top and line defects where there is no opportunity to conduct a proper formation repair, an option used by Aurizon Network, is to construct a 'trench drain', shown in Figure 5.11.



Figure 5.11: Application of a trench drain

A trench drain consists of a slot, excavator width wide, back filled with gravel or ballast. The objective is to drain the ballast and capping layers. As a short term expedient measure it is effective.

Aurizon Network has a program of removing redundant turnouts. A turnout may offer operational flexibility but it also creates a maintenance liability. Consequently Aurizon Network has reviewed a number of locations and assessed that a turnout can be removed with no major impact on operations. One solution identified is to remove one of the two turnouts into the bad order siding at Collinsville, shown in Figure 5.12.



Figure 5.12: Collinsville bad order siding

East of the Binbee Range the Newlands system traverses low level alluvial terrain. In this type of terrain there is always the risk of encountering weak silty or soft clay subgrades.

Figure 5.13 shows a site where, despite topping up with ballast and resurfacing, the top of the rail has still sunk; this indicates a subgrade failure. This site is monitored with white survey marks on the rail and will be reconstructed in the next six months using a standard Aurizon Network design incorporating geogrids and geofabric.



Figure 5.13: Formation failure west of Pring

5.2.3 Leading indicators

Although the Newlands system is performing well on all measures there are some indicators that show that some maintenance issues could be developing. These indicators are the increasing number of defects combined with formation failures such as the ones visited west of Pring.

The root cause of this is the use of the track by 26.5 tal traffic when the initial design was for 22.5 tal. This practice is working the track at the upper end of its capacity and any weak points in the track become apparent; when these weak points are addressed other weak points will surface. Aurizon Network is trialling alternative methods to full formation rebuild to control these: trench drains and shear keys. The performance of these can be assessed in the next CBA.

Currently Aurizon Network has the maintenance under control; and Aurizon Network has little choice but to continue managing the track as they are. However, careful monitoring of failures that can be attributed to the 26.5 tal traffic and watching for an increasing trend in these failures will indicate if Aurizon Network may need to develop an additional strategy to manage them.

5.3 Structures

5.3.1 Lagging indicators

Asset age

The structures on the Newlands system are in mixed condition. Recently constructed structures are in very good condition while some of the older culverts not designed for 26.5 tal need to be propped as a temporary measure.

Asset ages for bridges and culverts in the Newlands system are shown in Figure 5.14 and Figure 5.15.

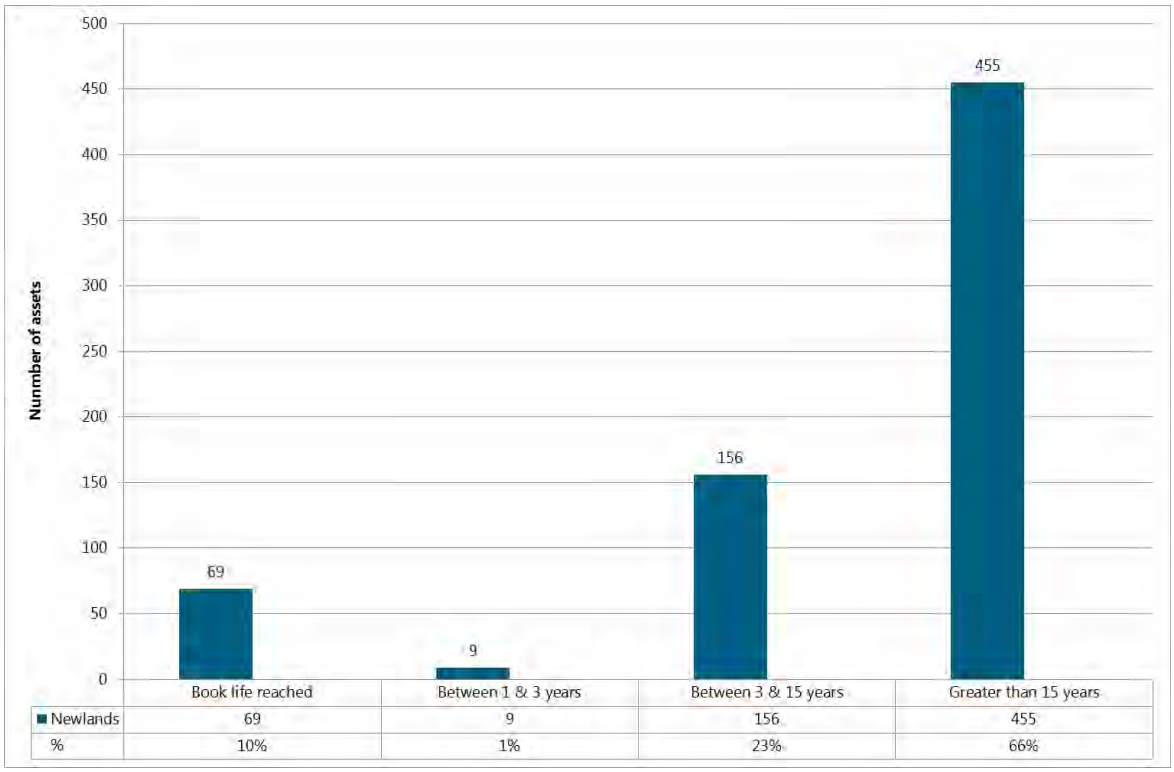


Figure 5.14: Newlands system – bridges and culverts remaining asset book life

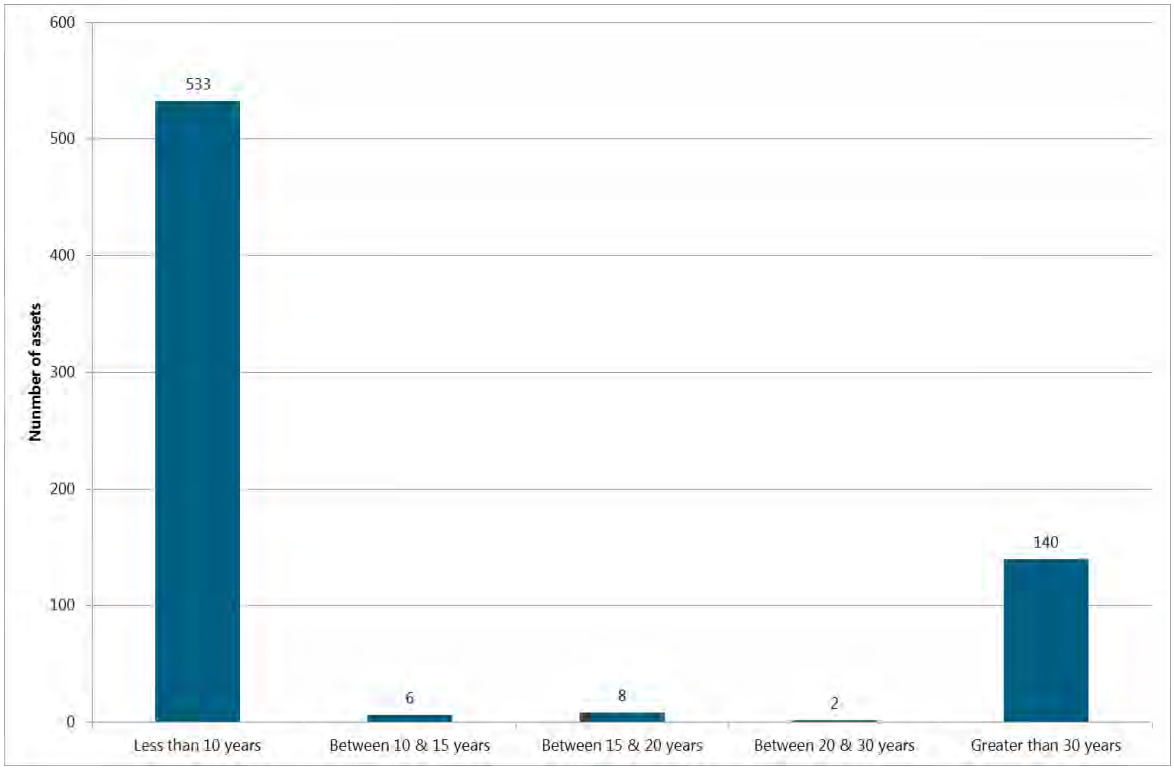


Figure 5.15: Newlands system – bridges and culverts asset age by acquisition date

Inspections

Table 5.2 summarises the inspection work orders in the Newlands system.

Table 5.2: Newlands system – inspection work orders[3]

Inspection work orders	Bridges	Drains	Overall
Number of total inspections:	21	16	37
Number of late inspections:	20	5	25
% of late inspections:	95.2%	31.3%	67.6%
Average number of days late:	16.1	8.0	14.4

Delays

No delays due to structures were reported for the Newlands system in FY 2016.

[3] The FY 2016 inspections was captured using Rail Infrastructure Management System (RIMS), which had an error where inspection due dates were shown to be the 15th of each month instead of the end of the month. Aurizon Network now uses AssetAsyst which captures inspection dates correctly.

5.3.2 Site visits

The Newlands system is a combination of new (designed and constructed to 26.5 tal), retrofitted (designed and constructed to 22.5 tal but with additional engineering to upgrade capacity to 26.5 tal) and legacy structures (remaining at 22.5 tal capacity). Figure 5.16 shows a culvert upgraded from 22.5 tal to 26.5 tal by sleeving with precast units grouted to the existing structure. The finish on these lined concrete works was inspected at a number of locations; all were good quality indicating that Aurizon Network managed these subcontract works well.



Figure 5.16: Original culvert, lined and strengthened, at 130.180

The box culvert at 94.900 featured in the previous CBA for FY 2012. During that CBA it was noted that the culvert had silted up and that vegetation was growing on the banks that had built up immediately downstream of the culvert.



Figure 5.17: Culvert at 94.900 with chloride damage and silt build up

The embankments were silted up as described and the invert levels appear to be too low to allow adequate drainage. This culvert also has chloride damage leading to spalling inside. Aurizon Network is considering relining the culvert as described earlier, but given the combination of the low lying surrounding countryside, chloride damage and drainage issues a short span bridge may be an alternative option.

Silting of culverts is a major issue on the Newlands system. Figure 5.18 shows a recently cleaned culvert where the silt level can clearly be seen. The corrugated iron culverts on the Newlands system were installed during the original 1980s construction are showing the impact of age, through corrosion, and the inability to handle the traffic load, requiring them to be propped. The props add to the maintenance task through obstructing the flow path and catching debris. Aurizon Network has a program to remove these culverts when they require excessive propping and replace them with short span bridges, shown in Figure 5.19.



Figure 5.18: Recently de-silted multi barrel culvert



Figure 5.19: Site of a corrugated iron culvert replaced by a short span bridge at 143.200

Figure 5.20 shows an original six cell box culvert designed and constructed to 22.5 tal, later lined with reinforced concrete to upgrade the capacity to 26.5 tal.



Figure 5.20: Culvert with gabion protection to prevent ballast loss

At this site Aurizon Network is trialling gabions, as seen in Figure 5.20, as a field expedient method to control loss of ballast in the event of overtopping. At the time of the site visit, this control method had not been tested by an overtopping event.



Figure 5.21: Gabion protection to prevent ballast loss

A number of structures on the Newlands system are being monitored or assessed as to how they are handling or whether they can handle 26.5 tal traffic. The bridge at 6.700 west of Pring was originally designed for 22.5 tal traffic and is currently under a speed restriction and being monitored with the current 26.5 tal traffic. It is an uncommon design for CQCN, with thin blade walls and short spans.



Figure 5.22: Bridge at 6.700 west of Pring

Another site under consideration is the original 22.5 tal Euri Creek bridge. This bridge is currently only used by unloaded traffic but this is being reviewed to see if it is capable of taking 26.5 tal traffic and consequently increasing operational flexibility.

Merinda Bridge is a precast concrete bridge at 1.110. It was discussed during site visits that some issues with the bearing pads on this bridge were identified as part of Aurizon Network's level 2 inspections.

Bearing pads are used to provide bridge flexibility and an elastomeric bearing pad is commonly used; these are used to accommodate for horizontal rotation and provide lateral shear movement. They are placed in between superstructures such as the bridge beam and substructures such as the vertical supports called piers. The pads extend the life of bridges by reducing wear and tear on the bridge materials.

Review of Aurizon Network's Structure Condition Inspection Report for this location showed a number of bearing pads are incorrectly bearing on top of the headstock mortar pad. As shown in Figure 5.23, the bearing pad supporting the right hand deck unit is not correctly placed above the mortar pad whereas the bearing pad on the left hand deck unit is directly above the mortar pad.



Figure 5.23: Incorrect placement of bearing pads on Merinda Bridge at 1.110

It also appears some bearing pads have deformed over time and have warped and even split, as seen in Figure 5.24. This deformation of the bearing pad looks attributed to either the incorrect initial placement of the pad or sliding of the pad causing eccentric loading through the bearing pad and deforming the pad accordingly.



Figure 5.24: Deformed bearing pads on Merinda Bridge at 1.110

Recommendations for the existing bearing pad are:

- Identify bearing pads in a state of disrepair
- Confirm bearing pad specification to ensure pads are suitable for bearing load
- Jack up existing deck units where possible and replace bearing pads.

5.3.3 Leading indicators

Based on the lagging indicators and site visits, the Newlands system performed well compared to the others systems. Inspections were performed better than in GAPE, Goonyella and Blackwater systems where less than 30 days were required to undertake inspections of more than half of the assets.

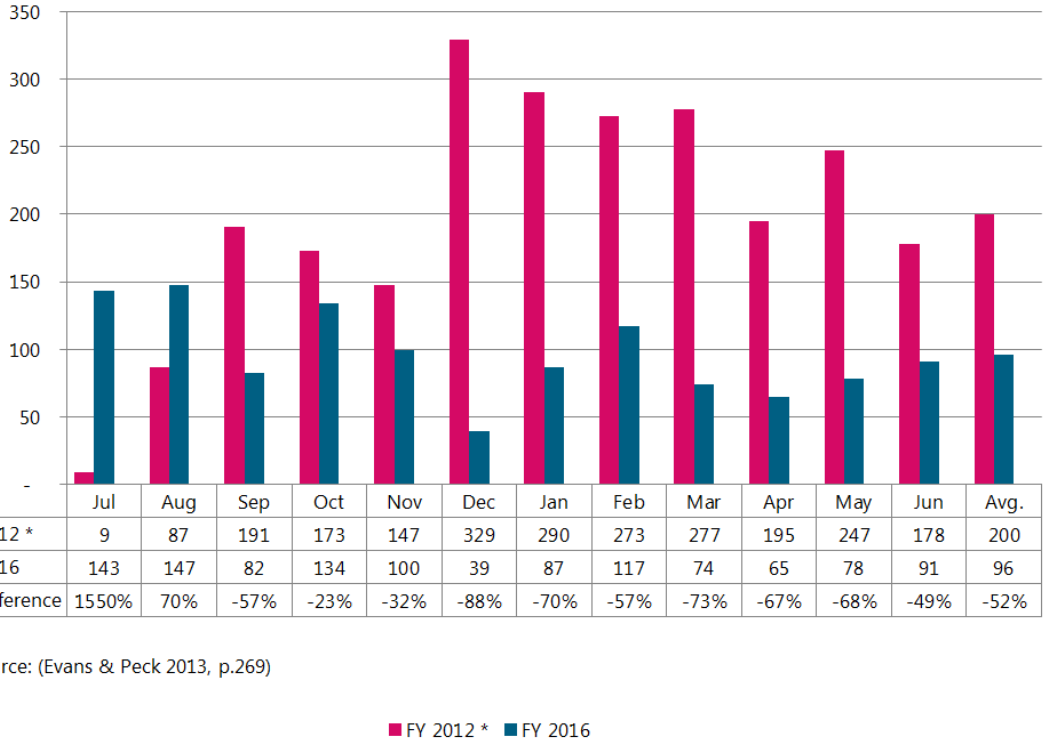
The Newlands system performed the worst for maintenance where more than half of all the asset maintenance was undertaken up to 30 days late. This in conjunction with the late undertaking of inspections may lead additional costs and works due to further degradation.

5.4 Train control systems and telecommunications

5.4.1 Lagging indicators

Signalling faults and delays

The percentage change in number of monthly signalling faults from the FY 2012 assessment is shown in Figure 5.25.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	9	87	191	173	147	329	290	273	277	195	247	178	200
FY 2016	143	147	82	134	100	39	87	117	74	65	78	91	96
% Difference	1550%	70%	-57%	-23%	-32%	-88%	-70%	-57%	-73%	-67%	-68%	-49%	-52%

* Source: (Evans & Peck 2013, p.269)

Figure 5.25: Newlands system –signalling faults for FY 2012 and FY 2016

The delays attributed to signalling on the Newlands system (including GAPE) are shown in Table 5.3.

Table 5.3: Newlands system – signalling delays

Signalling delays	Delay (minutes)	Normalised delay (min/billion NTK)
Signalling delays	27,530	16,644

Breakdowns of the signalling faults and delay minutes by equipment type and element are shown in Figure 5.26 and Figure 5.27.

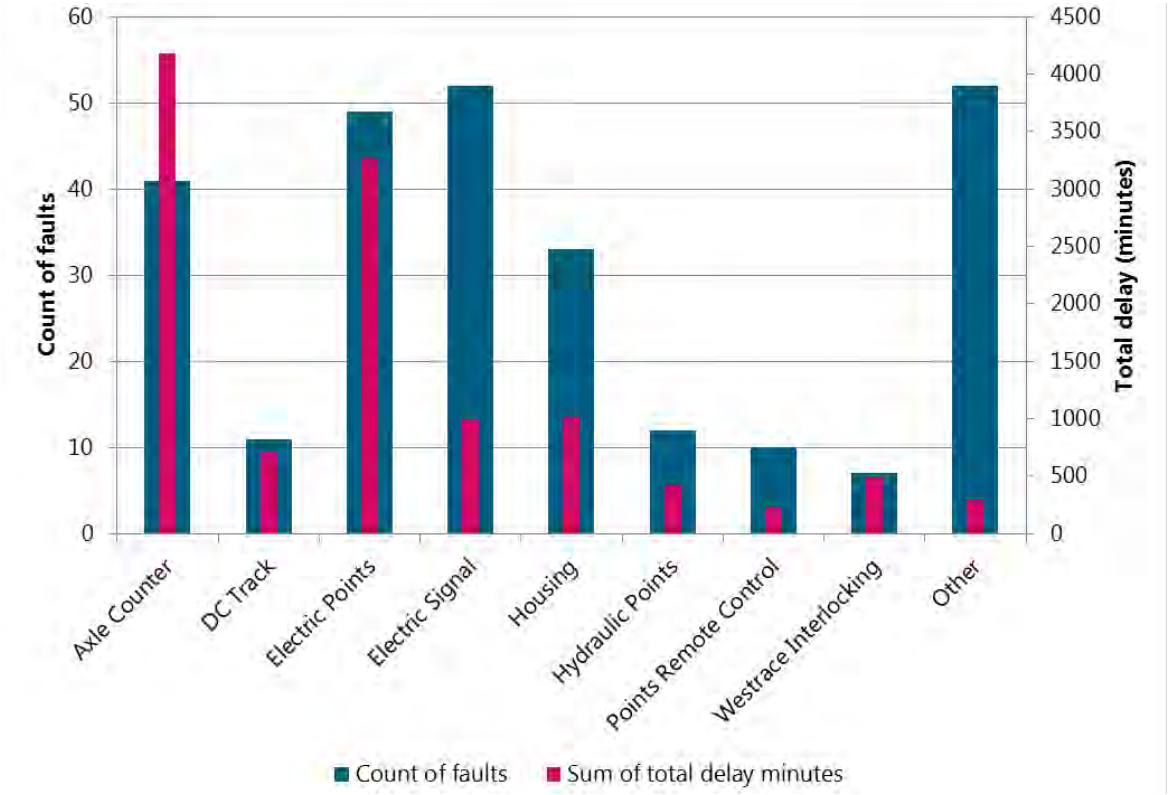


Figure 5.26: Newlands system – signalling faults and delays by equipment type

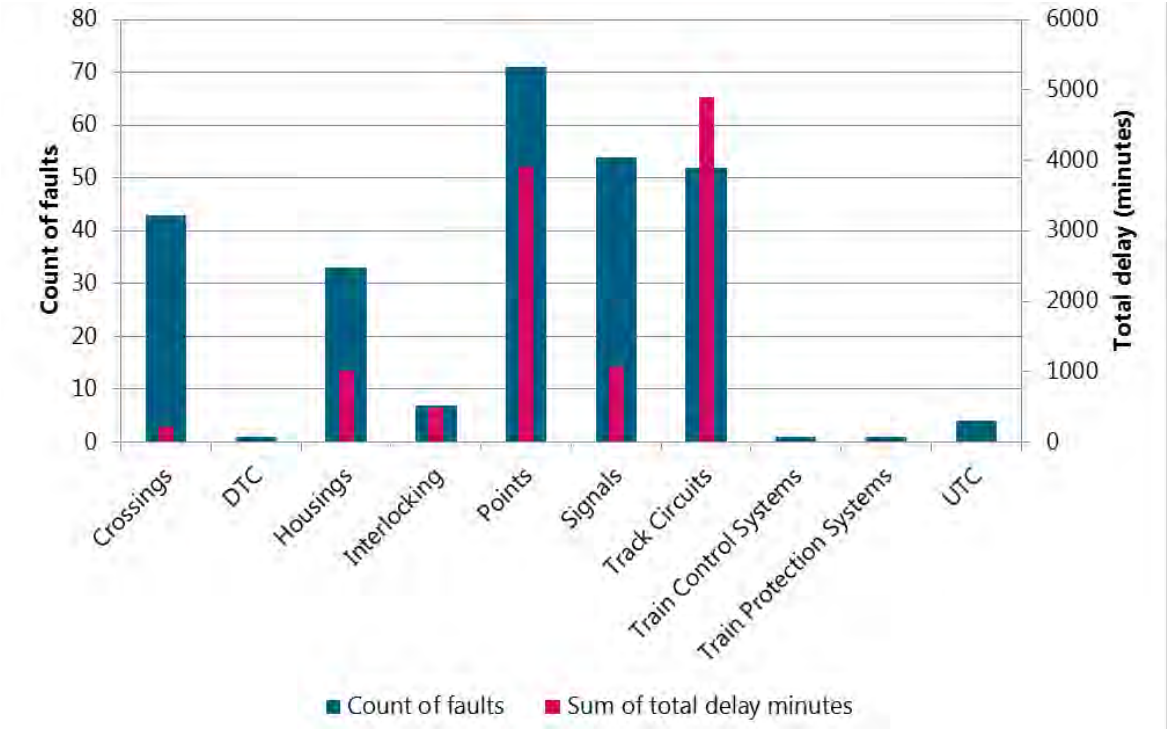
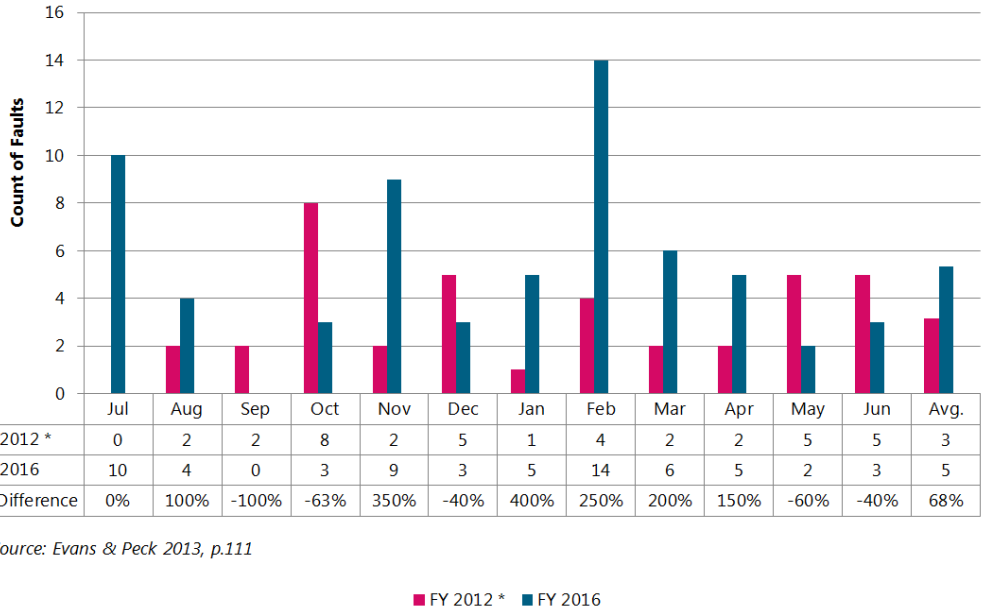


Figure 5.27: Newlands system – signalling faults and delays by element

Telecommunications faults and delays

The Newlands system relies on underground fibre optic wires as its primary means of communication while microwave towers provide a redundancy system. As the Newlands system is not electrified it does not have the option of optical ground wire (OPGW), so the underground optic fibre system is replaced as required.

The percentage change in number of monthly telecommunications faults from the FY 2012 assessment is shown in Figure 5.28.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	0	2	2	8	2	5	1	4	2	2	5	5	3
FY 2016	10	4	0	3	9	3	5	14	6	5	2	3	5
% Difference	0%	100%	-100%	-63%	350%	-40%	400%	250%	200%	150%	-60%	-40%	68%

** Source: Evans & Peck 2013, p.111*

Figure 5.28: Newlands system –telecommunications faults for FY 2012 and FY 2016

The average number of monthly faults has increased significantly since the FY 2012 assessment. The increased number of faults is not necessarily negative indicator, but could suggest an increased level of thoroughness in reporting practices as equipment nears the end of its design life.

The FY 2012 assessment highlighted that 299 minutes of delay attributable to telecommunications failures. The FY 2016 assessment has seen an improvement in delay minutes despite the increased number of reported faults indicating that reporting and maintenance practices have improved. Refer to Table 5.4 for telecommunications delay minutes.

Table 5.4: Newlands system – telecommunications delays

Telecommunications delays	Delay (minutes)	Normalised delay (min/billion NTK)
Telecommunications delays	44	26

Telecommunications delays for FY 2016 amounted to 44 minutes, of which 36 minutes occurred in a single delay in November 2015. This was recorded as a radio issue at Pring, delaying the departure of a train.

5.4.2 Site visits

A new points installation using a reconditioned points machine was inspected at the new Byerwen loading loop, shown in Figure 5.29. The points were clipped and in good condition.



Figure 5.29: Reconditioned set of points installed at Byerwen

At Havilah the solar panel array that powers the signalling equipment room (SER) and communications equipment room was inspected. Panels were in good condition and the backup generator was fuelled and in good condition.



Figure 5.30: Solar panels at Havilah

5.4.3 Leading indicators

Signalling faults per thousand track kilometres have decreased since FY 2012 from 200 to 96. The decrease in number of faults also translates to decreased delay minutes, from 34,103 in the FY 2012 assessment to 27,530 in the FY 2016 assessment.

Electric signals are the most common cause of faults and axle counters have had the biggest delay impact (4,184 minutes). Despite this, overall track circuit delays for FY 2016 are less than half of those for FY 2012.

Telecommunications faults on the other hand appear to have increased while delays have decreased. This indicates that more rigour may be being applied in defect reporting, increasing the number of faults detected prior to them resulting in effective delays. The redundancy built into the Aurizon Network assists this.

Train control and telecommunications systems in Newlands do not have any apparent anticipated maintenance issues.

5.5 Traction distribution and power supply systems

The Newlands system was intended to be electrified during the construction of GAPE; however electrification of the system was halted due to the 2008 financial crisis. As part of the Newlands upgrade that happened during GAPE construction, some track elements with ability to become electrified were installed. An example of this is the second bridge at Euri Creek which has beams extending beyond the width of the track for traction distribution mast installation.



Figure 5.31: The second Euri Creek Bridge (foreground) with extended beams for traction distribution masts





6

GAPE system

This newest system in the CQCN was commissioned at the end of 2012. The 81 kilometres of track connects the Goonyella system to the Newlands system.

6.1 Operational KPIs

GAPE connects the Goonyella system at North Goonyella with the Newlands system at Collinsville. The connection is approximately 70 km long and was completed in December 2011. The expansion was designed to increase the axle load to 26.5 tal and the capacity of this system from 25 mtpa to 50 mtpa.

GAPE is generally designed and constructed to current engineering standards, and is relatively new.

Below Rail Transit Time (BRTT)

GAPE has achieved BRTT targets consistently in FY 2016.The results are shown in Figure 6.1 below.

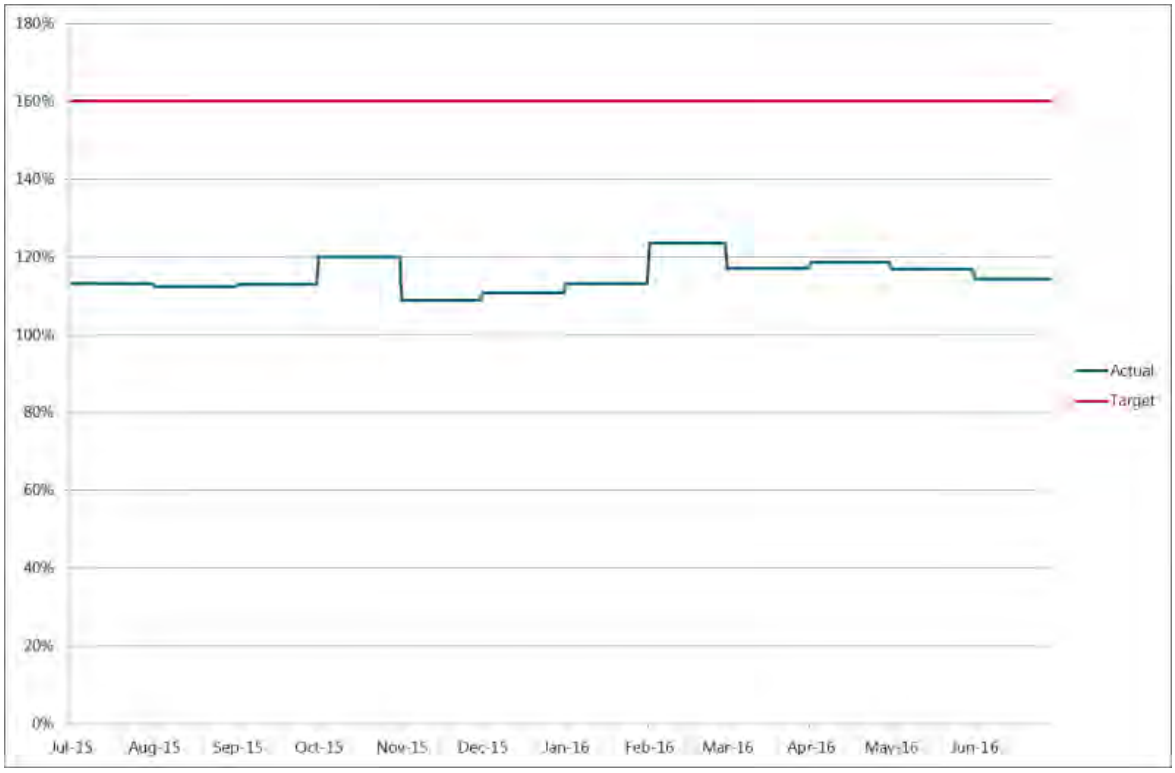


Figure 6.1: GAPE – BRTT

Overall Track Condition Index (OTCI)

Aurizon Network reporting does not differentiate between GAPE and Newlands system for the recording of OTCI data and these have been discussed in the Newlands system (section 5.1).

Speed restrictions

Aurizon Network reporting does not differentiate between the GAPE and Newlands systems for the recording of Temporary Speed Restrictions (TSR) and Section Run Time (SRT) data and these have been discussed in the Newlands system (section 5.1).

6.2 Track systems

6.2.1 Lagging indicators

Delays

Aurizon Network reporting systems group GAPE with the Newlands system for tracking of delays, shown in section 5.2.

Derailments

In FY 2016 there were no derailments in GAPE.

Defects

As the FY 2012 assessment did not differentiate between the GAPE and Newlands systems, there is no historical data available to determine percentage increase in defects for GAPE. The average number of monthly track and formation defects per track kilometre is shown in Figure 6.2 and Figure 6.3.

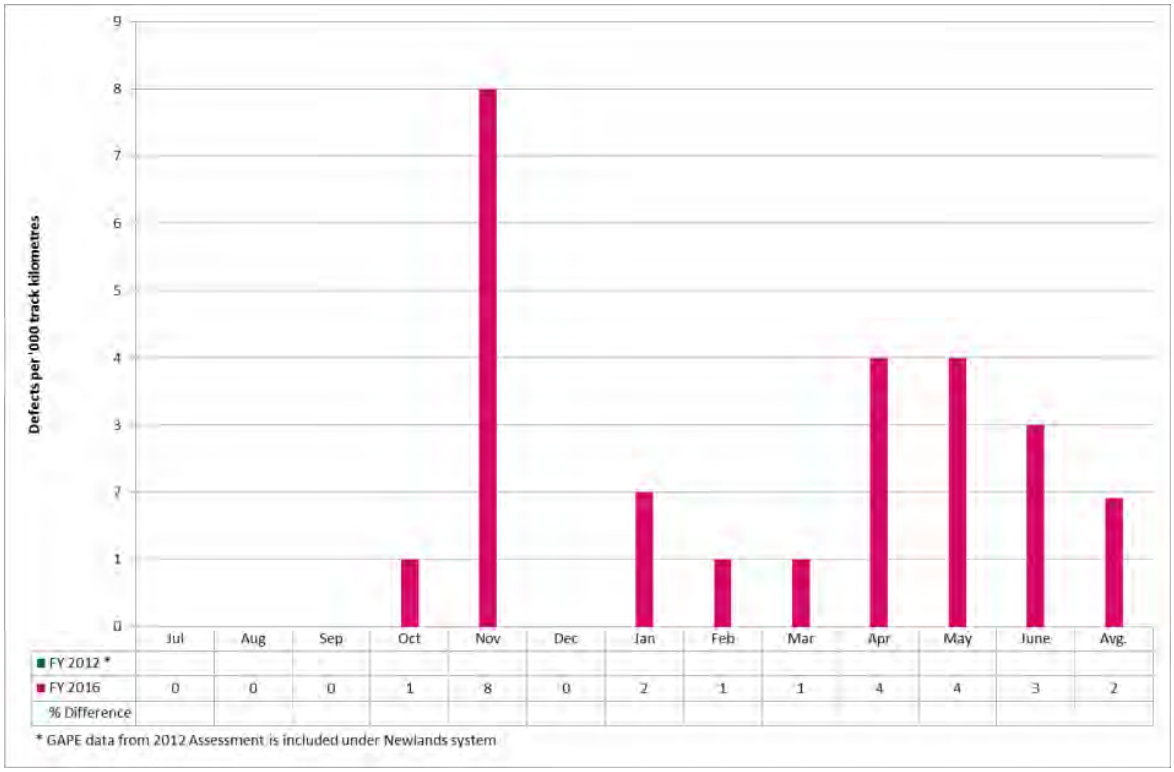
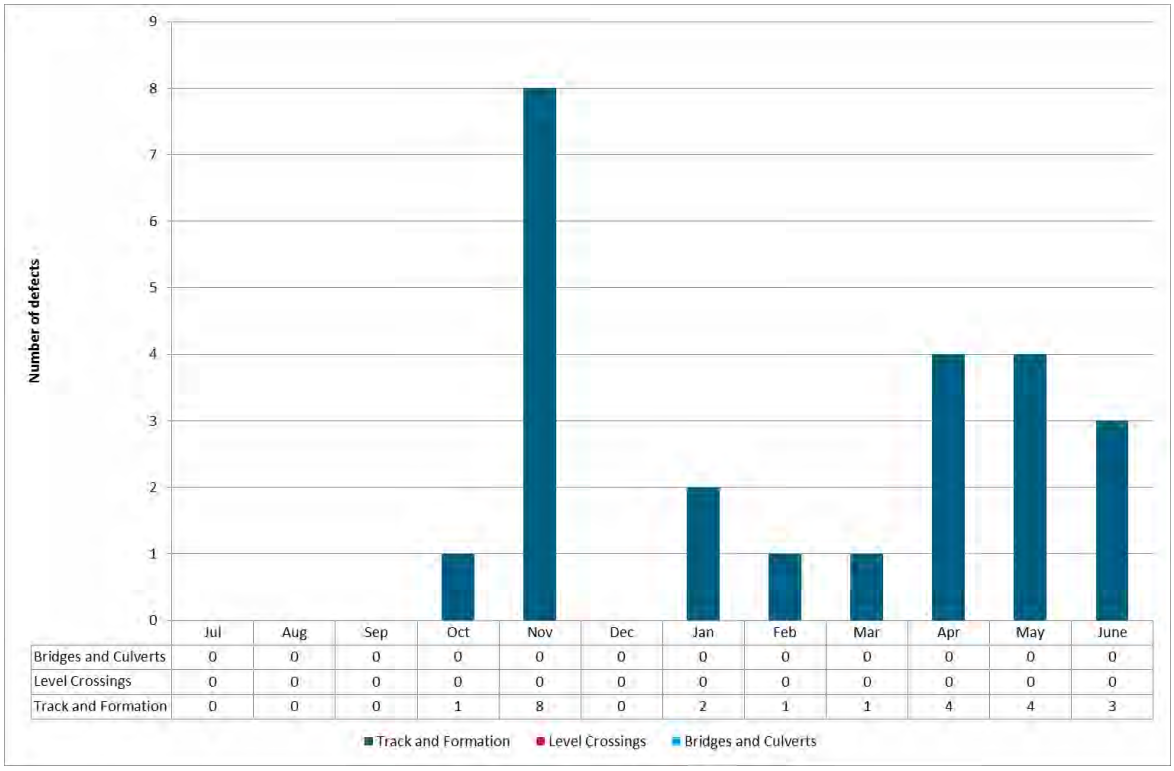


Figure 6.2: GAPE – track and formation defects by month



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bridges and Culverts	0	0	0	0	0	0	0	0	0	0	0	0
Level Crossings	0	0	0	0	0	0	0	0	0	0	0	0
Track and Formation	0	0	0	1	8	0	2	1	1	4	4	3

Figure 6.3: GAPE – monthly track and structures defects

6.2.2 Site visits

A number of sites were visited on GAPE. At Eaglefield a straight length of track was inspected, shown in Figure 6.4; no rail defects were identified and wear was an even 1 mm on both rails.



Figure 6.4: Straight 60 kg/m head hardened rail in the vicinity of Eaglefield

At the same site a turnout vee which had been replaced was inspected. There was no visible sign of a defect on the removed vee and little sign of wear; however, an ultrasonic inspection had identified a defect. Subsequent review of the inspection report identified that the ultrasound had identified a horizontal split head defect. A horizontal split head is a longitudinal defect that can originate from the manufacturing process. This type of defect cannot be detected visually until it is well progressed.

The welds on the replacement vee are shown in Figure 6.5 below. The weld identifier is clear; this weld was completed by welder 327 in 2016 and it was their 44th and 46th weld of the year. This identifier ensures accountability and aids quality control.



Figure 6.5: Location of replaced defective turnout vee at Eaglefield

A new loading loop constructed at Byerwen shown in Figure 6.6 was inspected. This loop is not operational and the points are clipped. Aurizon Network has installed a set of swing nose points at this location, shown in Figure 6.7. These points are more expensive than fixed vee points but create a much lighter maintenance burden.



Figure 6.6: New loading loop at Byerwen



Figure 6.7: Swing nose vee at Byerwen

6.2.3 Leading indicators

A combination of the trends in OTCI, lag indicators and site visit results indicate that the GAPE project is a well-engineered and well-constructed project. It is showing only light wear after four years of operations. This system is also showing that it handles wet weather well with minimal increase in TSR which indicates the ballast and formation is in good condition.

6.3 Structures

6.3.1 Lagging indicators

Asset age

GAPE has predominantly new structures as can be seen in Figure 6.8 and Figure 6.9 below.

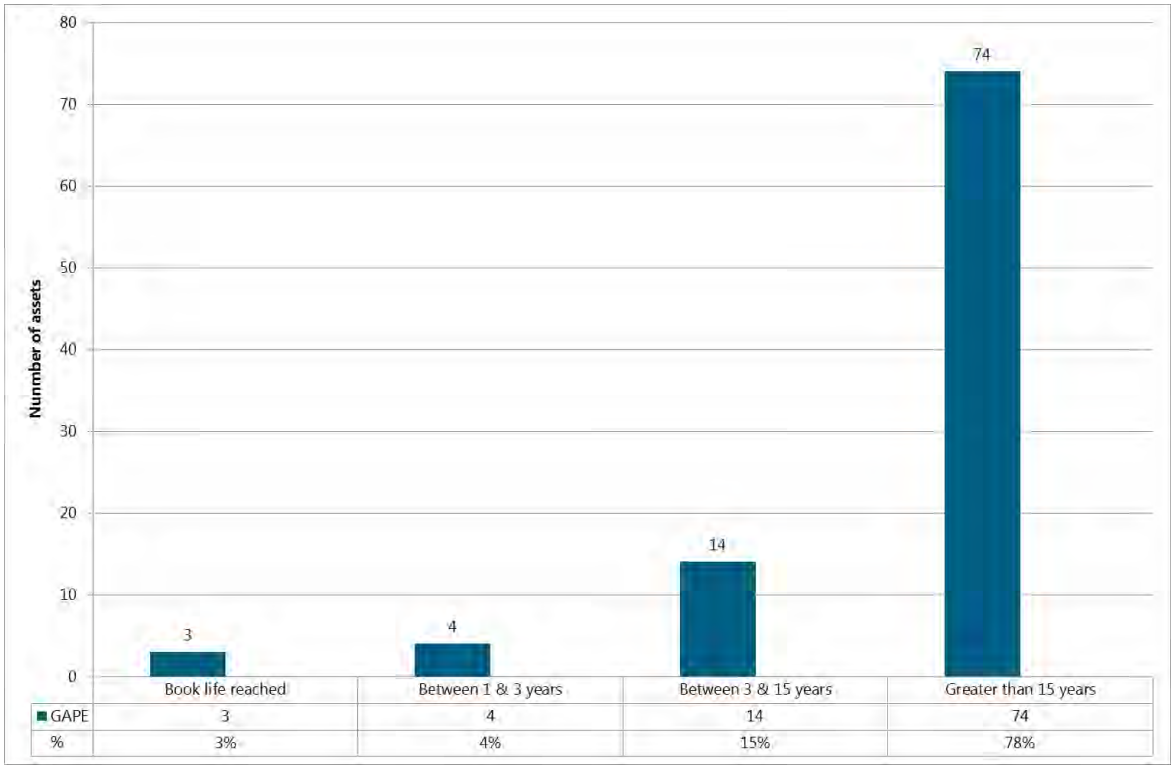


Figure 6.8: GAPE – bridges and culverts remaining asset book life

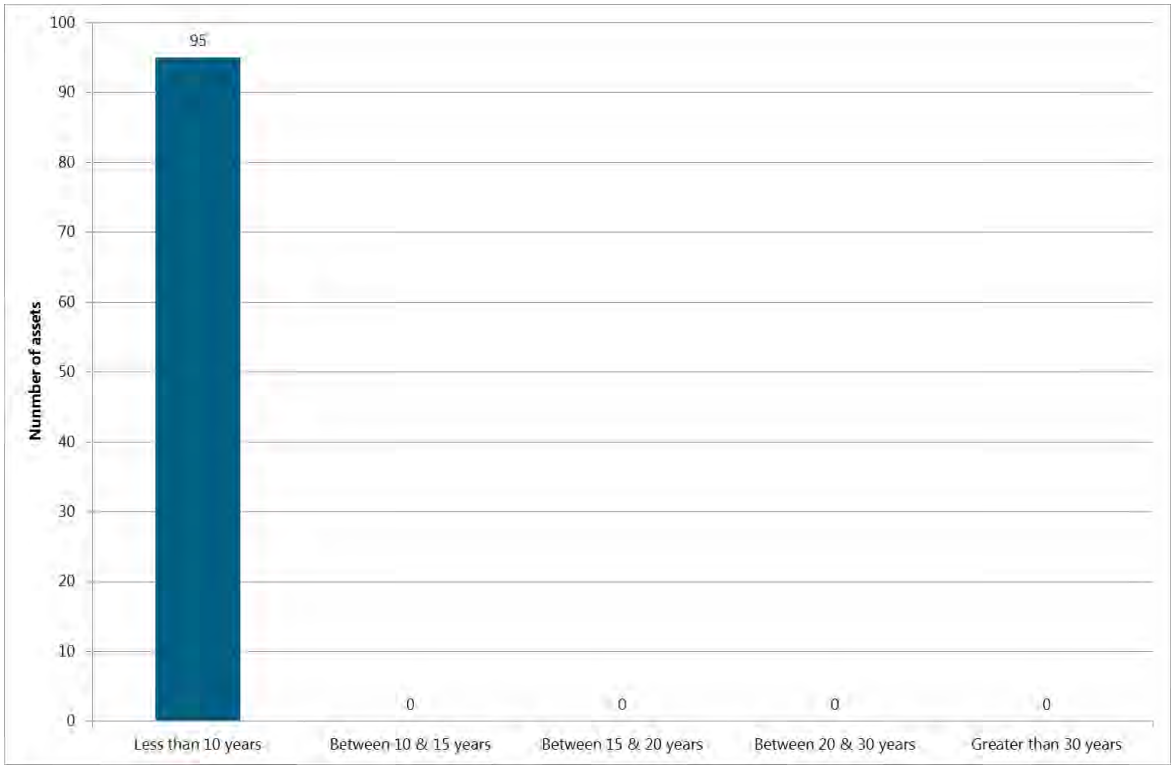


Figure 6.9: GAPE – bridges and culverts asset age by acquisition date

Inspections

Inspection work orders showed that inspections on all 11 bridges on GAPE were conducted on time. A review of one inspection report indicated that some bridges were having issues with bearings. This issue appears to be being monitored well.

Delays

Due to Aurizon Network reporting methods, delay incidents along GAPE are reported as part of the Newlands system, shown in section 5.3.

6.3.2 Site visits

The GAPE bridges are prestressed concrete bridges constructed by the CoalConnect Alliance for Aurizon Network in 2011/2012. The bridges are generally in good condition, as seen in Figure 6.10, although some inspection reports note some bearing issues and some minor cracking was observed, shown in Figure 6.11.



Figure 6.10: Pre-stressed concrete girder bridge at 177.690



Figure 6.11: Close up of bridge at 177.690 showing cracks

6.3.3 Leading indicators

Based on the lagging indicators, GAPE performed well. As one of the newer systems, with 75% of all assets having greater than 15 years remaining book life, this is to be expected. Similar to both the Goonyella and Blackwater systems, routine inspections were late by up to 30 to 60 days for over half of the assets.

On GAPE the structures are all new and performing well with no delays being caused and all inspection being carried out on time. The only two issues that appear to be developing are some issues in regards to bearings which could lead to a requirement to jack a bridge and reposition or replace the bearings, and some cracking, which could require an epoxy repair in the future.

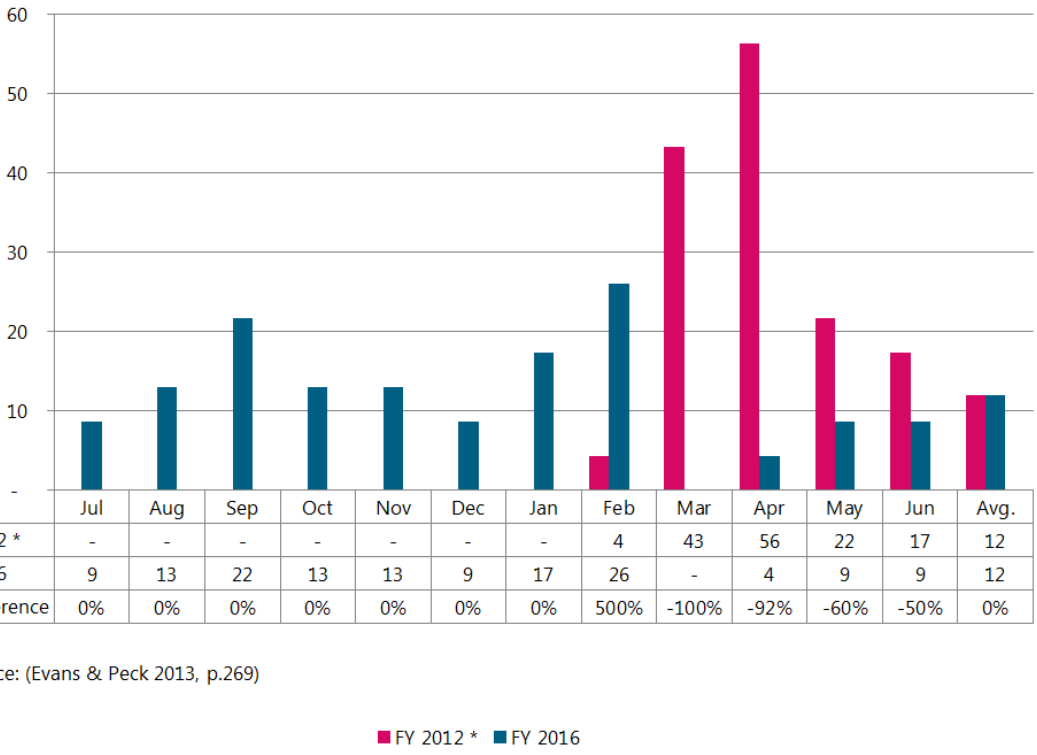
As with most of the CQCN, it seems maintenance activities are either taking longer to undertake or are being pushed for higher priority items.

6.4 Train control systems and telecommunications

6.4.1 Lagging indicators

Signalling faults and delays

The percentage change in number of monthly signalling faults from the FY 2012 assessment is shown in Figure 6.12.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	-	-	-	-	-	-	-	4	43	56	22	17	12
FY 2016	9	13	22	13	13	9	17	26	-	4	9	9	12
% Difference	0%	0%	0%	0%	0%	0%	0%	500%	-100%	-92%	-60%	-50%	0%

* Source: (Evans & Peck 2013, p.269)

Figure 6.12: GAPE – signalling faults for FY 2012 and FY 2016

Breakdowns of the signalling faults and delay minutes by equipment type and element are shown in Figure 6.13 and Figure 6.14.

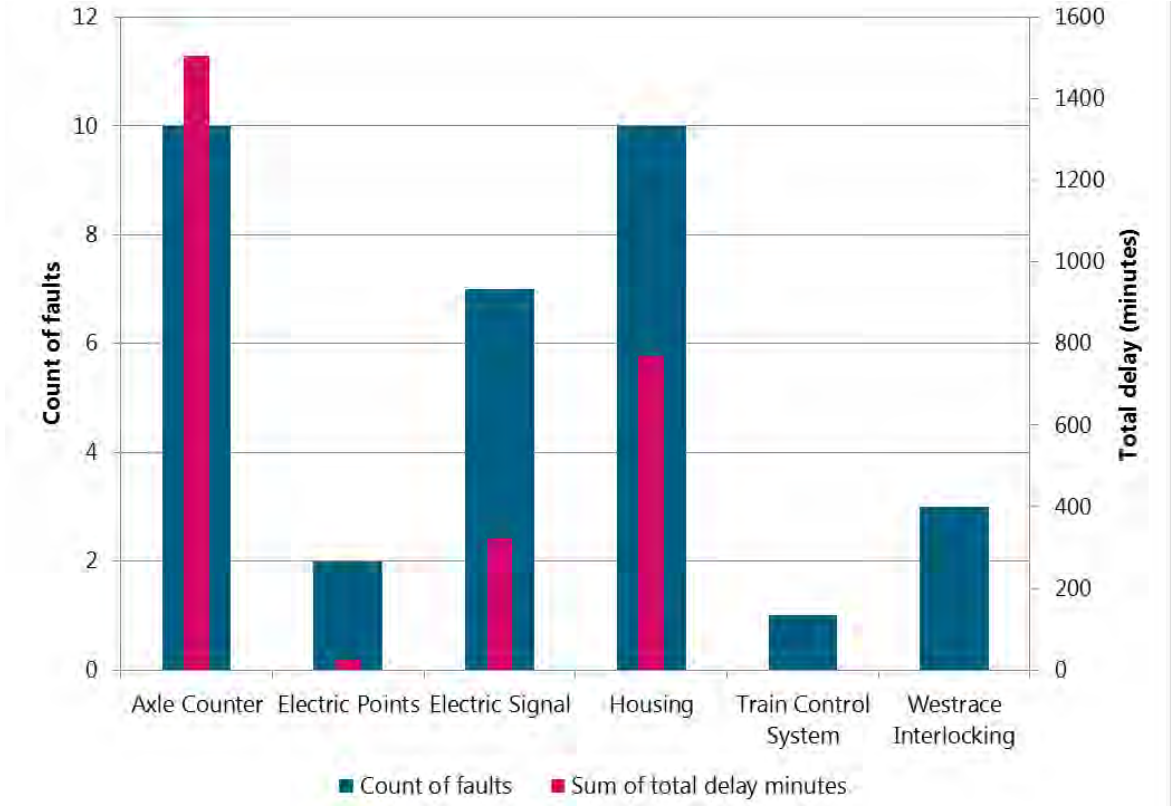


Figure 6.13: GAPE – signalling faults and delays by equipment type

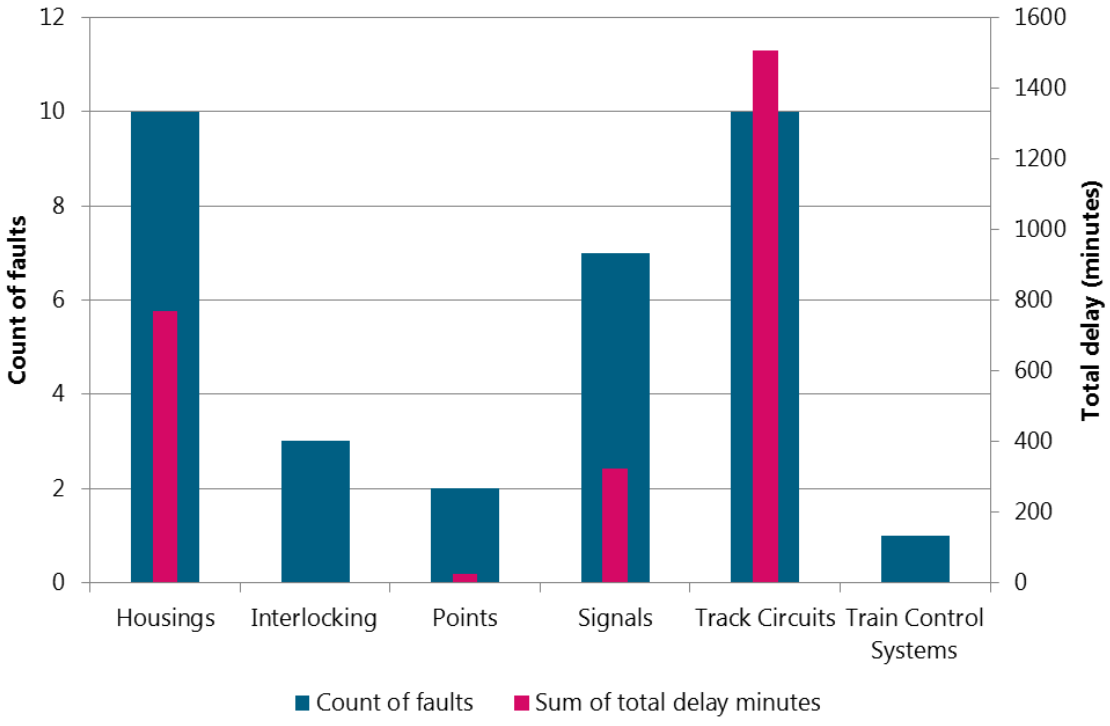
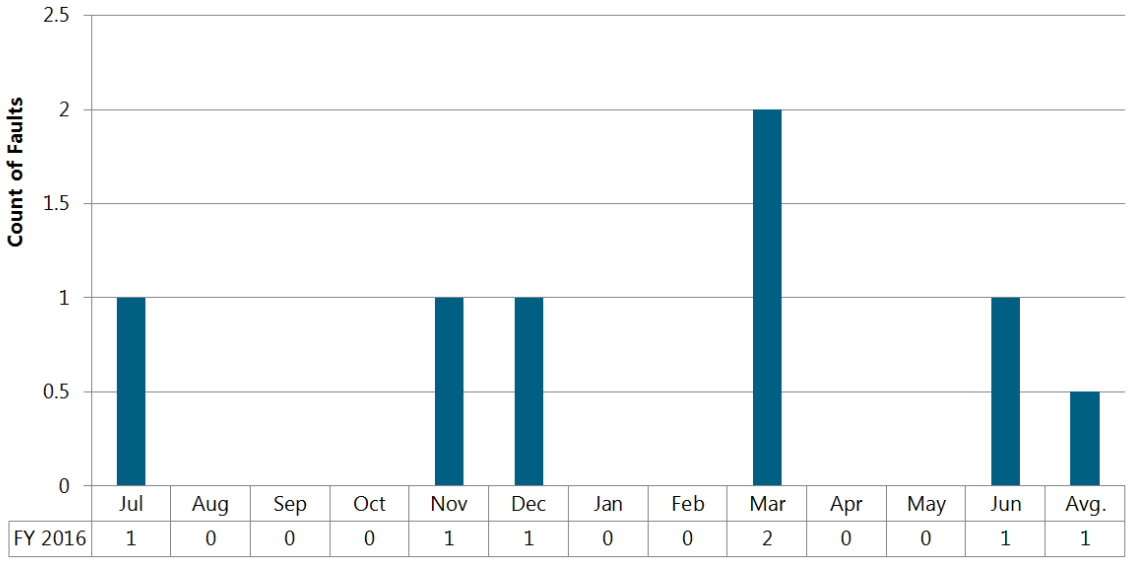


Figure 6.14: GAPE – signalling faults and delays by element

Telecommunications faults and delays

The count of GAPE telecommunications faults was not made in the FY 2012 assessment, so there can be no comparison against past performance in this respect. Similar to the Newlands system, GAPE relies on underground fibre optic wires as its primary means of communication with microwave towers providing a redundancy system.

The monthly telecommunications faults are shown in Figure 6.15.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2016	1	0	0	0	1	1	0	0	2	0	0	1	1

Figure 6.15: GAPE – telecommunications faults

6.4.2 Site visits

The GAPE telecommunications and signalling assets are relatively new and no issues were identified during the site inspections. The points at the Eaglefield Creek passing loop were inspected and found to be in good condition, as shown in Figure 6.16.



Figure 6.16: Eaglefield Creek points

The new signalling installation at the Byerwen loading loop was inspected. This installation is complete but not operational yet. The installation was in good condition with the points clipped in a number of locations as this was a swing nose installation, as seen in Figure 6.17.



Figure 6.17: Clipped points at Byerwen

Two interesting aspects at Byerwen are that Aurizon Network used a reconditioned set of points and that the installation included signal masts fitted with counterweights to allow easy access without having to work at heights, shown in Figure 6.18.



Figure 6.18: Folding signal mast at Byerwen

6.4.3 Leading indicators

The count of faults per thousand track kilometres in the FY 2012 assessment is the same for those in FY 2016. Fault occurrences in FY 2016 all occur between the months of February and June, indicating that the faults may be due to settling after heavy rainfall in the area between December and May. The largest impact on delay minutes is caused by axle counters, consistent with the main delay cause in the Newlands system. It may be worth Aurizon Network investigating the use of axle counters across the GAPE and Newlands systems to reduce operational delays.

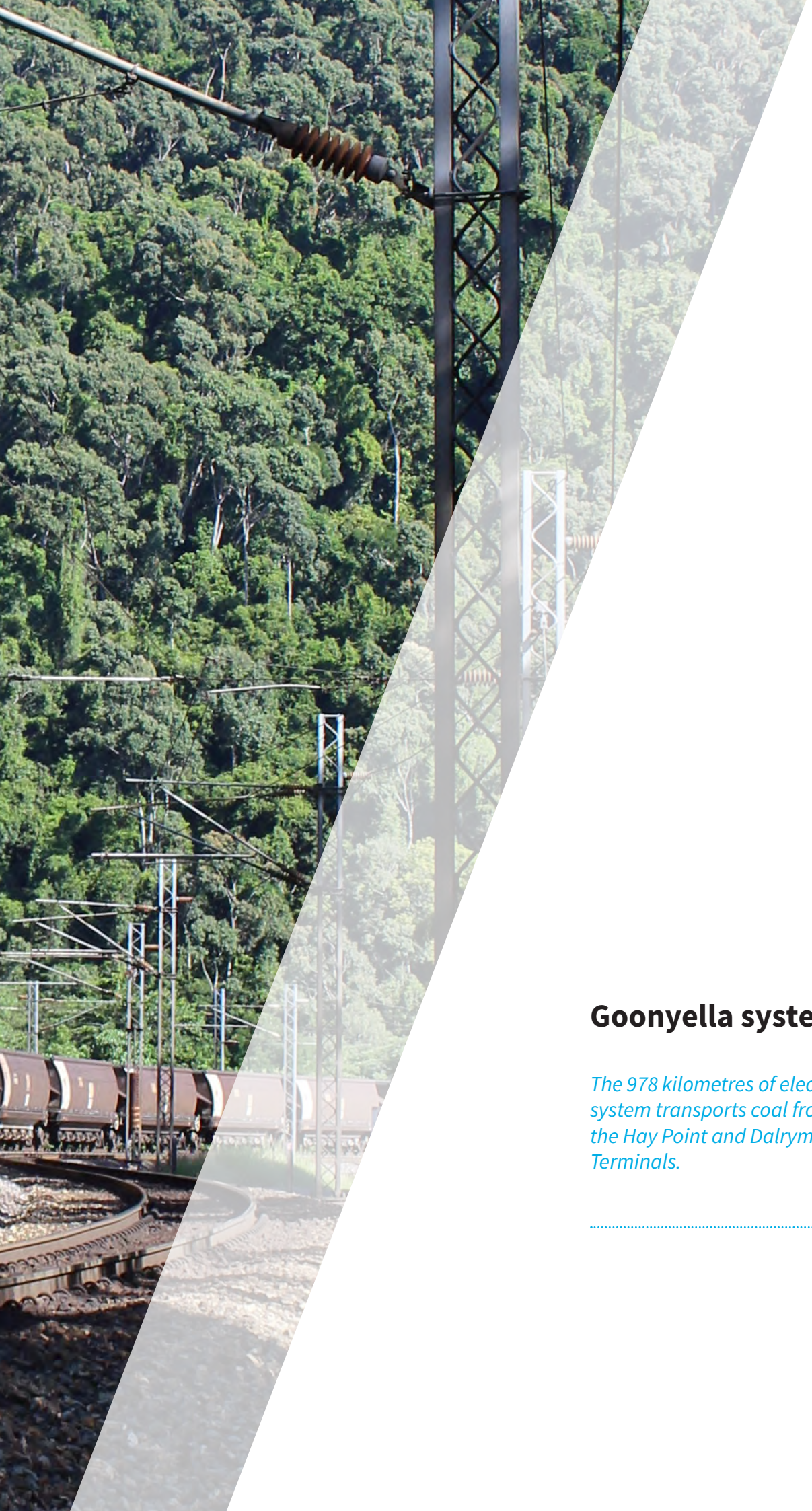
Telecommunications delays for FY 2016 were negligible (9 minutes) with six faults reported for the period.

Aside from delays caused by axle counters, there are no other anticipated issues in GAPE.

6.5 Traction distribution and power supply systems

GAPE was intended to be electrified during its construction; however electrification of the system was halted due to the 2008 financial crisis.


3714
3714
3714



7

Goonyella system

The 978 kilometres of electrified track in this system transports coal from the Bowen Basin to the Hay Point and Dalrymple Bay Coal Terminals.

7.1 Operational KPIs

Below Rail Transit Time (BRTT)

The Goonyella system has achieved BRTT targets consistently in FY 2016. The results are shown in Figure 7.1 below.



Figure 7.1: Goonyella system – BRTT

Overall Track Condition Index (OTCI)

The Goonyella system has achieved OTCI targets consistently in FY 2016. The results are shown in Figure 7.2 below.

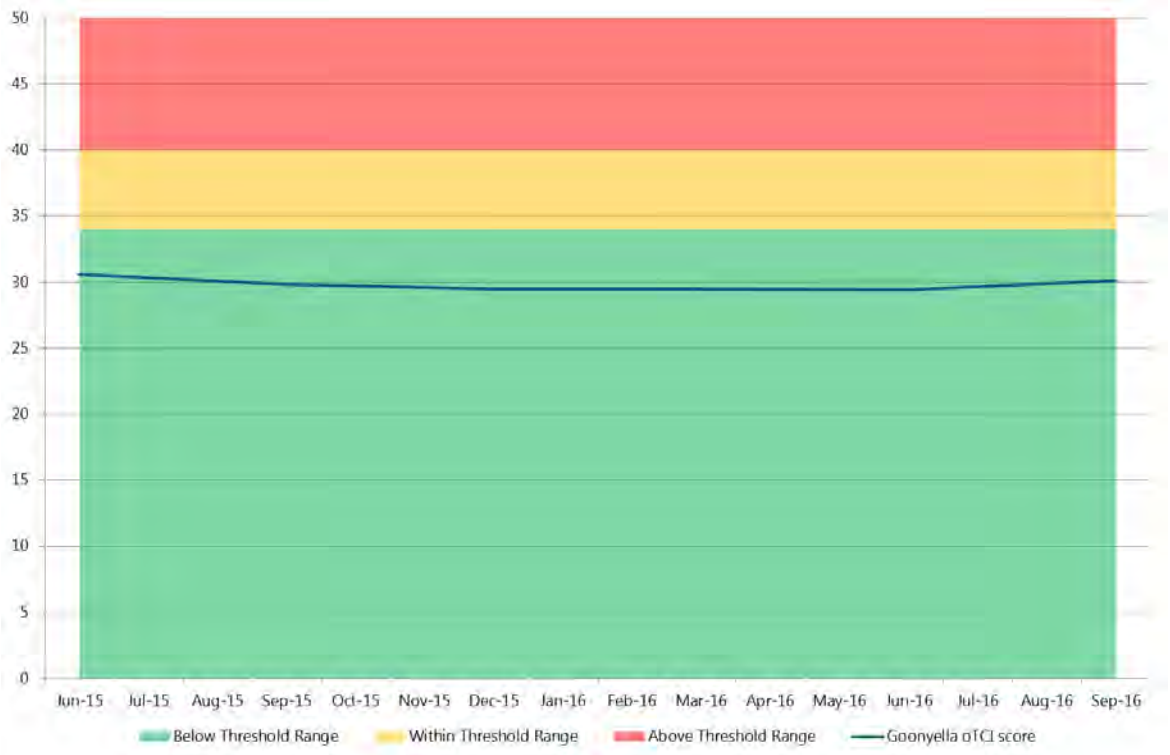


Figure 7.2: Goonyella system – OTCI

The results in Figure 7.1 and Figure 7.2 indicate a well maintained track.

Speed restrictions

In the Goonyella system in FY 2016, 21.3% of days were recorded to have a weighted section run time (WSRT) performing better than section run time (SRT) targets, as shown in Figure 7.3. There is a correlation with this track and its performance in wet weather.

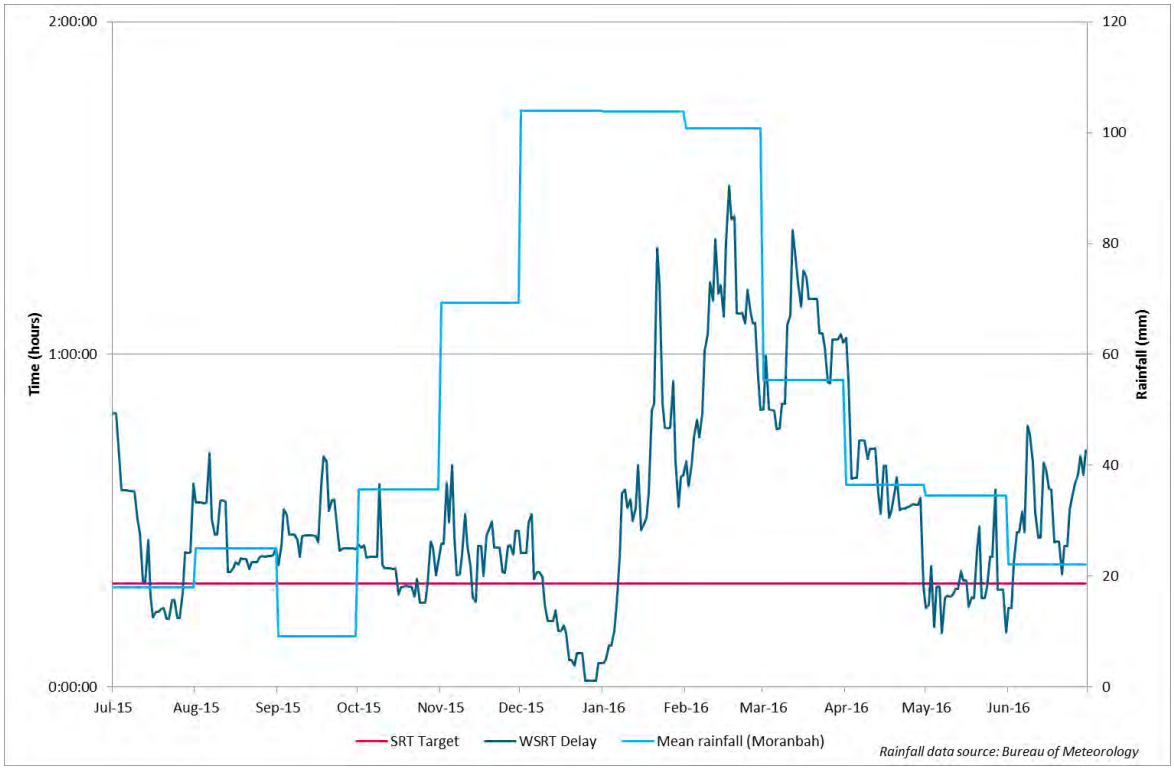


Figure 7.3: Goonyella system – WSRT

Delays

The detailed causes of below rail delays in Goonyella are shown Figure 7.4 below. Crossing activities had the greatest impact, followed by speed restrictions. The specific below rail impacts follow; in order, permanent way, signalling and traction distribution.

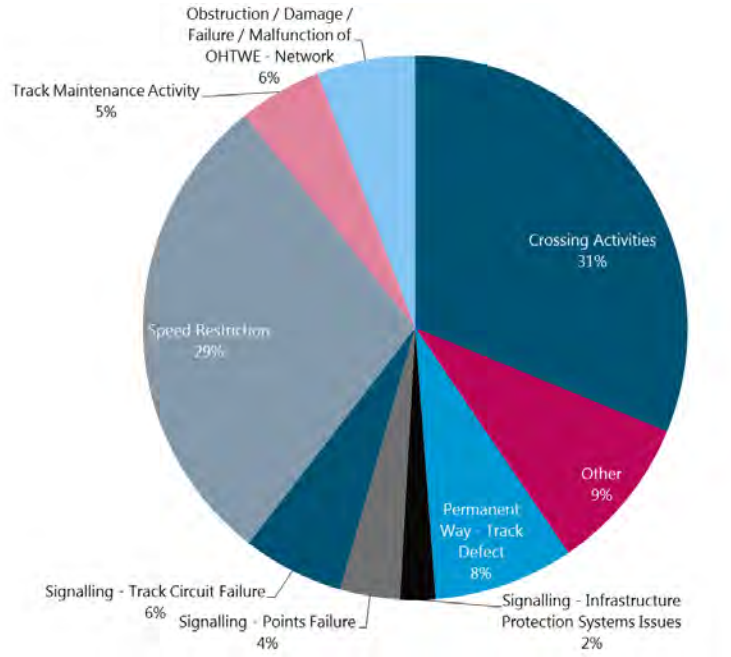


Figure 7.4: Goonyella system – specific causes of rail delays

7.2 Track systems

7.2.1 Lagging indicators

Delays

The delays attributed to the permanent way on the Goonyella system are shown in Table 7.1 below.

Table 7.1: Goonyella system – permanent way delays

Permanent way delays	Delay (minutes)	Normalised delay (min/billion NTK)
Delays due to track maintenance and defects	64,771	2,622

These delays can be broken down into the below two categories:

- 2,321 minutes per billion NTK attributable to track defects
- 301 minutes per billion NTK attributable to track maintenance and repair.

Derailments

Derailments in the Goonyella system in FY 2016 are shown in Table 7.2. There were ten derailments on the Goonyella system during FY 2016. None of these were main line derailments: three at sidings, three at Jilalan Yard, two unloading at Dalrymple Bay and one at Blair Athol loading loop.

Table 7.2: Goonyella system – derailment summary

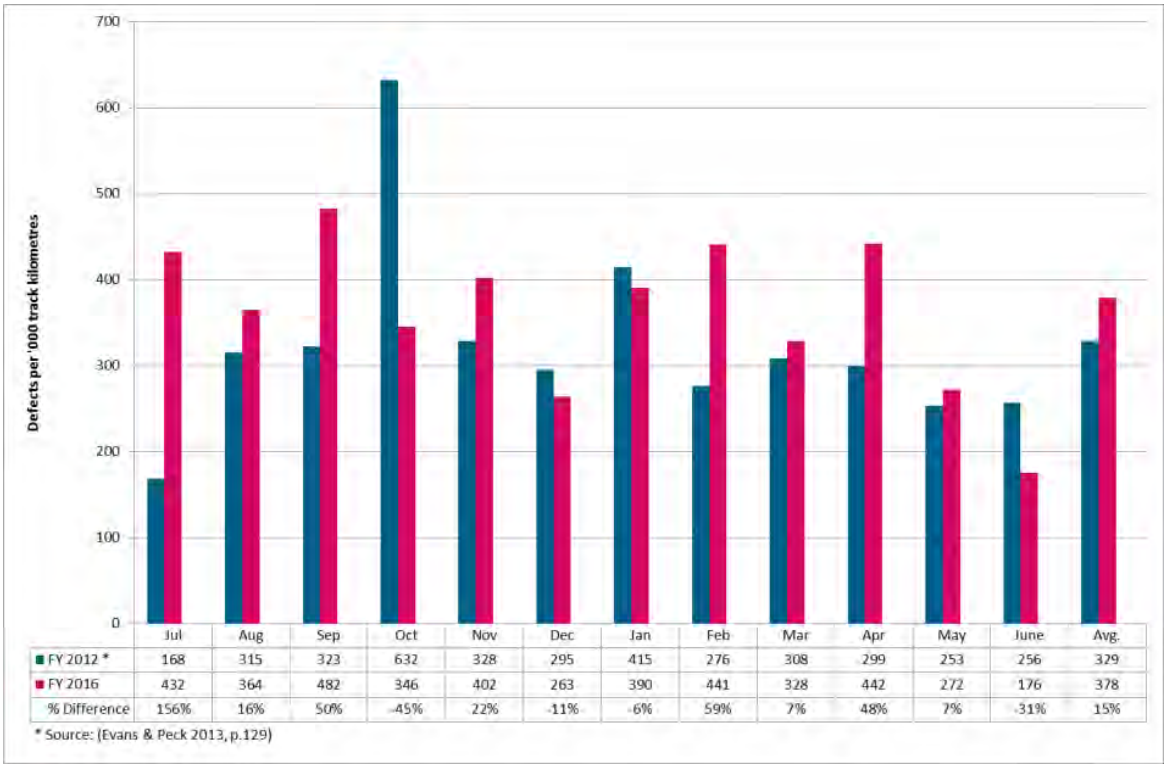
Date	Location	Incident Summary Ds	Delay (minutes)
16/07/2015	Mt. McLaren	DERAILMENT 67G4 Mt McLaren: Rails spread over ~10 sleepers just inside the catch points at the Villafranca end of the Release. FCC advised.	819
13/08/2015	Jilalan	Jilalan Bypass Provisioning road 2. EJ18 derailed.	144
08/10/2015	Jilalan	Incident with Pacific National locomotive 7120 when moving from 3 road to LMF over 82 points at walking pace due seized traction motor. Wheel set required to be lifted clear of rail prior to movement.	0
19/11/2015	Waitara	Waitara – PN light engine LJ01 shunting in Waitara advised they have derailed in the ballast siding	484
16/01/2016	Dalrymple Bay	Dalrymple Bay: UV23 derailed. Wagon rerailed. Track confirmed fit for service. Unloading recommenced, damage to triggers slowing unloading.	2,492
30/01/2016	Dalrymple Bay	Dalrymple Bay – Derailment of train TV25 on line 2 at the 29th wagon due to coal build up.	175
09/02/2016	Broadlea	Advice received that Ballast train 0WB3 has derailed at the lead bogie of the front wagon. 1253 hrs train re-railed, track inspected and certified safe for traffic.	0
09/02/2016	Broadlea	Advice received ZW00 derailed in Broadlea yard Up road. Machine rerailed at 1711 hrs. Investigation ongoing.	0
05/05/2016	Blair Athol Mine	BLAIR ATHOL: EV17 derailed due to coal build up under train during load. Lead bogie derailed on 101st wagon. Aurizon Operations leading investigation.	728
20/05/2016	Jilalan	Derailment: Jilalan Yard – Wagons Ex No.7 road run away through No.4 straight road and derailed at JN105a Catch Points. Wagons re-railing completed at 1035 hrs. 1100 hrs track certified fit service.	125

The derailment with the greatest impact was on 16 January at Dalrymple Bay, which caused a greater delay than all others combined. It highlights the potential impact of a failure at the critical point in the supply chain, the unloading loops, can cause. The unloading loop also has the combined effects of difficult access for maintenance and excessive coal build up and contamination in the ballast and formation.

There also appears to be issues with derailments at sidings, possibly bad order sidings, at Jilalan Yard. There is no clear trend or pattern though.

Defects

The percentage increase in average number of monthly track and formation defects per track kilometre is 15.2% since the 2102 assessment. This is shown in Figure 7.5 and Figure 7.6.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Avg.
FY 2012 *	168	315	323	632	328	295	415	276	308	299	253	256	329
FY 2016	432	364	482	346	402	263	390	441	328	442	272	176	378
% Difference	156%	16%	50%	-45%	22%	-11%	-6%	59%	7%	48%	7%	-31%	15%

* Source: (Evans & Peck 2013, p.129)

Figure 7.5: Goonyella system – track and formation defects for FY 2012 and FY 2016

This is in part due to better reporting of defects by Aurizon Network, and this should be encouraged. If the pattern of increasing defects continues, then there may be an actual increase in defects which should be investigated for any future CBAs.

Figure 7.6 indicates that the majority of defects are track and formation with very few for level crossings or structures.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bridges and Culverts	18	4	23	12	4	0	0	13	0	0	0	0
Level Crossings	4	0	16	10	37	6	8	5	4	11	8	2
Track and Formation	300	253	335	240	279	183	271	306	228	307	189	122

Figure 7.6: Goonyella system– monthly track and structures defects

7.2.2 Site visits

At German Creek, and a number of other sites, the faces of embankments were scoured, as shown in Figure 7.7. This is due to the in situ soils being highly erodible. Where possible, it is preferable to protect the face with vegetation or non-dispersive soils. In practice there is a choice to be made between the additional capital cost and the additional maintenance cost of regular cleaning; this is a case by case assessment. Although scoured cuttings were observed at a number of sites they did not appear to be impacting performance of the asset.



Figure 7.7: Scouring of cuttings due to dispersive soils

Normally, defects on an R1000 curve in flat country would not be expected; however at 142.500 there are two R1000 curves back-to-back. This chicane creates a maintenance load where if the track had been constructed without the curves there would be none.



Figure 7.8: Back-to-back R1000 curves at 142.500

The impact on the track is shown in Figure 7.9 below with gauge face damage through the curves. This damage illustrates what can occur when loaded trains at speed are forced into even slight direction changes. It is curious as to why these two curves exist here when the two tracks could have been laid straight removing this maintenance burden. Possibly, during construction in the 1980s it was expeditious for construction purposes to build it this way; however what is easiest for construction can create a longer term maintenance burden. Options for Aurizon Network at this site could be to ease or remove these curves; however the positions of the traction distribution masts will constrain any adjustment, unless these are also adjusted.



Figure 7.9: Gauge shelling at 142.500

A recently ballasted undercut and relayed rail site at 115.972 was inspected, shown in Figure 7.10. This site was in good condition.



Figure 7.10: Track relayed in November 2016 at 115.972

Aurizon Network has a rigorous program of track recording car (TRC) inspections. The Asset Maintenance and Renewal Policy requires TRC runs five times a year for the busiest lines down to twice a year for branches, balloons and passing loops. This is an appropriate risk based frequency. The TRC data is summarised at system level to provide the OTCI results.

The real value of the TRC is in the detail. An example of a TRC report illustrating a number of interesting points and the level of accuracy obtained is shown at Figure 7.11 below.

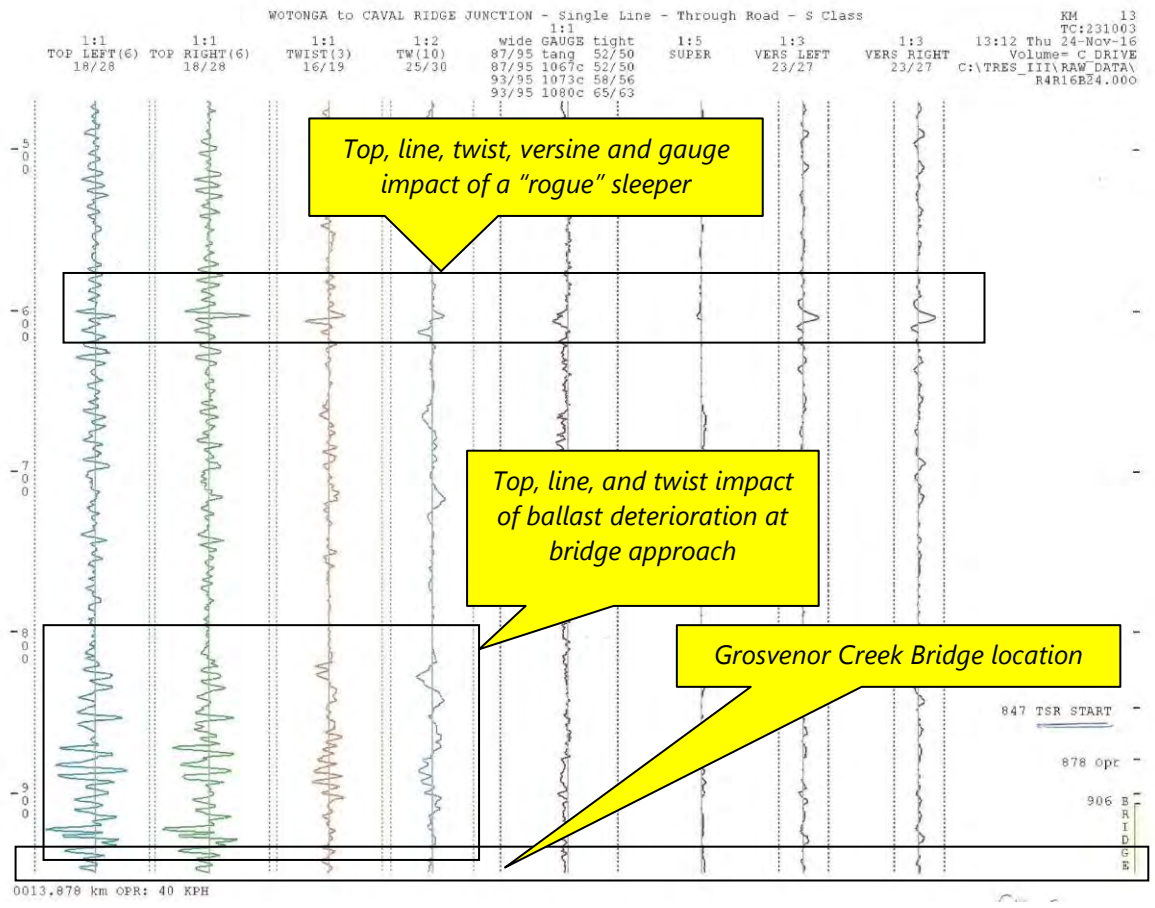


Figure 7.11: TRC result for Grosvenor Creek 13.930

This TRC result is for the location immediately east of the Grosvenor Creek bridge as it clearly indicates the impact of a 'rogue' Pandrol E Clip sleeper in amongst track laid with FIST sleepers, shown in Figure 7.12, and ballast deterioration/pumping at the bridge approach, shown in Figure 7.13.



Figure 7.12: Rogue Pandrol E Clip sleeper amongst FIST sleepers identified at Grosvenor Creek 13.930

The odd sleeper indicates that although all sleepers and fasteners are constructed for a design gauge of 1,067 mm, even the slightest dimensional differences between manufacturers means they are not identical and can lead to maintenance issues.



Figure 7.13: Ballast deterioration and pumping identified by TRC at approach to Grosvenor Creek 13.930

The ballast deterioration and pumping at a bridge approach is a common problem on the CQCN and is an inevitable result of the ballasted track joining a rigid bridge structure combined with the inability to use under cutters to clean ballast adjacent to bridges.

One of the derailment locations was Waitara. The bad order siding is shown in Figure 7.14 below. These sidings are necessary for defective wagons or track machines but are not maintained to the same standard as main line track. These bad order sidings normally have a turnout at each end but Aurizon Network is eliminating one of the turnouts to reduce maintenance cost at some sidings.



Figure 7.14: Bad order siding at Waitara

One of the reasons Aurizon Network prefers to eliminate unnecessary sidings is that the fixed vee turnouts are a major maintenance burden. Figure 7.15 below shows the type of damage inflicted on the fixed vee of a turnout under loaded traffic at speed.



Figure 7.15: Damaged fixed vee (frog) at Waitara

The other option to removing a turnout is to install, or replace the existing turnout with, a swing nose vee. Figure 7.16 shows a recently installed swing nose vee at Waitara. The swing nose vee is more expensive but gets damaged less under traffic.



Figure 7.16: Newly installed swing nose vee at Waitara

Another impact of turnouts is that they will shake off fugitive coal. This was noticed at many sites on the CQCN. Figure 7.17 below shows a heavily contaminated turnout location at Waitara. The contaminated ballast impacts the ballast strength and can make the glued insulated joints (GIJs) move under traffic. To try to better control this Aurizon Network has moved to bonded mechanical joints instead of four bolt GIJs.



Figure 7.17: Contaminated ballast at Waitara and bonded mechanical joint

Aurizon Network now has supersites installed in three systems: Newlands, Goonyella and Blackwater. These systems help manage the important wheel rail interface. These sites monitor a variety of aspects including as wheel profile and axle load.



Figure 7.18: Waitara supersite

The supersites are operated by the above rail Aurizon Operations and their objective is to successfully manage wheel wear and damage. In this they are being successful; Figure 7.19 below shows a 51% reduction in wheel usage. As the wheel rail interface is vital to track maintenance it is reasonable to assume that they are having a positive effect on rail life as well. In Advisian's view the supersites are a commendable initiative.



Figure 7.19: Reduction in wheel usage[4]

[4] Aurizon Operations 2016 Sustainability Report

The capacity constraint for Aurizon Network on the Goonyella system is Black Mountain. Black Mountain is the steepest part of the system and has curves as small as 297 m radius, shown in Figure 7.20. This leads to excessive braking and traction loads and consequent damage and wear on the rails.



Figure 7.20: Tight steep curves on Black Mountain

Evidence of rail flow as shown in Figure 7.21, and rolling contact fatigue (RCF) as shown in Figure 7.22 were observed. The defects observed were not severe and are being managed appropriately.



Figure 7.21: Rail flow at the bottom of the gauge face at 38.079 at Black Mountain

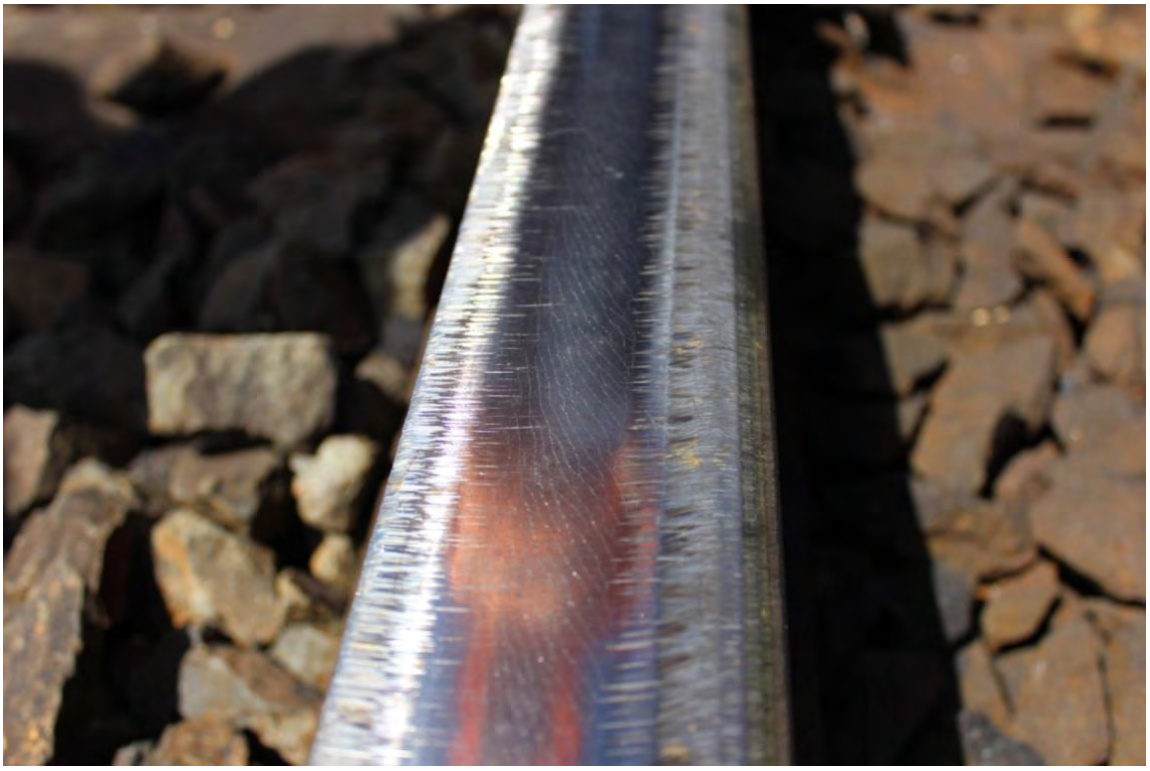


Figure 7.22: RCF on the low rail of the R300 curve at 36.427 at on Black Mountain

Head hardened 60 kg/m rails can have a life as short as three years on Black Mountain. Any rail replacement is complicated by difficult access in some places and the heavy traffic on this section. As a means to reduce the requirement to frequently replace rail Aurizon Network is trialling 370 LHT rail. This rail has a distinctive brand, shown in Figure 7.23. These trials should be reviewed in the next CBA.



Figure 7.23: Brand markings denoting 370 LHT low alloy heat treated rail

In a better attempt to understand the performance rail on Black Mountain, Aurizon Network has installed creep monitors, shown in Figure 7.24. Aurizon Network also conducted rail temperature testing of trains under heavy braking conditions to explore whether the rail installation stress free temperature should be adjusted at Black Mountain. Currently Aurizon Network uses a stress free temperature of 38°C at all sites.



Figure 7.24: Creep monitor on Black Mountain at 38.079

Solar powered lubricators are installed at critical locations to reduce rail wear at tight curves, shown in Figure 7.25. These lubricators are monitored remotely through a telemetry system.



Figure 7.25: Solar powered track lubricator

Due to the steep topography and rainfall, Black Mountain is exposed to slope stability issues. There have been instances where large parts of the slope have failed and Aurizon Network has stopped traffic and completed emergency repairs. Aurizon Network has installed inclinometers and debris detectors, as shown in Figure 7.26, to provide early warning to allow traffic to be stopped before an incident.



Figure 7.26: Early warning slope stability catch fence

Figure 7.27 shows an internal rail defect that has been plated (fastened with Robel clamps) as a risk control measure prior to being removed from track. The rail defect was identified by the ultrasonic testing car. The potential failure mechanism is a rail break if not removed in time.



Figure 7.27: Plated internal rail defect

Defective welds are identified by ultrasonic testing and marked with yellow paint. The defective weld is then cut out and replaced, with blue paint marking the repair. Figure 7.28 shows a weld that was installed in late 2016, which was then identified as defective by an ultrasonic test and cut out and replaced in 2017, shown in Figure 7.29.



Figure 7.28: Defective weld identified by ultrasonic test and marked yellow



Figure 7.29: Repaired defective weld identified blue markings

A recently ballasted undercutting operation was inspected at Hatfield. Notwithstanding the ballast cleaning, the site appears to have potential formation issues in wet weather with soft clays. At the ballast site the removed ballast was dumped beside the track, shown in Figure 7.30. Piles of contaminated ballast can cause issues in constrained corridors.



Figure 7.30: Recently formation at 33.185 Hatfield

At 25.714 near Jilalan, examples of the impact of sighting signalling infrastructure which impacts loaded traffic on an uphill grade were observed. The signals in Figure 7.31 are part of a group of signals potentially causing trains to stop and restart on an uphill grade.



Figure 7.31: Signals at 25.714

The types of defects caused by this are shown in Figure 7.32 and Figure 7.33 below. Figure 7.33 also clearly illustrates the lower strength of the heated zone of a flashbutt weld compared to the head hardened rail on either side.



Figure 7.32: Series of squats at 23.300 Jilalan



Figure 7.33: Running surface damage, a squat, at a weld location 23.744 Jilalan

A damaged GIJ was observed at approximately 23.700 near Jilalan, as seen in Figure 7.34. This GIJ has the potential to transfer a current which would thus make it ineffective. This GIJ may not be operational, which is perhaps why it has not been repaired.



Figure 7.34: Badly damaged GIJ at approximately 23.700 Jilalan

The Hay Point Coal Terminal (HPCT) was found to have contaminated ballast, shown in Figure 7.35. If unmaintained, this type of condition can lead to derailments, particularly in wet weather. The single biggest derailment impact on delays in FY 2016 was caused by a derailment at Dalrymple Bay Coal Terminal (DBCT), which occurred due to a build-up of coal debris. Control of this requires close above rail/below rail cooperation.



Figure 7.35: Contaminated ballast at HPCT

7.2.3 Leading indicators

A combination of the trends in OTCI, lagging indicators and site visit results indicates that the Goonyella system is performing well and no major maintenance issues are anticipated. The increase in the impact of TSR, indicated by the WSRT, should be monitored by Aurizon Network. In the event the TSR backlog, particularly during the wet season, becomes excessive this could create an environment which requires expensive short notice type repairs.

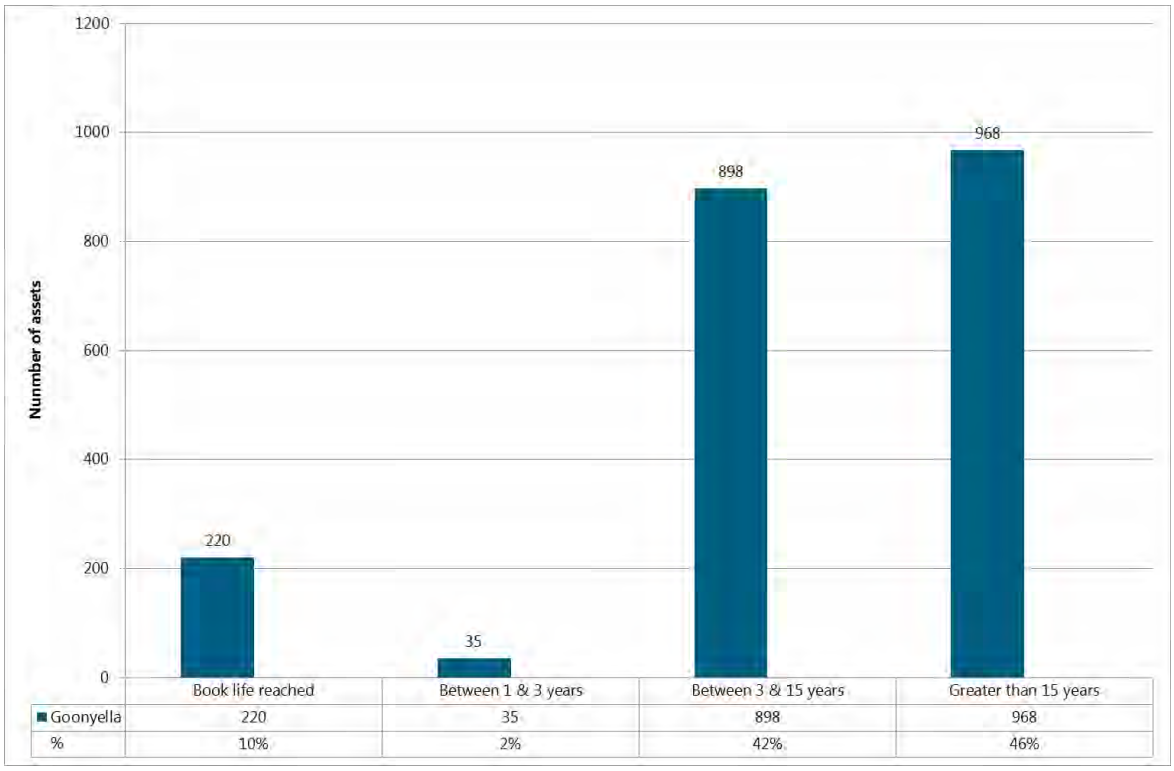
The innovations that Aurizon Network is trialling on Goonyella should be reviewed in the next CBA. These include the use of the Voestalpine LHT rail, the use of the supersite data, the creep monitors and the heat measurement of the wheel rail interface on Black Mountain traffic.

7.3 Structures

7.3.1 Lagging indicators

Asset age

Asset ages for bridges and culverts in the Goonyella system are shown in Figure 7.36 and Figure 7.37.



	Book life reached	Between 1 & 3 years	Between 3 & 15 years	Greater than 15 years
Goonyella	220	35	898	968
%	10%	2%	42%	46%

Figure 7.36: Goonyella system – bridges and culverts remaining asset book life

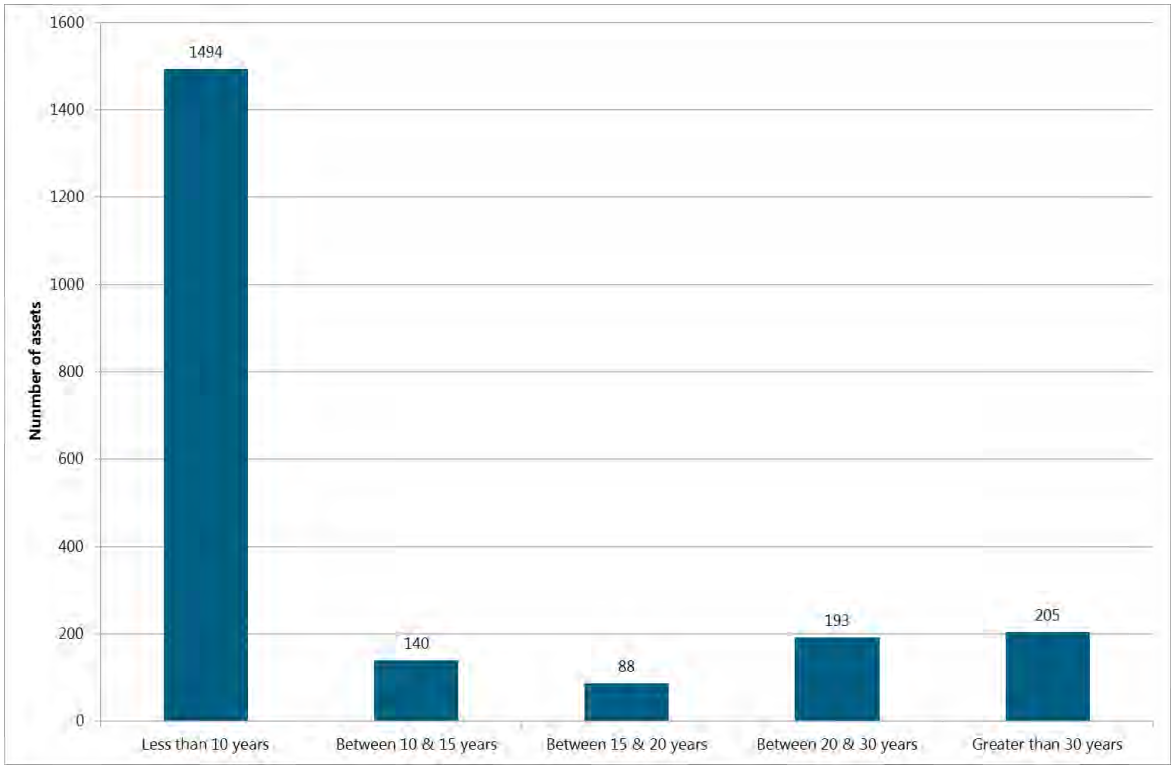


Figure 7.37: Goonyella system – bridges and culverts asset age by acquisition date

Inspections

Table 7.3 summarises the inspection work orders in the Goonyella system.

Table 7.3: Goonyella system – inspection work orders[5]

Inspection work orders	Bridges	Drains	Overall
Number of total inspections:	86	1233	1319
Number of late inspections:	36	499	535
% of late inspections:	41.9%	40.5%	40.6%
Average number of days late:	12.1	13.3	13.2

[5] The FY 2016 inspections was captured using RIMS, which had an error where inspection due dates were shown to be the 15th of each month instead of the end of the month. Aurizon Network now uses AssetAsyst which captures inspection dates correctly.

Delays

Table 7.4 summarises the delays due to structures in the Goonyella system.

Table 7.4: Goonyella system – permanent way delays

Permanent way delays	Delay (minutes)	Normalised delay (min/billion NTK)
Delays due to structures (bridges and culverts)	46	2

7.3.2 Site visits

The structures for the Goonyella system were generally in good condition as seen at Figure 7.38 (13.800) and Figure 7.39 (23.780).



Figure 7.38: Goonyella (13.800) bridge 1



Figure 7.39: Yukan-Jilalan (23.780) culvert 2

Inspection of a sample of structures on the Goonyella system identified the following issues:

- Propping/bracing concrete culverts
- Corrosion of galvanised steel culverts
- Blocked culverts with poor upstream and downstream drainage.

A propped culvert is shown in Figure 7.40 (98.200). Although this is a short term solution to maintain capacity of the culvert, it should be avoided. This solution has now created a trap for debris and will contribute to increasing maintenance costs into the future as maintenance staff now have a confined space with restricted access to maintain. Alternative remediation options to consider could be lining with smaller diameter pipes, repairs and local strengthening or worst case replacement. This avoids unnecessary partial blocking of the culvert which ultimately affects performance during rain events.



Figure 7.40: Goonyella (98.200) culvert 1

Some galvanised lined culverts commonly found along the Goonyella system are starting to show signs of corrosion, as shown in Figure 7.41 (42.240).



Figure 7.41: Black Mountain (42.240) culvert

Corrosion of galvanised lined culverts is also accelerated due to blockages and pooling of water after rain events and poor drainage upstream and downstream of the culvert. Such pooling is shown in Figure 7.42 (12.000).



Figure 7.42: North Goonyella (12.000) culvert 2

As galvanised lined culverts near their end of life and become corroded, a resin treatment can be applied, as shown in Figure 7.43 (42.620). This solution was found to be cheaper and have a shorter installation time as opposed to traditional retro fitting with reinforced concrete precast sections.



Figure 7.43: Black Mountain (42.620) culvert

Another example of a partially blocked culvert can be seen in Figure 7.44.



Figure 7.44: Cameron Creek (40.200) culvert

A good example of repaired/strengthened reinforced concrete box culvert can be seen in Figure 7.45 (125.200). Due to the reduced culvert capacity, energy dissipaters have been included to control flow. Energy dissipaters can be altered following the effects of a major rain event.



Figure 7.45: German Creek (125.200) culvert (left and right)

Full replacement of culverts has been undertaken where no other remediating works were possible, as seen in Figure 7.46 (25.690).



Figure 7.46: Yukan (25.690) culvert

7.3.3 Leading indicators

Based on the lagging indicators and site visits, the Goonyella system performed the worst of all the systems. As an older system with 25 to 50% of assets have greater than the 15 years remaining book life and higher tonnages, further maintenance will be required all structures.

Aurizon Network's culvert renewal program will continue where further galvanised lined culverts will require replacement. Temporary solutions such as propping of culverts will also require ongoing maintenance to ensure integrity as well as general clearing of obstructions and vegetation. Inspection and identifying potential maintenance tasks have continually slipped by 30 to 60 days for over half of the assets.

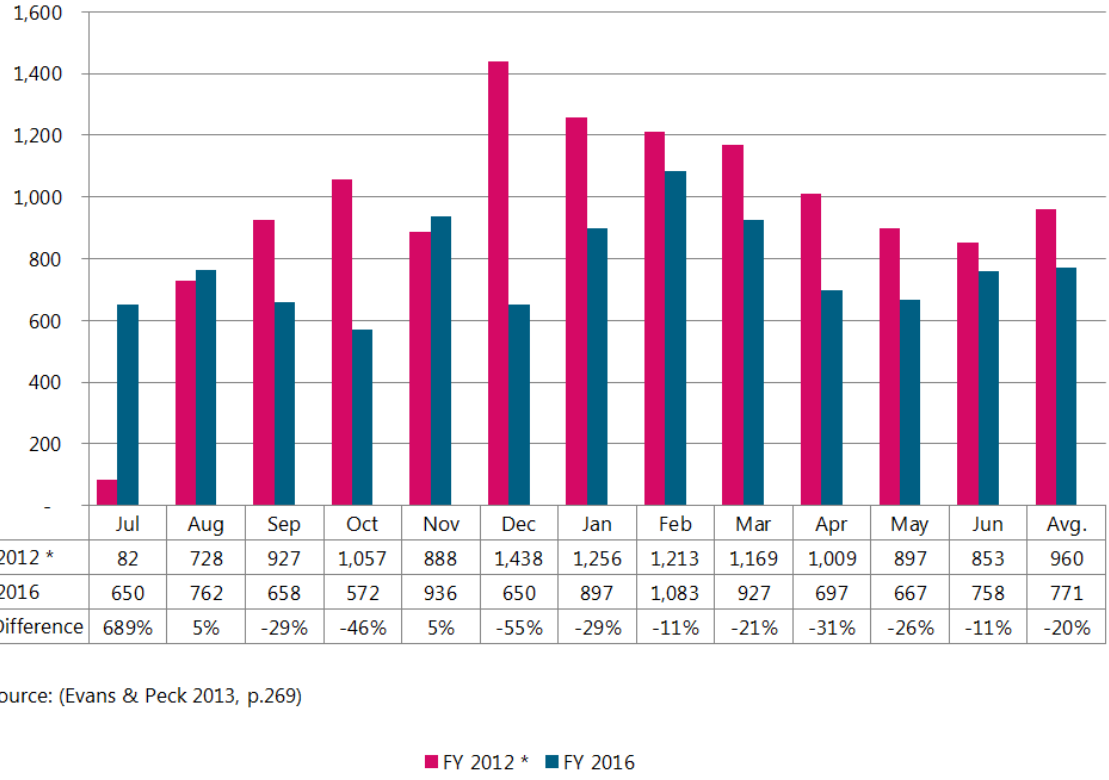
Overall, all maintenance tasks were complete on time.

7.4 Train control systems and telecommunications

7.4.1 Lagging indicators

Signalling faults and delays

The percentage change in number of monthly signalling faults from the FY 2012 assessment is shown in Figure 7.47.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	82	728	927	1,057	888	1,438	1,256	1,213	1,169	1,009	897	853	960
FY 2016	650	762	658	572	936	650	897	1,083	927	697	667	758	771
% Difference	689%	5%	-29%	-46%	5%	-55%	-29%	-11%	-21%	-31%	-26%	-11%	-20%

* Source: (Evans & Peck 2013, p.269)

Figure 7.47: Goonyella system – signalling faults for FY 2012 and FY 2016

The delays attributed to signalling on the Goonyella system are shown in Table 7.5.

Table 7.5: Goonyella system – signalling delays

Signalling delays	Delay (minutes)	Normalised delay (min/billion NTK)
Signalling delays	107,275	4,343

Breakdowns of the signalling faults and delay minutes by equipment type and element are shown in Figure 7.48 and Figure 7.49.

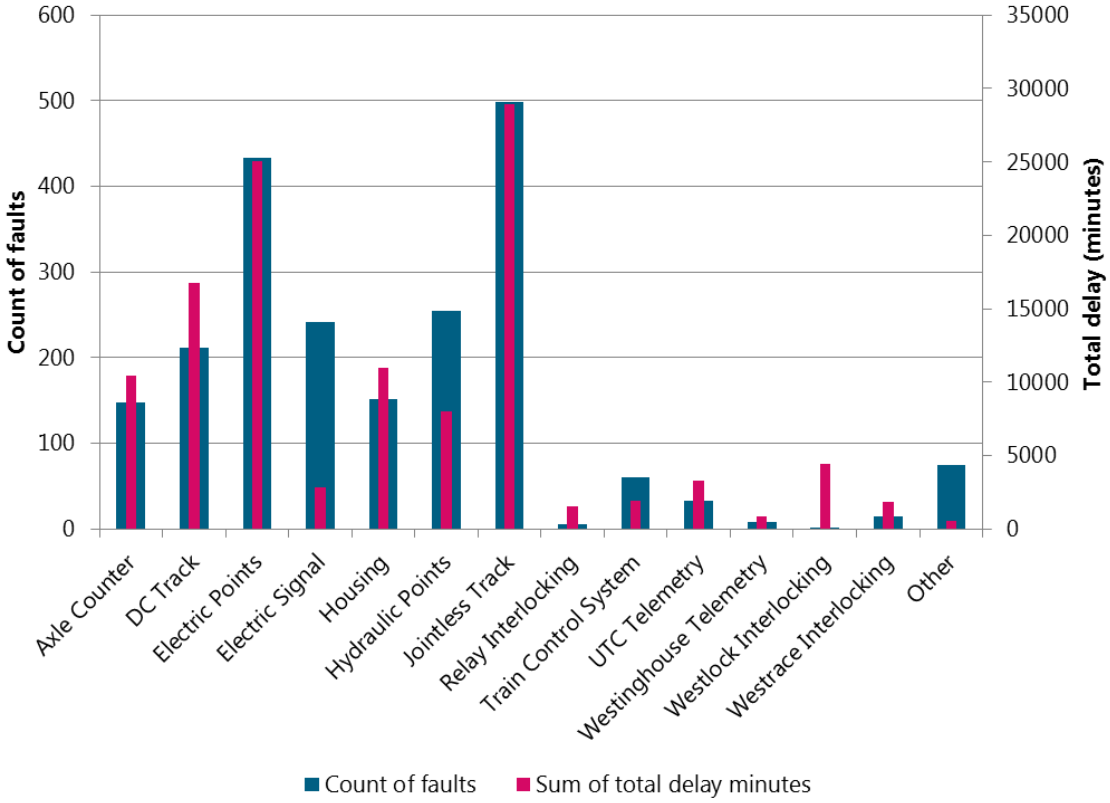


Figure 7.48: Goonyella system – signalling faults and delays by equipment type

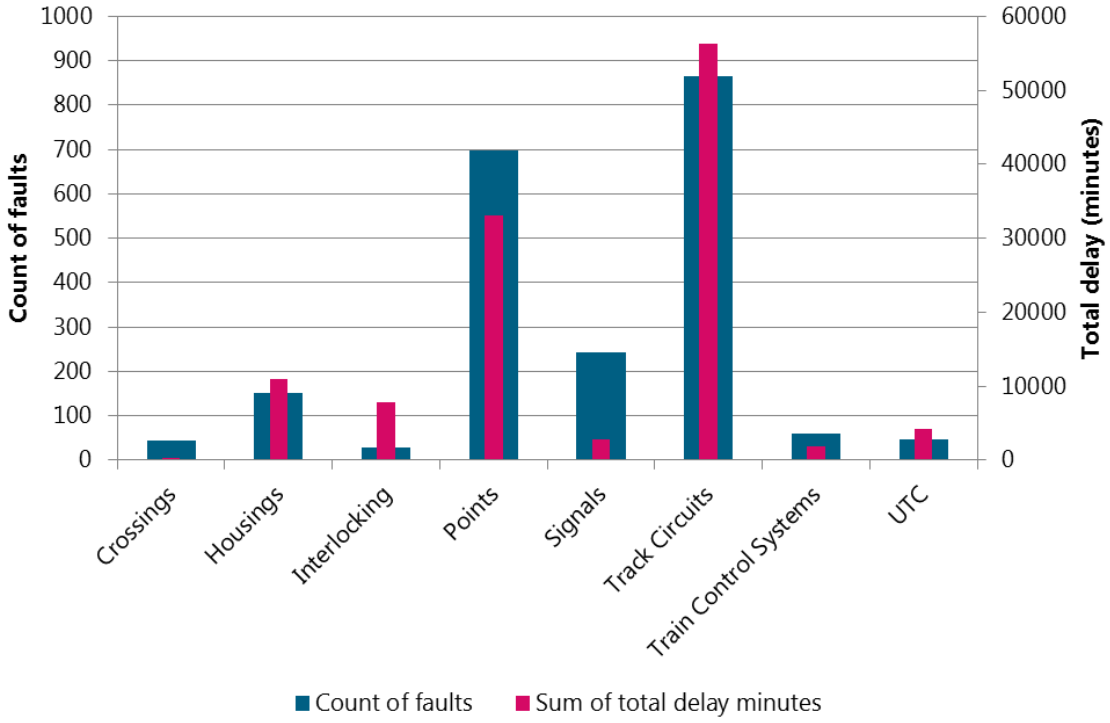
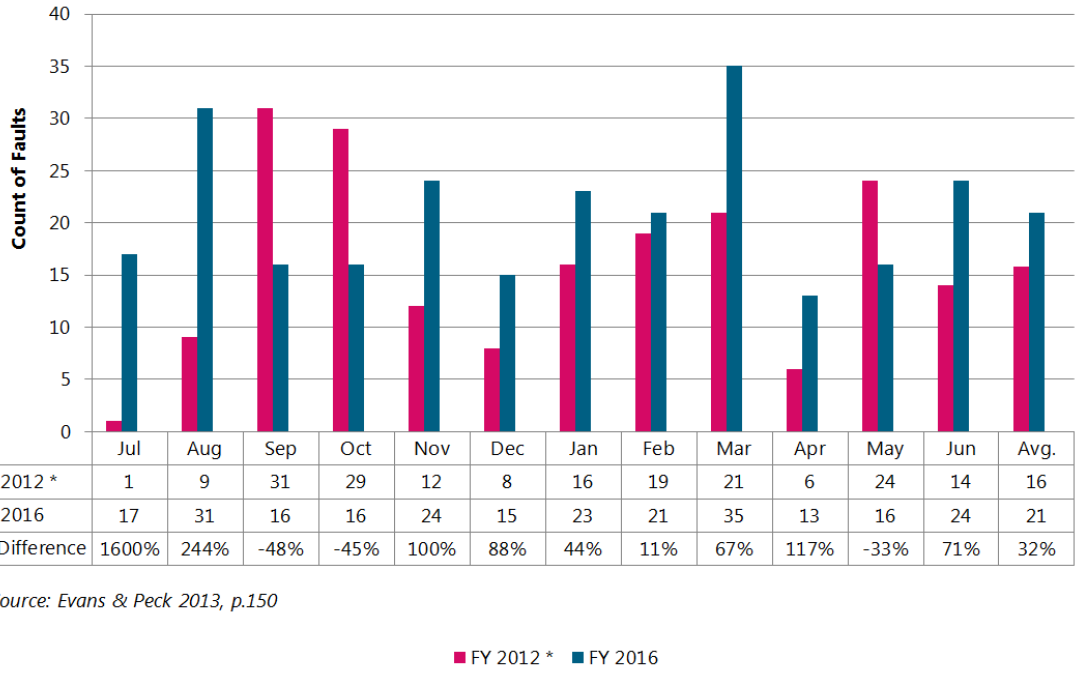


Figure 7.49: Goonyella system – signalling faults and delays by element

Telecommunications faults and delays

The Goonyella system relies on underground fibre optic wires as its primary means of communication with microwave towers providing a redundancy system.

The percentage change in number of monthly telecommunications faults from the FY 2012 assessment is shown in Figure 7.50.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	1	9	31	29	12	8	16	19	21	6	24	14	16
FY 2016	17	31	16	16	24	15	23	21	35	13	16	24	21
% Difference	1600%	244%	-48%	-45%	100%	88%	44%	11%	67%	117%	-33%	71%	32%

** Source: Evans & Peck 2013, p.150*

Figure 7.50: Goonyella system – telecommunications faults for FY 2012 and FY 2016

The average number of monthly faults has increased since the FY 2012 assessment. The increased number of faults is not necessarily negative indicator, but could suggest an increased level of thoroughness in reporting practices as equipment nears the end of its design life.

The FY 2012 assessment highlighted 8,455 minutes of delays attributable to telecommunications failures. The FY 2016 assessment has seen an improvement in delay minutes despite the increased number of reported faults indicating that reporting and maintenance practices have improved. Refer to Table 7.6 for telecommunications delay minutes.

Table 7.6: Goonyella system – telecommunications delays

Telecommunications delays	Delay (minutes)	Normalised delay (min/billion NTK)
Telecommunications delays	569	23

The 596 minutes of telecommunications delays is attributable to:

- August 2015: inverter failure (198 minutes) – this is noted to be more of a signalling failure, yet it was recorded as a communications failure
- August 2015: rectifier failure (114 minutes) – rectifier was an older unit and replaced
- August 2015: external supply failure caused a circuit breaker trip (111 minutes)
- August 2015: breaker trip disrupted signalling system (30 minutes)
- October 2015: 2015 fault that required the selecting and de-selecting the main bearer on a main switching unit (97 minutes). This fault could not be replicated
- Not disclosed: 19 minutes.

7.4.2 Site visits

13 sites were visited in the Goonyella section. A detailed inspection was carried out at Mindi on signal MI16, points 12A and track circuits 14B2T and 28A2T. An inspection of the track circuit bonding for track circuit 23A2T against the bonding plan was carried out at Praguelands. Other sites visited were:

- German Creek
- Lake Vermont
- Peak Downs
- Caval Ridge
- Coppabella
- Waitara
- Wandoo
- Mackay Disaster Recovery Centre
- Black Mountain
- Jilalan
- Dalrymple Bay.

At German Creek, the Tait radio system mentioned in the FY 2012 report as approaching obsolescence was seen to be still in use. The Tait radio was installed in the mid-1990s with an intended life span of 20 years. It is understood that a contract was awarded in January 2017 for a replacement Tetra radio system, which will permit the abolition of the Tait system. Also noted at German Creek were Siemens axle counters still in use, although a new Frauscher axle counter was sighted in the relay room ready for installation.



Figure 7.51: German Creek radio antennae and Tait radio unit

The rail infrastructure at Lake Vermont Junction is relatively new, the mine having only begun operations in 2008. The interlocking is of the current standard for the north region of CQCN, being an Ansaldo Microlok II, with a Genisys non-vital interface. The interlocking was neat and clean, with cabling and terminations in a good state of repair.



Figure 7.52: Lake Vermont Microlok II interlocking

Peak Downs was specifically selected for inspection, as the previous asset condition report highlighted a number of significant issues at this location. In particular, the signalling equipment room (SER) structure was in poor condition, due to instability of the bank at the rear of the room. At that time the roof structure was supported by temporary bracing.



Figure 7.53: Peak Downs SER before (2013) and after (2017)

Since 2013, the building has been stabilised and a new roof has been constructed and the internal equipment is all in good condition.



Figure 7.54: Peak Downs SER and bank stabilisation

The sections either side of Peak Downs are fitted with axle counter blocks. One of the sections has been fitted with a new Frauscher axle counter, replacing the older Siemens axle counter. Recent works to divert the railway and Dysart Road due to mine expansion has required a new level crossing about 3.5 km north of Peak Downs. The project was implemented using Thales axle counters, resulting in three different types of axle counters at the one location. This is not a desirable situation in terms of signalling maintenance, as it requires multiple spares and increases the likelihood of errors. This is considered poor equipment selection on behalf of the project designers, indicating a lack of consultation with maintenance staff.

Caval Ridge is also a new mine, having commenced operations in 2014. The signalling has been designed with all of Aurizon Network's latest initiatives: Microlok II interlocking, optical ground wire (OPGW), pivoted signal posts and Thales axle counters. Axle counters have been used throughout, requiring no track circuits and no consequent GRJs.

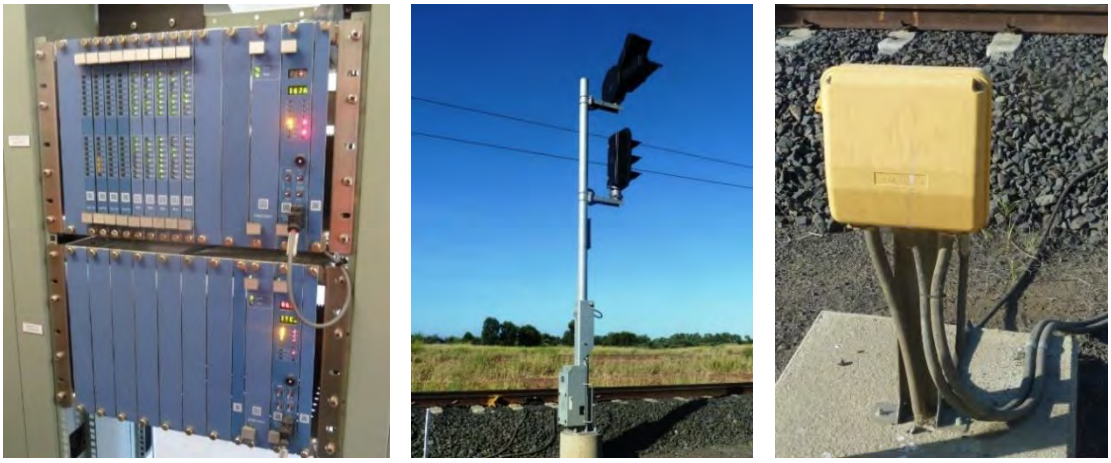


Figure 7.55: Caval Ridge signalling equipment: Microlok, pivoted signal and Thales axle counter

Additionally, the bad order siding (cripple siding) at Caval Ridge is equipped with a point machine, but operated by a local shunters panel, with a point indicator to indicate switch position. This allows local staff to identify and detach defective wagons, providing direct control of the operation.



Figure 7.56: Caval Ridge shunters panel and point indicator

The Coppabella microwave site, which was highlighted in the FY 2012 report as being in a poor state of maintenance, was again visited. Most of the equipment was the same as viewed previously, although the cleanliness of the equipment room was better than described in the FY 2012 report. Wiring at the rear of one rack was messy, with low loops that could easily be caught by a foot and pulled out.



Figure 7.57: Coppabella microwave site: microwave tower and equipment racks in hut

The trap points which protect the exit from the up side loop and engineering roads have been motorised, with a capacitor bank to supplement the power, avoiding an expensive power system upgrade. Two sets of trap points are operated by the same point machine, with a second detector fitted to the switch farthest from the machine. The tip of this switch was noted to be damaged.



Figure 7.58: Coppabella trap points

A detailed site inspection at Mindi was carried out. Mindi has an older free wired relay interlocking, with an S2 remote control system. The SER is generally well maintained and tidy, although there is evidence of termite trails running up the walls. A close inspection of the roof structure may be advisable to ensure there in no deterioration in any timbers. Cabling and terminations are in good condition and there was evidence of rat baiting in the conduits. In the telecommunications room, a Siemens fibre unit has been recently replaced by a newer Nokia model. The room was not as clean as the signalling room, with significant dust and dirt on the wiring at the rear of one of the communications racks. In the power room, the diesel generator is reasonably clean and well maintained. It is serviced annually.



Figure 7.59: Mindi interlocking, termite trails and backup generator

Signal MI16 has a three aspect head with right hand turnout indicator and a subsidiary signal (MI3B) below the main signal head. The units are all have LED lamps.

The platform at the rear of the main head and turnout indicator has a protection cage with mesh to the cess side to prevent maintenance staff from coming into contact with the 25 kV feeder wire.

The post and base are in good condition and there is a termination box near to foot of the post. The signal tail cable is buried and is not visible.



Figure 7.60: Mindi Signal MI16

Mindi 12A points are operated by a Westinghouse M23 machine with hand throw lever. There is a considerable amount of coal dust contamination in the area and the motor compartment in particular was quite dirty. Fortunately the lock and detector compartments are better sealed and did not contain so much coal dust. Rods and fixing were all in good order and the slide chairs were lightly lubricated, but showed only slight signs of wear. The switches also had roller chairs fitted. The tail cable is buried and was not visible other than the terminations in the machine.



Figure 7.16: Mindi 12A point machine, machine motor compartment and switch slide chairs

Mindi 28A2T track circuit is a DC track that runs through 12A points. The track relay is in location 102W and is a BR930 style relay type QTA1. Tail cables are buried and are not visible but track leads and rail connections are in good condition. The track circuit is single rail traction and both traction bonds and signalling bond were in good condition. This GIJ on the cess side rail adjacent to MI16 signal has suffered from rail head flow in the past which has been chiselled away to maintain the integrity of the insulation.



Figure 7.61: Mindi damaged GIJ and new Bombardier EBI Track 200 track circuit receiver

Track circuit 14B2T is an audio frequency ML21 track circuit. However the track receiver has been replaced a new style Bombardier EBI Track 200 receiver. This is a significant improvement on the older ML receiver, in that is has an access port though which status information can be read and an LED readout window with button pad to give various status information on the unit. The receiver is interfaced to the existing ML matching units and a 1200A ML impedance bond at the GIJ abutting track circuit 28A2T. The tails cables are buried and are not visible, but the track leads via the traction bond leads, which are in good condition.

At Waitara, 48 points have been equipped with a point monitor. The unit is a CDS Rail Atlas MiniLogger Plus, interfaced via an Ethernet connector into the communications system. The datalogger can record various parameters such as motor drive current, peak current, normal to reverse movement time and rail temperature. The data output can be reviewed remotely.

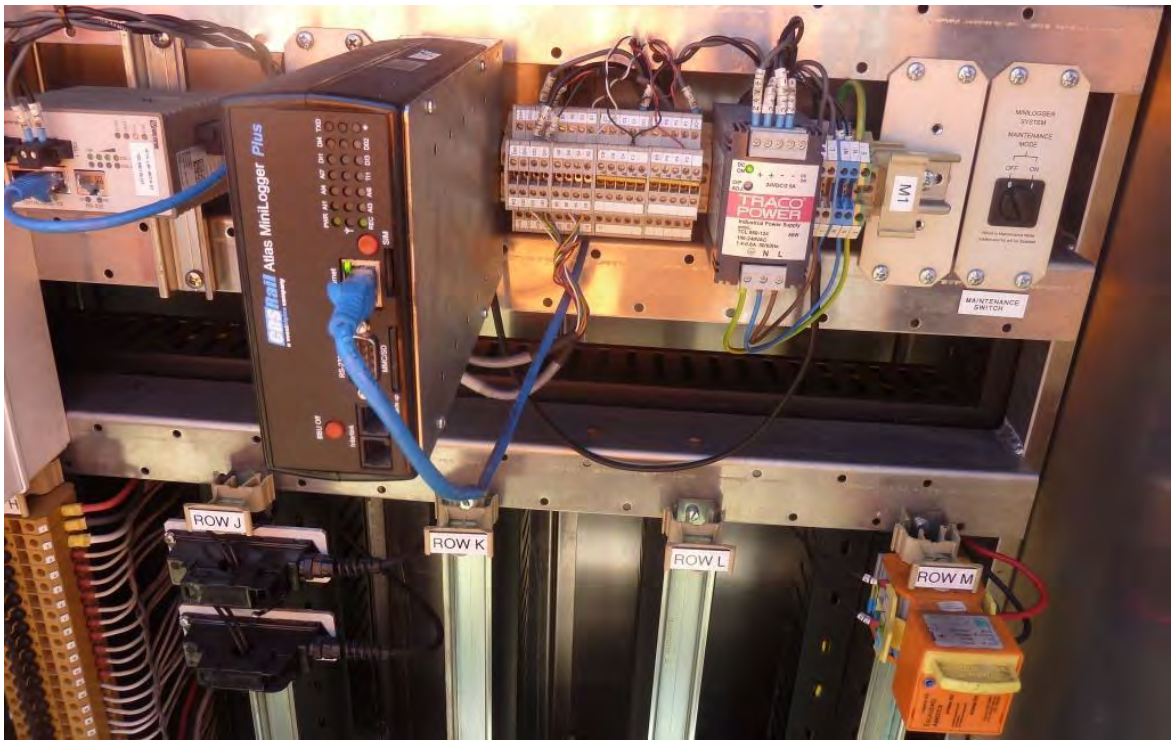


Figure 7.62: Waitara points datalogger

At Wandoo there is a trial installation of the new Voestalpine Ecostar point machine, a compact electro-hydraulic, driving a Spherolock drive and locking mechanism and detector unit. The Spherolock is a Voestalpine patented design that comprises a fully sealed pre-lubricated locking system with locking jaws that clamp onto cylindrical surfaces. The design ensures that no lock releasing forces occur due to switch movements as a train passes over the points. The components are easy to install and have low inspection and maintenance requirements.

The installation has been relatively trouble free to date, but it will be a few months before it can be determined whether this new system can become a long term, cost effective alternative to conventional point machines.



Figure 7.63: Wandoo Voestalpine Ecostar point machine and Spherolock drive and lock mechanism



Figure 7.64: Wandoo rotary back drive and dry slide chair

At Mackay, the original control centre for the north region has been retained as a disaster recovery centre. It is configured such that it is able to control the whole of the CQCN if the is a major event affecting the Rockhampton Control Centre. This is a wise precaution in a region occasionally impacted by cyclones and severe weather and with a network covering such long distances to remote locations.



Figure 7.65: Mackay Disaster Recovery Centre desk arrangement, screen display and control cabinets

The SER at Black Mountain has experienced subsidence under the power room end of the building. The power room floor has cracked in places and the generator slab has lifted from the concrete floor at one end. The end pillars have been reinforced with steel bracing frames and the upper coursed of blocks have been lifted and additional mortar injected into the gap between the second and third courses. Concrete has been poured at the end of the building to try to underpin the structure. This work is likely to be only a temporary as there is evidence of the creek that passes through a culvert immediately south of the SER having over topped the rail line and possibly washing away the foundations. The situation needs to be carefully monitored until a permanent solution can be found.



Figure 7.66: Black Mountain SER showing corner bracing, jacked block courses and generator slab

At Jilalan a Westlock interlocking was installed by Queensland Rail (QR) in 2009. The system uses Westrace units as object controllers rather than the previous standard SSI configuration of Trackside Functional Modules (TFM). The Westlock is somewhat of an orphan in the Aurizon Network, being the only example of its kind within CQCN. Westlock data constructs are of a very different nature to the other Siemens interlocking product, Westrace, which is used in numbers within CQCN.



Figure 7.67: Jilalan Westlock, Westrace object controllers, Moviola and maintenance terminal

At Praguelands, track circuit 23A2T was selected for a check of the bonding on site against the bonding plan.

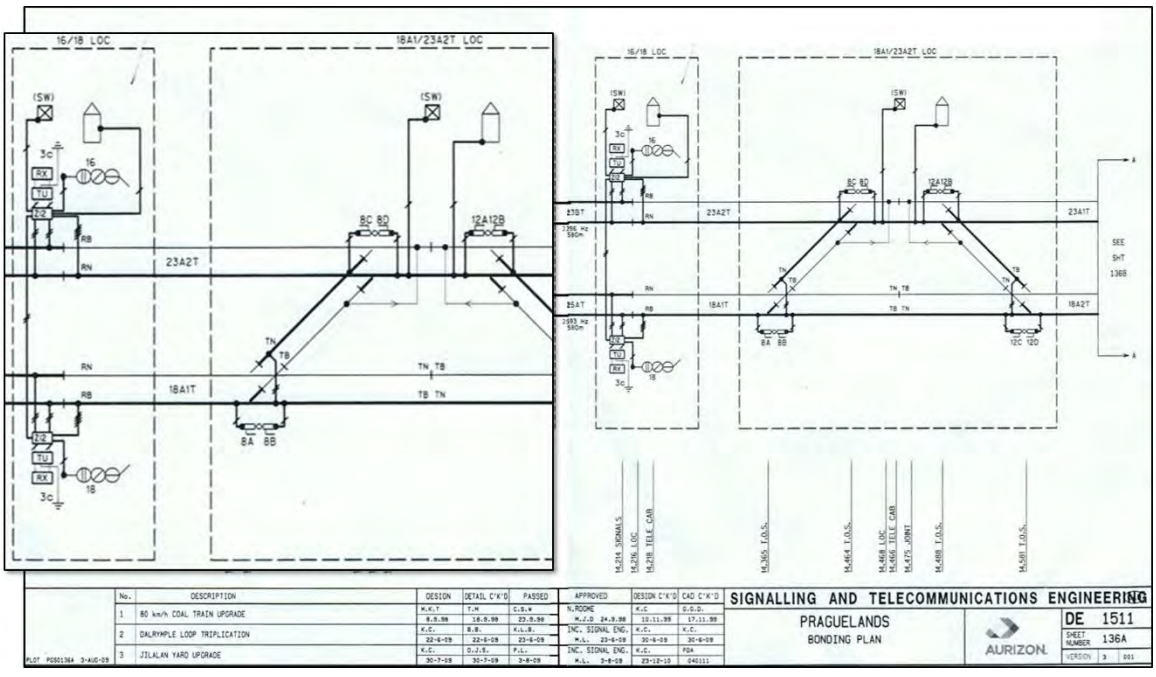


Figure 7.68: Praguelands bonding plan with inset close up for track circuit 23A2T

Track circuit 23A2T is a DC track running from GIJs in the up line adjacent to signal 16 through turnout 8C/D to a GIJ in the up line midway between crossovers 8 and 12. The turnout leg of the track circuit extends through to turnout 8C/D to GIJs adjacent to the crossing of turnout 8A/B. The adjoining audio track circuit at signal 16 is an ML 21 track circuit of 2296 Hz and the other adjoining track circuits are all DC tracks.

All bonds on the bonding plan were in place and were in reasonable condition. It was noted however that some bonds are not included on the bonding plan. These include bonds between the centre tap of the impedance bond to the overhead earthing wire and the pigtail bonds on the crossings, as shown in Figure 7.69, which ensure electrical integrity through the switched crossing rather than relying on contact between the switch blades. Responsibility for the various bonds is divided between the signalling and electrification teams, but it is suggested that a single comprehensive bonding document may avoid confusion and possible errors.



Figure 7.69: Turnout crossing pigtail bonds

It was noted that some rail connections were of the cadweld type. Whilst these were still serviceable, they are no longer the Aurizon Network preferred rail connector and are being superseded by the Cembre AR connector system.

The final quick inspection was in the rail yards at Dalrymple Bay. There was significant ballast contamination noted on the unloader exit roads.



Figure 7.70: Dalrymple Bay exit siding ballast

7.4.3 Leading indicators

The number of signalling faults per thousand track kilometres has decreased by 20% since the FY 2012 assessment. The reduction in number of faults corresponds to a similar reduction in delay minutes, approximately 17.5% (from 142,078 minutes to 117,243 minutes). The biggest cause of faults and delay minutes were track circuits, specifically:

- DC track circuits – 25,642 minutes (main causes: power interruption, equipment failure and equipment damaged)
- Jointless track circuits (TI21 and CSEE) – 28,910 minutes (main causes: component/equipment failure and broken rail).

Track detection systems in the Goonyella system have caused the most delay but are trending downwards. Although the percentage of signalling delays attributed to track circuits has increased from 42% in FY 2012 to 48% in FY 2016, delay minutes have decreased from 59,492 to 38,054.

Telecommunications faults in the Goonyella network have increased since FY 2012; however effective delay minutes have decreased from 8,455 to 569 minutes. This is a significant improvement and is a sign that management of communication system maintenance has improved. It may be a result of better fault reporting practices that had shifted maintenance operations from being reactive to proactive.

Train control and telecommunications systems in Goonyella do not have any apparent anticipated maintenance issues.

7.5 Traction distribution and power supply systems

7.5.1 Lagging indicators

Autotransformer oil analysis exceptions

Aurizon Network has a program to replace the autotransformers based on condition. The original autotransformers are 32 years old with the purchase being predominantly in 1985[6]. Normally this type of transformer would have a nominal 40-year life span, however in this case it is generally accepted that there was a design fault which has resulted in excessive liberation of some combustible gases due to corona discharge. The lifetime for these transformers is considered to be 25 years.

The corona discharge indicator is predominantly high hydrogen levels found by the dissolved gas analysis. Accompanying this is significant but much lower levels of methane. Some autotransformers have high ethane levels, which is indicative of overheating[7] .

[6] Aurizon Network 2012 Strategic Asset Plan
[7] *A Guide to Transformer Oil Analysis*, I.A.R. Gray Transformer Chemistry Services

Aurizon Network has investigated the corona discharge problem during autotransformer refurbishment and has determined that it is occurring due to a manufacturing/design problem which is not easily rectified. However, compared with the FY 2012 assessment most of these have been eliminated. In FY 2012, 21% of autotransformers in Goonyella showed exceptions based on the oil analysis results. For FY 2016, 11% (13 autotransformers) have been nominated by the Aurizon Network analysts as having unsatisfactory oil analysis results. This represents a significant improvement over the previous assessment. However, Advisian has reviewed the test results against the exception levels for each gas used in the FY 2012 assessment and found that 12 units would have not been classified as unsatisfactory. Therefore, on an equal basis, the exception level will drop to 10%.

Feeder transformer oil analysis exceptions

The Goonyella system has 22 feeder transformers. In the FY 2012 assessment there were 20 feeder transformers and since then Wotonga has been built adding a further two. In FY 2012 assessment, there was one transformer at Moranbah South that raised oil analysis exceptions. It showed oil that had an unsatisfactory dielectric strength. This was likely due to high moisture content. This problem has been rectified with the breakdown voltage level now being 71 kV and the moisture content being 6 ppm. Previously the breakdown voltage was 13 kV and the moisture content was 51 ppm. The limits are >30 kV and <35 ppm respectively. Aurizon Network has clearly taken action on this transformer.

All the Goonyella transformers were sampled in November 2016. Out of these, one unit raised exceptions, which is 5%. This was T91 at Dalrymple Bay. This transformer was showing a high hydrogen level which was above the Aurizon Network exception value. It was also showing a low interfacial tension. Whilst the interfacial tension level of 23 was still higher than the Aurizon Network exception level of 20 it would not be considered ideal. This lower value indicates there is sludge formation in the transformer due to oxidation of the oil. The hydrogen indicates heating in the 200 to 300°C range. This transformer has been in place approximately 10 years and therefore this is not an age-related problem. Aurizon Network will need to investigate the internal heat source that is leading to this deterioration. A failure at Dalrymple Bay is backed up by Oonooie and will therefore not cause any curtailment of traffic. In fact, T91 has in recent times has been out of service quite often due to failures on the harmonic filters.

Contact wire wear

Aurizon Network has conducted surveys of the overhead contact wire wear at 120 locations throughout the Goonyella system during 2013 to 2016. The analysis of this data shows that the average wear was only 1 mm, as seen in Figure 7.71.

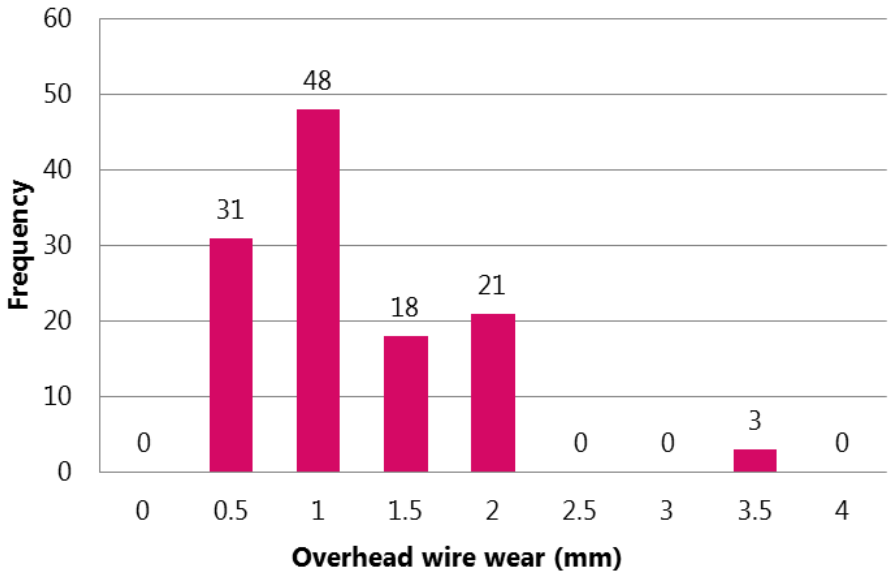


Figure 7.71: Goonyella system – contact wire wear

The wear limit that gives a 33% (35 mm^2) area reduction is 4.06 mm. When measured, this translates to a contact wire height of 8.28 mm as illustrated in Figure 7.72 (the original conductor is 12.34 mm in diameter).

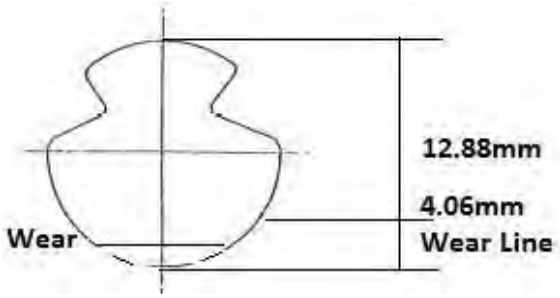


Figure 7.72: Goonyella system – contact wire cross section

In reality the actual wear on average is much less than what has been projected by Aurizon Network. Some of this contact wire will have been replaced due to dewirements over the years, which will explain its good condition. Nevertheless, the remaining lifetime based on just the average wear could be considered to be at least another 60 years.

However, there are two sites in the Goonyella system which has cross-sectional area reduction levels of approximately 24% which is nearing the maximum limit. These are near the Bolingbroke feeder station and at Praguelands. Given that these readings were taken in 2014 targeted monitoring is justified to avoid an unexpected dewirement due to cable brakeage.

Delays

Delays attributed to overhead line (OHL) and power supply are shown in Table 7.7.

Table 7.7: Goonyella system – OHL and power supply delay

OHL and power supply	Delay (minutes)	Normalised delay (min/billion NTK)
Damage/Failure/Malfunction of OHL equipment	40,282*	1,631
Power supply – trips (overcurrent)	2,646*	107

** Note: The indicated figures include delays on electrified sections of Newlands and GAPE*

It can be seen in Figure 7.73 that there are 24,070 minutes attributed to the overhead contact system for Goonyella in April 2016. In other months delays are less than 5,000 minutes. This high peak was due to one incident where a section insulator failed in the Jilalan Bypass. These are the roads leading to the Dalrymple Bay port. Issues at this location can potentially delay many trains. Therefore, the delay minutes can accumulate to a relatively large number in a short time.

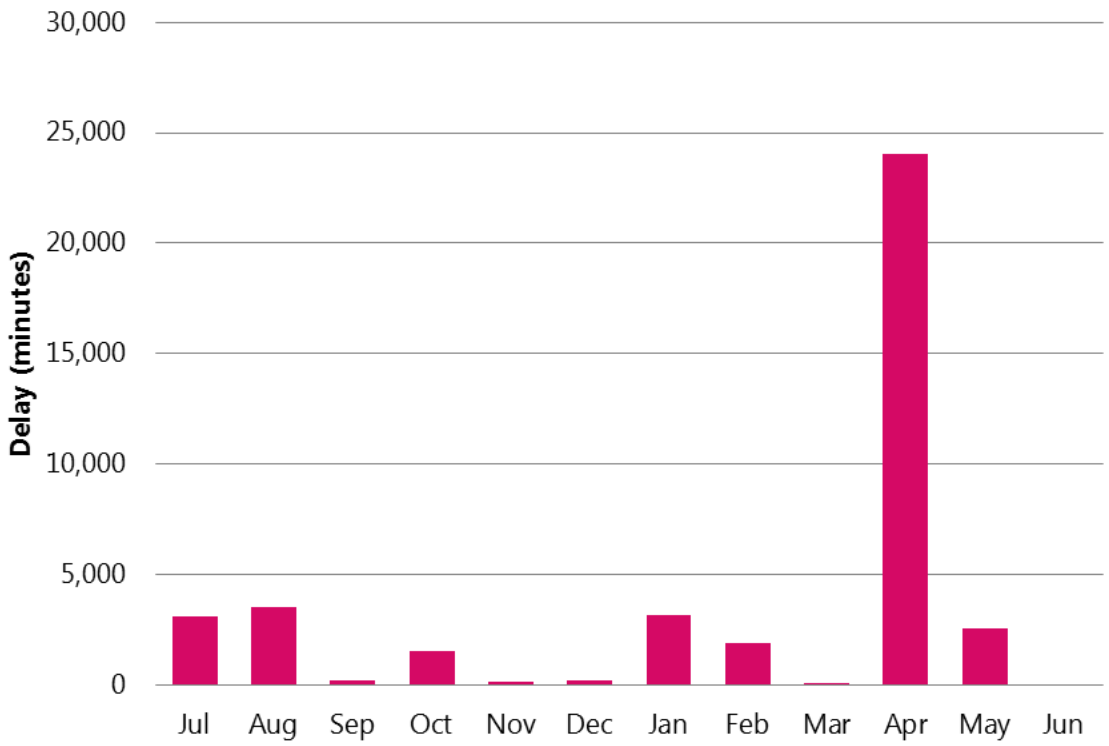


Figure 7.73: Goonyella system – delay minutes due to the overhead contact system

As shown in Figure 7.74 the downtime is evenly split between the OHL equipment and the sectioning. Sectioning or neutral section failures can have a large impact on the delay minutes and is therefore prudent to focus effort on this area.

In the previous assessment for FY 2012 the normalised delay for Goonyella was 2,054 min/billion NTK. Therefore, there has been a significant improvement.

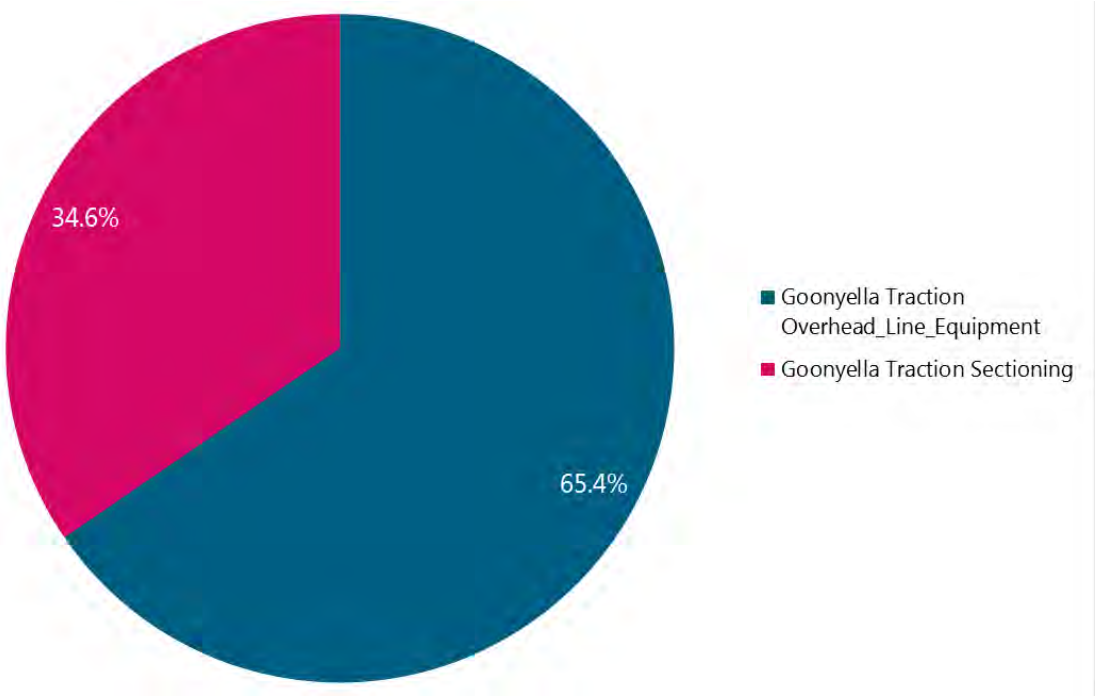


Figure 7.74: Goonyella system – maintenance focus

Dewirements

Dewirements for the Goonyella system in FY 2016 are shown in Table 7.8.

Table 7.8: Goonyella system – dewirement records

Date	Location	Description	Details
24/08/2015 13:37	Broadlea – Coppabella	Overhead trip	EG61 stuck insulator with lead loco on section 155.250.
30/01/2016 18:26	Oaky Creek – Lilyvale	Overhead trip	Double trip from lightning strike on subsection T19. Damage to insulator caused catenary to disconnect.
03/04/2016 17:57	Jilalan Bypass – Unknown	Overhead trip	JJ78 advised movement and flash in OHL equipment causing double trip.

Figure 7.75 shows that dewirements for the Goonyella system has been generally decreasing in recent years.

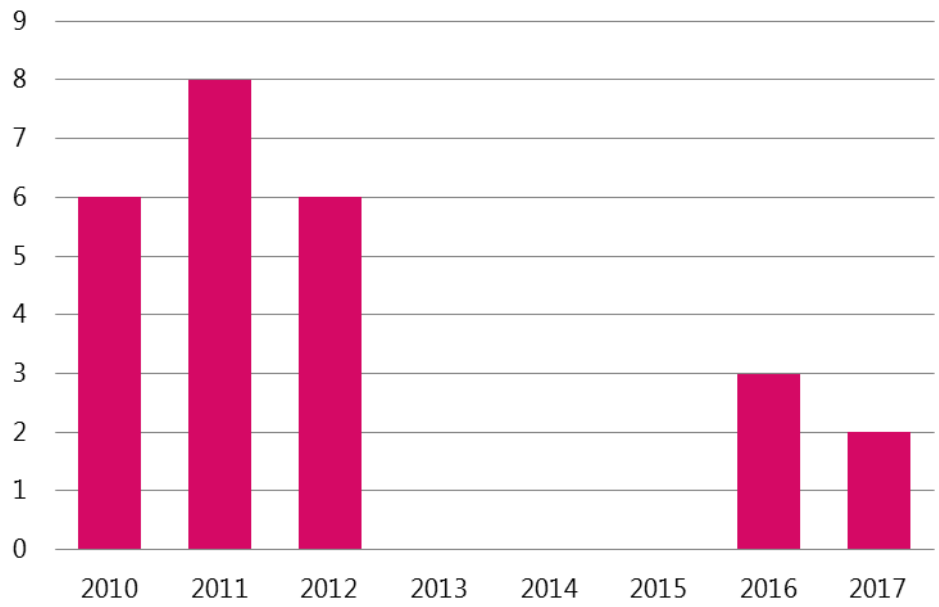


Figure 7.75: Goonyella system – count of overhead dewirements

7.5.2 Site visits

Over the period Wednesday 25/2/2017 to Friday 27/02/2017 Advisian comprehensively inspected Aurizon Network's traction power (TP) and OHL distribution network in the Goonyella rail corridor from German Creek track sectioning cabin (TSC) through to Dalrymple Bay feeder station. Advisian was accompanied by the power section supervisor and the district traction engineer responsible for that area.

During the site visits the agenda for the locations inspected was set by Advisian with constraints on what was inspected only set by the time available for inspection, the time required to travel to inspect certain sites and electrical and rail safety issues. Access was readily provided to all areas requested. The attending senior Aurizon Network staff had the necessary keys, access permits and knowledge to answer all questions. This allowed for an open and honest appraisal of the electrical asset.

Inspections were conducted using four check sheets which covered: feeder stations, TSCs and track condition units (TCUs), autotransformer sites and OHL sections. The site inspection sampling was as follows:

- 9 of the 11 feeder station sites (82%)
- 8 of the 13 TSC/TCU sites (62%),
- 6 of the approximate 35 autotransformer sites (18%)
- 5 randomly selected OHL sections.

The feeder stations not visited in the Goonyella system were Wotonga FS and Mt McLaren FS due to time constraint issues. Mt. McLaren is located 76 km along the Blair Athol line which represented a prohibitive travel time relative to the site visit schedule.

There were several common issues identified throughout the feeder station sites, including:

- The auxiliary supply backup isolation transformer and power conditioners were either disconnected or due for disconnection due to an overheating and fire risk
- Fire extinguisher inspections were out of date. Fire detection equipment, where fitted, was not connected to fire suppression systems and experienced spurious alarms
- Some autotransformer silica gel dryers were approaching replacement or were contaminated by oil. Silica gel free dryers are being trialled at a number of sites but these have not gained favour
- At some locations signage is starting to fade. Fencing is generally in good condition
- At most feeder stations the emergency exit lights are not working
- Corrosion is evident on battery terminals. This appears to be difficult to clean off when the batteries are located within the building. Terminals should be coated with a battery terminal protector product
- Vegetation control and removal of dead vegetation from feeder station surfaces is improving but an ongoing struggle.



Figure 7.76: Fire extinguisher inspection record



Figure 7.77: Poor feeder station surface condition



Figure 7.78: Grading ring out of ground Wandoo FS



Figure 7.79: Trial transformer breather



Figure 7.80: Power conditioner that was on fire

The Dalrymple Bay feeder station has the harmonic filters cut out due to a failure of a filter inductor. There is an ongoing problem with these filter inductors due to surface electrical tracking when they are exposed to the environment. This issue needs to be resolved.



Figure 7.81: Harmonic filter inductor cut out and earthed (also shows innovative animal deterrent)

At Dalrymple Bay there was significant verdigris on the battery terminals, indicating maintenance was required.

In the Dalrymple Bay feeder station there were structures which had bird nests. This can be an issue since the birds will potentially bridge the insulators and cause a fault.



Figure 7.82: Harmonic filter inductor cut out and earthed (also shows innovative animal deterrent)

The newer feeder station cable pits, where the XLPE underground cables come up under the feeder station buildings, more often than not contain water. This is due mainly to defective pumps or the pumps not being controlled adequately.



Figure 7.83: Water in cable pit

The Dalrymple Bay traction transformer returned a poor dissolved gas analysis result. The hydrogen is higher than desirable and the interfacial tension is low. This indicated that the oil is in poor condition due to an internal heat source. It is possible this transformer has functioned without the harmonic filters operating. Given that Aurizon Network is still operating DC traction in this area the harmonic currents sourced by these can cause heating in the transformer when the filters are cut out. This requires further investigation.

Currently one traction transformer at Bolingbroke was observed to be out of service due to overvoltage issues.

The main issue with the older feeder stations built in the mid-1980s is the condition of the ground surface. This is an issue of electrical safety. The design and maintenance of the surface condition is to ensure the lowest risk of step or touch potential to staff working within the feeder station compounds. At most sites the surface is a combination of stone, decomposed granite, coal dust and dying or dead vegetation. At some sites to overcome this issue at the bottom of isolation switches a grounded earth mat on the top of the stone has been installed. The approach to electrical safety due to surface condition should be consistent across the feeder stations. Having said this, although poor in some areas, vegetation control in the older feeder stations is significantly better in the Goonyella system compared to the FY 2012 audit when it was very poor. The poisoned biomass, although mainly dead, still remains a risk when forming part of the ground surface.

Other issues with older feeder stations include:

- Many harmonic filter current transformers appear to have surface tracking.
- The battery terminal conditions are poor
- There is rusted guttering which in some cases is falling off
- External lighting is not working in some locations
- There is broken or badly fitting concrete cable duct covers
- Some auto isolators are cut out pending review
- The emergency exit lighting rarely works
- At Wandoo FS and Norwich Park FS the neutral sections have arc tip burning and contamination on the insulators and require inspection.



Figure 7.84: Current transformer with surface tracking

TSCs and TCUs suffer from similar issues to the feeder stations with the more remote TSCs being in the poorest condition. As an example, Red Mountain had the following:

- Poor signage
- Some loose cable clamps on the fence earthing
- Debris in the autotransformer bunding
- Cracked or broken concrete cable ducts and covers
- Emergency lighting was out of service

Jilalan TSC has the outside of the building covered in mould but otherwise is in good condition.



Figure 7.85: Broken battery caps indicating poor battery maintenance

The autotransformer sites pose little risk to train operations. Most autotransformer sites are now able to be disconnected from the OHL if faulty; it appears that only a few sites remain to have isolators installed. Again the new sites are in good condition with installed bunding and the control building outside the transformer enclosure. Some older remote autotransformer sites suffer from similar issues as the feeder stations and TSCs, including:

- Poor vegetation control (particularly Praguelands)
- Corroded battery terminals
- Faded signage
- Poor fencing.



Figure 7.86: Poor vegetation control and no bunding at Praguelands autotransformer site

An additional environmental issue at the older sites is the lack of transformer bunding.

There has been a big effort in recent times to ensure the transformers are in a satisfactory condition by changing out any that show poor electrical or dissolved gas results. Other than some units with dark transformer oil and some contaminated or end of life silica gel the autotransformers physical appearance and maximum operating temperature parameters were reasonable.

The overhead contact wire is in good condition and where issues were identified, either these are known or plans are in place to address them. The occupational crossing height gauges at many locations were checked against the specification and found to be satisfactory.

The gap in the overhead conductor network at 134.750 is in good condition and appears to be functioning correctly. A train was observed traversing the section with no issues.



Figure 7.87: Eastern side of the gap

The following OHL items were inspected at each site and were found to be in good condition:

- Masts
- Droppers
- Drapes
- Insulators
- Connections and suspension clamps
- Wind stays
- Contact wire
- Catenary wire
- Feeder and earth wires
- Hinged fittings
- Steady arms and steady arm to registration tube connections
- Mid-point anchors
- Stagger.

There were minor OHL issues with the following:

- Arrestor blow out devices missing (plastic plug)
- Section insulators having some contamination
- Bird nests in masts
- Surface corrosion of cantilever assembly (upper arm, strut and registration tube)
- Disconnected motorised isolators
- Some neutral sections having minor arcing on the arc tips or contamination on the insulator (all earth connections to the central neutral section earthed point were in good condition).

In the Goonyella system there are some tensioning weights that are very close to the lower limit and may soon need adjustment (this was not observed in the Blackwater system).

The issue of surface corrosion of the cantilever assembly occurs mainly along the coast between Dalrymple Bay and Jilalan yard. The bird nest issue is being addressed by the mast modification with a substantial number of the masts now modified, but not all.



Figure 7.88: Surface corrosion on upper arm, strut and registration tube, between Hay Point and Grasstree TSC

The requirement for the full complement of motorised isolators is currently under review and a number will likely be withdrawn from service. A large number of new section insulators (Jacques Galland) were observed along the network and in particular Jilalan yard and along the track at Oonooie FS.

At this point in time there is significant redundancy with the power supply network and most issues can be addressed by switching around faulty components. This has enabled a high level of reliability. Some of the older feeder stations are showing the signs of their age Aurizon Network is currently investigating shutting down some of the older feeder stations. They have become redundant due to the introduction of AC traction which does not suffer from the same voltage drop issues that the DC traction technology produced. As a consequence the investment in maintaining some of the older feeder stations has been reduced.

The OHL is well maintained and observations during the site visit reveals that the electrical network is in reasonable condition and is an improvement over the FY 2012 assessment.

7.5.3 Leading indicators

Scheduled and unscheduled electrical system work orders

The scheduled and unscheduled work orders have been analysed based on the allocated downtime. This gives a comparative indication of the effort being put into scheduled preventative maintenance as opposed to unscheduled failures. The graph shown in Figure 7.89 covers the downtime for both traction power and the overhead contact system in Goonyella. It can be seen that the scheduled downtime was 468 hours compared with only 33 hours of unscheduled downtime which covers responding to corrective faults. Most downtime has been associated with scheduled work on sectioning which includes track switches, neutral sections and section insulators. This effort appears to have been beneficial since there was very little downtime associated with unscheduled corrective faults. Also there has been 97 hours invested in preventative maintenance on transformers for which there has been no unscheduled downtime recorded.

As shown in Figure 7.89, most of the unscheduled corrective downtime has occurred due to OHL equipment. However, this category has a greater exposure to environmental factors which are out of Aurizon Network's control (e.g. birds, snakes, lightning strikes, etc.).

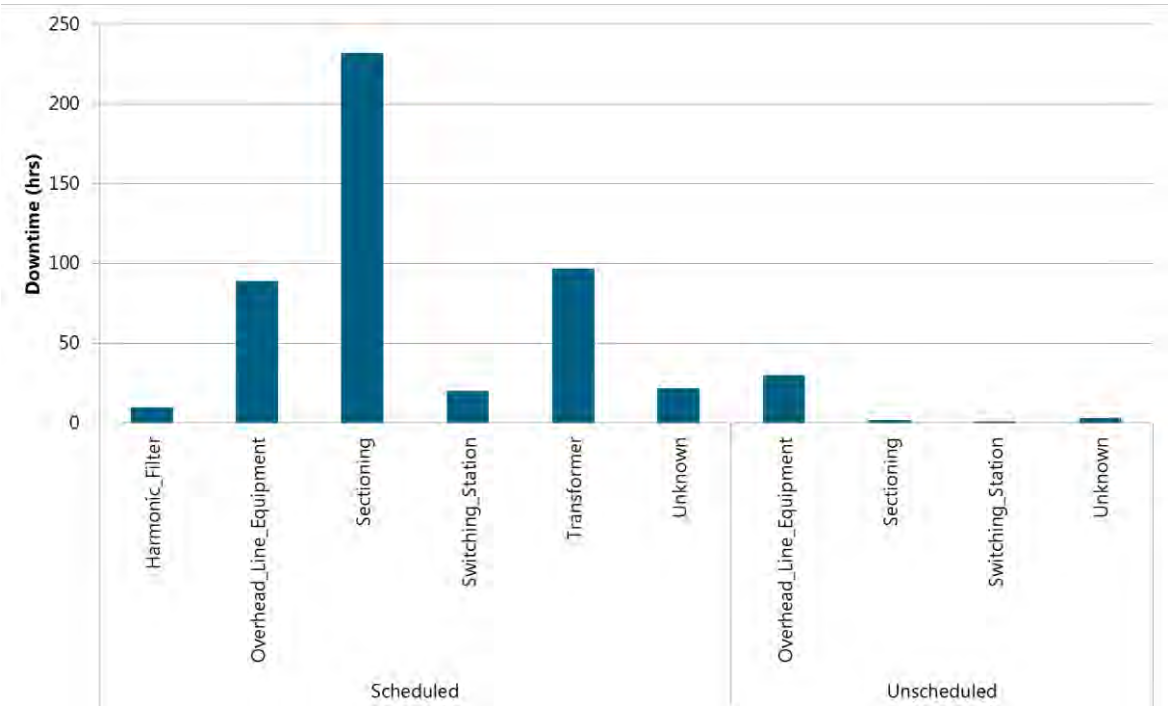


Figure 7.89: Goonyella system – scheduled and unscheduled downtime by equipment

A more detailed analysis of the downtime categories in Figure 7.90 shows that the focus has, similar to Blackwater, been on autotransformers. In addition to this there have been significant issues associated with the conductors and earthing/bonding. It is understood Aurizon Network has a project to verify the earthing and bonding in Goonyella.

In summary, for Goonyella the data shows that Aurizon Network has been very proactive in rolling out an effective preventative maintenance program and this is demonstrated by the low number of unscheduled downtime hours.

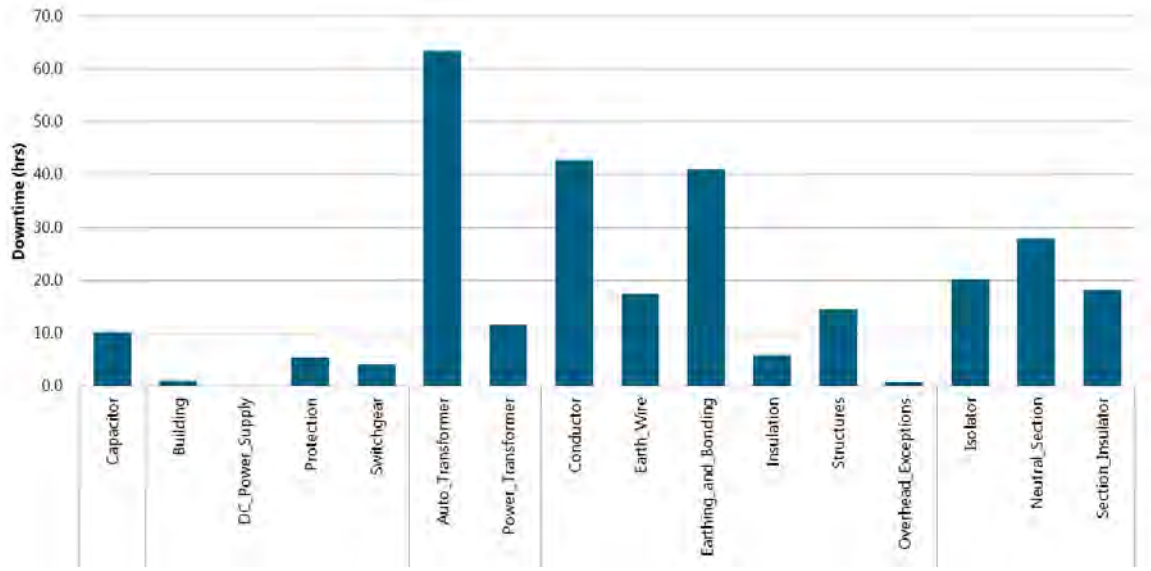


Figure 7.90: Goonyella system – total downtime by equipment

Autotransformer refurbishment and replacement policy – preventative maintenance

The original autotransformers have historically suffered from partial discharge problems. It is thought this may be due to a design issue. Aurizon Network has in the past refurbished the autotransformers based on condition indicated by dissolved gas in oil levels. However, the current refurbishment scope does not address the original design problem. Therefore, after refurbishment the partial discharge problem persists. It is not feasible to refurbish the autotransformers for a second time.

The Aurizon Network autotransformer asset policy states that the minimum design life is 25 years. Figure 7.91 shows the autotransformer age analysis for Goonyella. There are essentially three groups of autotransformers: original units purchased in 1985, those purchased from 2002 through to 2007 and 44 almost new units. There are 119 units that fit into the 1985 category. However, as only 123 units in service, only 59 out of the 119 are actually deployed. There will be 60 old units which are either condemned or are spares. The 59 older autotransformers that are still in service would have already had one refurbishment and therefore will require replacement over the next 5 years. The transformer oil analysis results indicate that 12 will require replacement in the next 12 months. Aurizon Network is identifying the units that require replacement based on condition, using oil testing and analysis. The Aurizon Network policy states that autotransformers greater than 15 years in age shall have more frequent scheduled maintenance. However, the oil sampling interval is maintained at 12 months.

Aurizon Network has shown it is managing the autotransformer aging since in the last assessment there were 39 units that required refurbishment before FY 2017. These will be largely complete. Going forward the program will be renewal based on condition. It is likely that 59 units will require replacement over the next five years and based on the oil analysis there will be 12 this year. The future projected renewal requirement for Goonyella is similar to Blackwater. Advisian is confident this is being managed in a satisfactory manner based on condition.

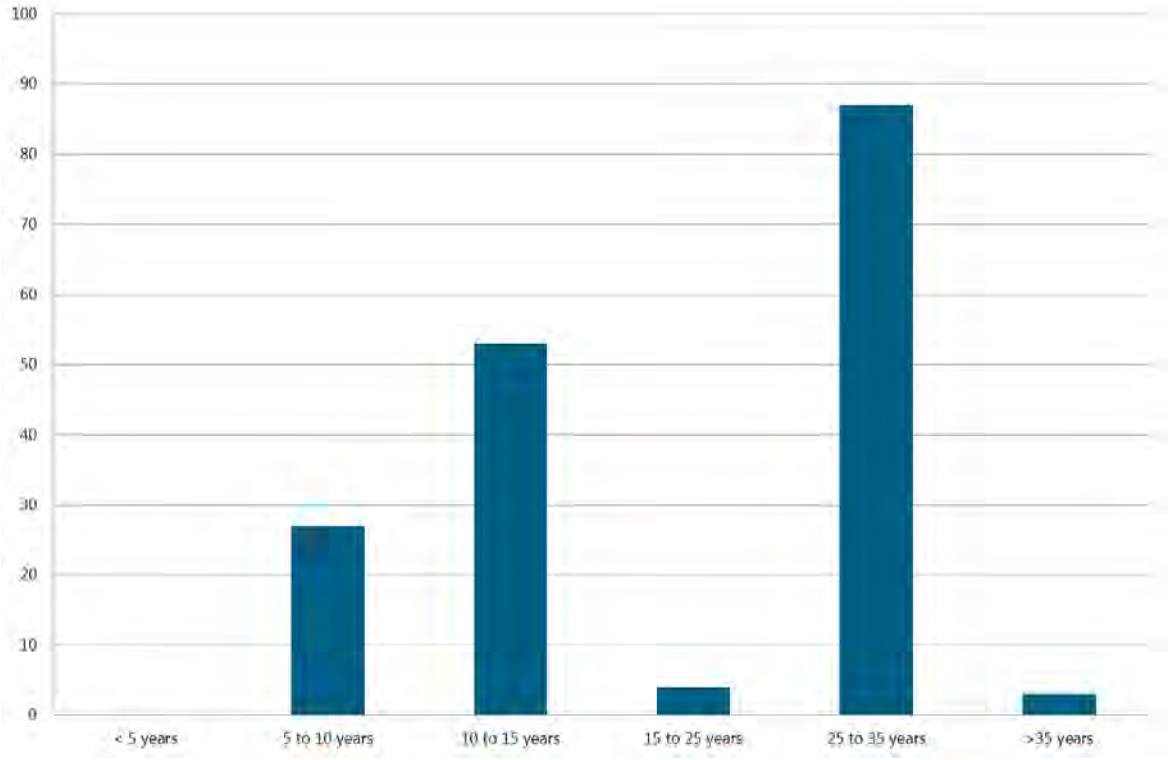


Figure 7.91: Goonyella system – autotransformer age by acquisition date

Table 7.9 shows a summary of the current Goonyella autotransformer condition status.

Table 7.9: Goonyella system – autotransformer condition status

Total number in FAR	Installed number	Age <15 years	Age >25 years and in service	Condemned or Spares	Number to be replaced in next 5 years	Number requiring replacement in next 12 months
184	123	64	59	60	59	12

Traction distribution faults

Aurizon Network has conducted analysis of the electrical system faults in Goonyella from calendar year 2011 to 2015, from Aurizon Network's Yearly Fault Report 2015. The previous assessment indicated there were 690 faults in FY 2012. This only included faults associated with feeder station protection operations. This is consistent with the electrical section faults shown in Figure 7.92. For Goonyella there has been a slight decline in the electrical section faults in 2015 compared to 2012. However the year to year variance is much greater in Goonyella compared to Blackwater and is also typically higher. All other fault classifications are relatively steady. The electrical sections with the high normalised values are Jilalan to Bolingbroke and Bolingbroke to Wandoo. These sections are located on the Connors Range where the track ascends through subtropical rainforest. It can therefore be expected the contribution of wildlife and other environmental factors to faults will be higher in these areas and higher than Blackwater where the terrain is completely different.

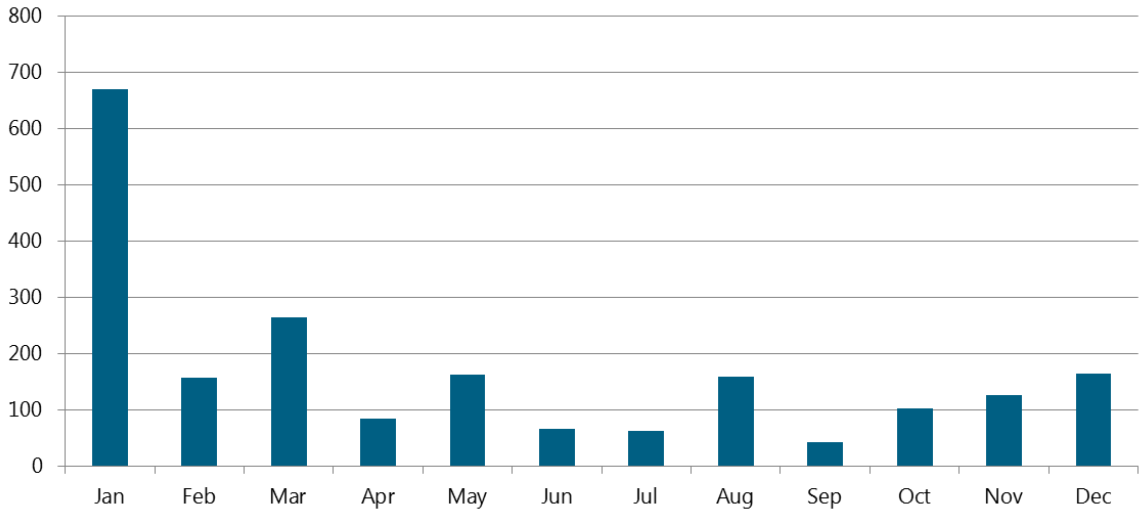


Figure 7.92: Goonyella system – number of feeder station trips by month

Once normalised, it can be seen that Goonyella has averaged at approximately 0.9 faults per annum per track kilometre, but there is more year to year variability. As stated above we believe this variability is a function of the terrain through which the track passes. This is generally near to or less than the accepted benchmark for electrified railways of one fault per annum per track kilometre. This means that the reliability of the Goonyella overhead sections is within the acceptable boundaries.

The normalised electrical section fault figure is likely to be maintained into the medium term due to the maintenance focus being on preventative rather than corrective maintenance. There are a relatively low number of tasks associated with corrective faults and corrective maintenance. This means the available maintenance resources are being employed to improve the reliability of the system rather than simply responding to failures.

Also of importance is that Aurizon Network is now analysing the data and presenting it in a useful format. This is a distinct improvement over what was seen in the FY 2012 assessment.

Advisian has analysed the electrical section faults based on distance protection and Delta I protection operations for Goonyella. These will account for the vast majority of short circuit the faults attributed to the electrical section. This was done for the FY 2016 period. There were 590 electrical section faults in the period with a highest number being biased towards the summer months. This is typically due to wildlife such as snakes being more active in the summer period. The electrified track length is approximately 750 km for Goonyella which results in a normalised value of 0.78 faults per annum per track kilometre for FY 2016. This is consistent with the Aurizon Network 2015 calendar year and historical levels and is a good result in terms of the typical benchmark.

These leading indicators show that in the medium term the frequency of faults in Goonyella will be maintained or possibly reduce due to the high level of preventative maintenance that is being executed.

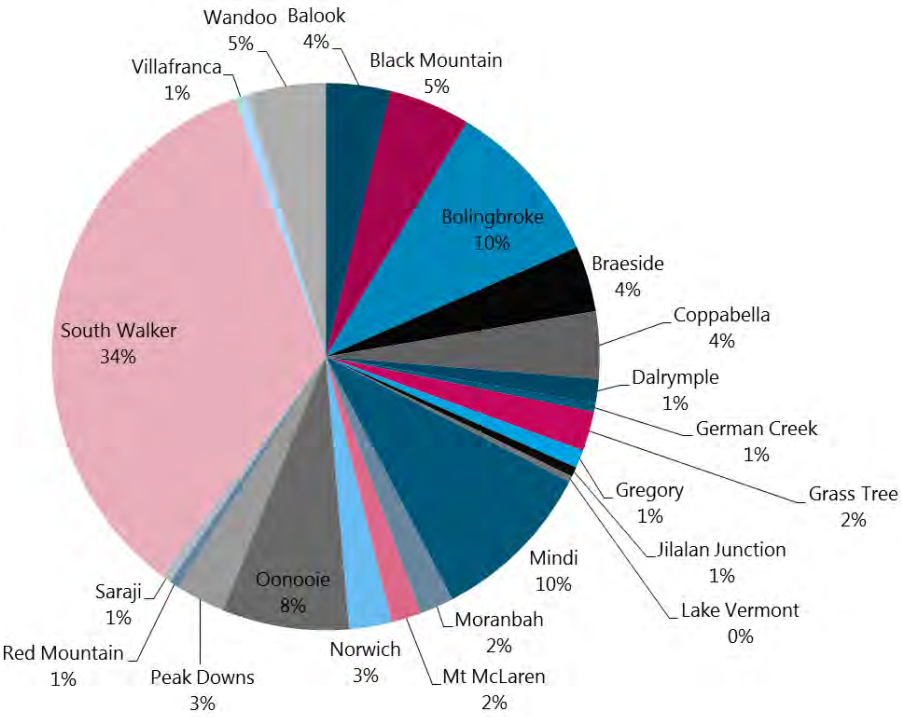


Figure 7.93: Goonyella system – distribution of feeder station trips

Circuit breaker health

Aurizon Network has conducted comprehensive circuit breaker testing in Goonyella at both the older feeder stations and the TSCs. The older switchgear uses the following circuit breakers:

- Type – vacuum bottle
- Rated voltage – 55 kV
- Rated short circuit breaking current – 12.5 kA
- Nominal contact resistance – 23 μΩ
- Number of breaks per phase – 2 (2 phases)
- Close coil – 48 V DC
- Mechanism – spring
- Trip coil – 48 V DC spring winding motor voltage – 48 V DC.



Figure 7.94: Dingo circuit breakers showing the vacuum bottles

Aurizon Network uses the ISA CBA 2000 HV circuit breaker analyser and micro-ohm meter to assess the circuit breaker condition and operation. This unit measures the following parameters:

- Current level in closure coil at close
- Current level in trip coil at trip
- Contact resistance
- Opening time
- Closing time.

In addition, Aurizon Network also quantifies the following:

- Wear or 'burn-off' of the contacts
- Total number of operations
- Physical condition based on observation.

The number of operations varies considerably from site to site due to the particular operational profile and electrical section fault propensity.

In Goonyella, Aurizon Network inspected 64 circuit breakers in feeders stations and 20 in TSCs. the feeder stations and TSCs that were covered are as follows:

- Coppabella FS
- Mt McLaren FS
- Moranbah FS
- Norwich Park FS
- Oonooie FS
- Peak Down FS
- Red Mountain FS
- Wandoo FS
- German Creek TSC
- Saraji TSC
- South Walker TSC
- Braeside TSC
- Villafranca TSC.

Only the older feeder stations were selected for testing since the new ones are assumed to be still in very good condition.

Figure 7.95 shows the scores for circuit breakers in Goonyella, with 1 being excellent and 5 being poor.

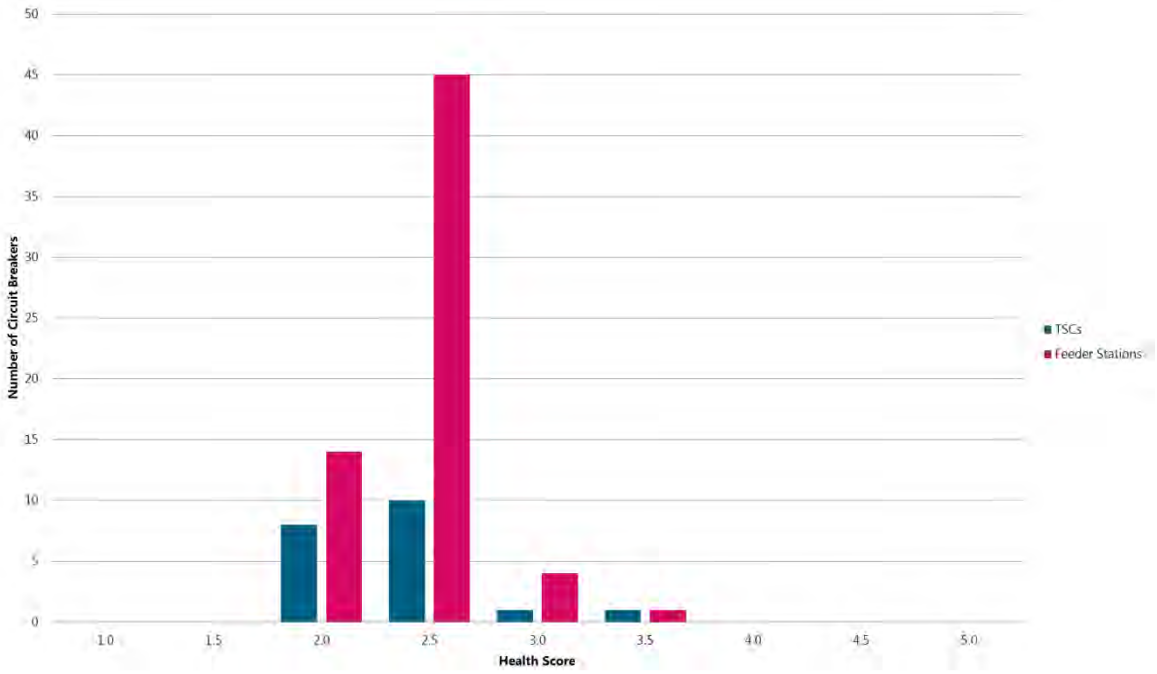


Figure 7.95: Goonyella system – circuit breaker health score

The majority (65%) of circuit breakers have scored 2.5. 26% of the circuit breakers have scored 2. Therefore it can be considered that these circuit breakers are still in reasonable condition despite their age. The largest issue will be obsolescence since the vacuum bottles are not likely to be available as spare parts.

To investigate any differences between circuit breakers in the TSCs and feeder stations the two categories have been analysed separately. The TSC circuit breakers have a higher percentage in the score of 2 and less in the 2.5 category compared to the feeder stations. This is not unexpected since the TSCs are likely to have less operations and the maximum fault current that is interrupted will always be lower than that at the feeder station.

These results demonstrate there is still significant life expectancy in the circuit breakers. Obsolescence will in the future become more of a problem which will need to be dealt with. Aurizon Network is investigating shutting down some of the older feeder stations which will not be required once the older DC traction is completely phased out. This will free up a significant number of spare parts. Already a number of older TSCs were freed up for spare parts in Blackwater due to the new feeder stations that were implemented during the system upgrade. Therefore, spare parts will become less of a problem.

Aurizon Network's Yearly Fault Report 2015 showed that there were eight circuit breaker faults in Goonyella, which is relatively insignificant compared with the 614 electrical section faults which are largely caused by environmental effects and rollingstock operational issues. Therefore, Advisian considers the old circuit breakers will continue to provide similar reliability to historical levels, in the medium term.





8

Blackwater system

This 1,802 kilometres of electrified track transports coal to Stanwell Power Station, Gladstone Power Station, RG Tanna Coal Terminal and Barney Point Coal Terminal.

8.1 Operational KPIs

Below Rail Transit Time (BRTT)

The Blackwater system has achieved BRTT targets for all but one month in FY 2016. The results are shown in Figure 8.1 below.

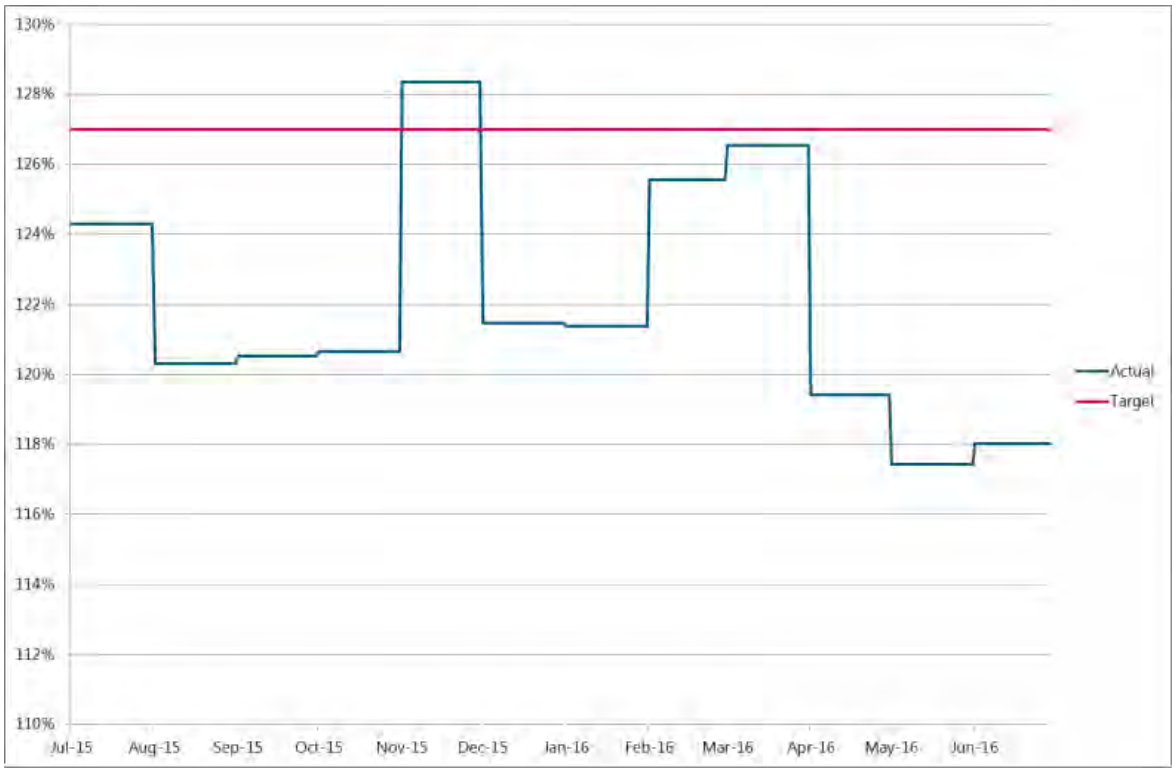


Figure 8.1: Blackwater system – BRTT

Overall Track Condition Index (OTCI)

The Blackwater system has achieved OTCI targets consistently in FY 2016. The results are shown in Figure 8.2 below.

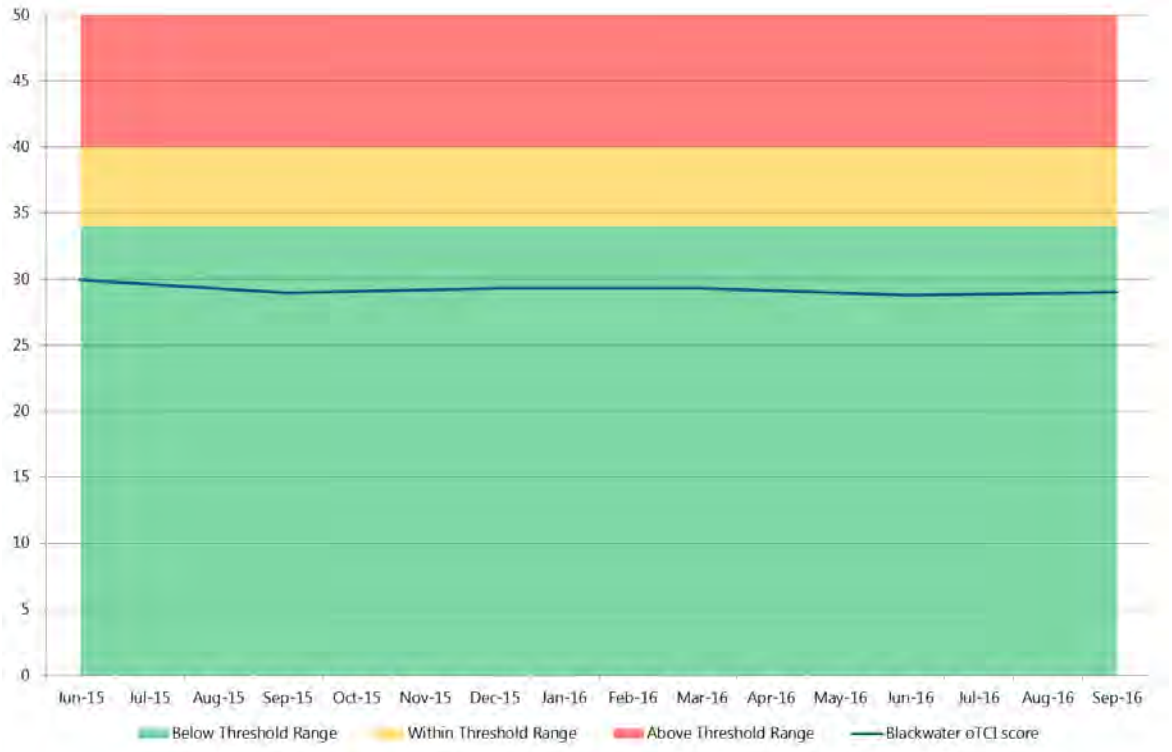


Figure 8.2: Blackwater system – OTCI

The results in Figure 8.1 and Figure 8.2 indicate a well maintained track.

Speed restrictions

In the Blackwater system in FY 2016, 12.0% of days were recorded to have a weighted section run time (WSRT) performing better than section run time (SRT) targets, as shown in Figure 8.3. There is a correlation with this track and its performance in wet weather.

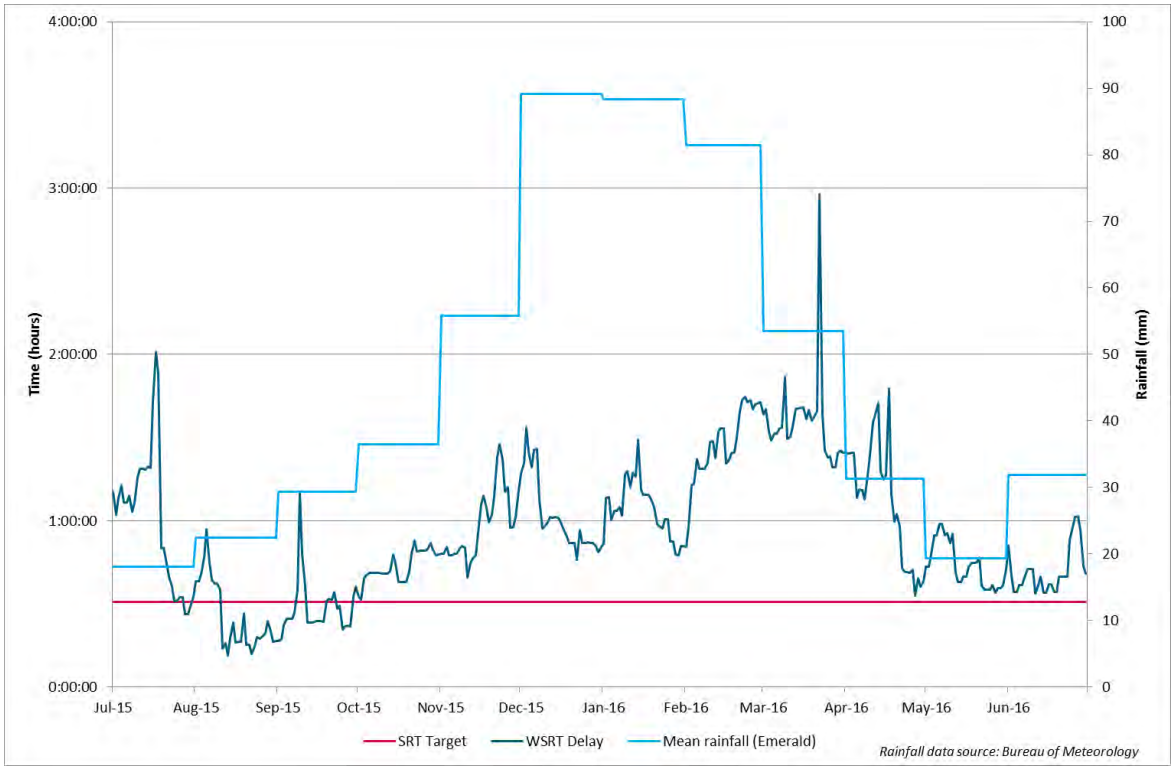


Figure 8.3: Blackwater system – WSRT

Delays

The detailed causes of below rail delays in Blackwater are shown in Figure 8.4 below. It can be seen that speed restrictions are the major cause of delay.

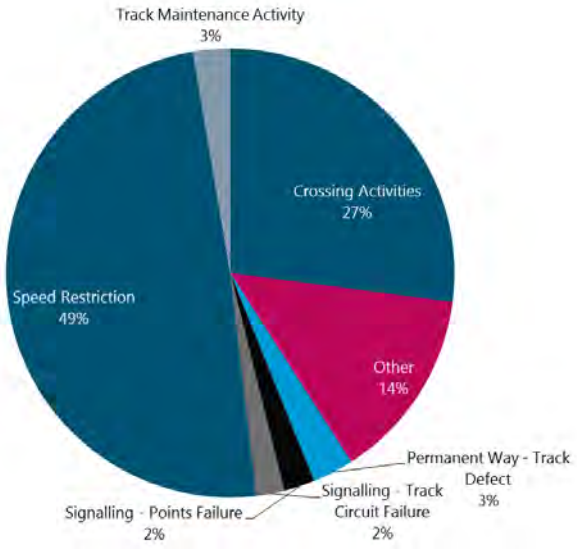


Figure 8.4: Blackwater system – specific causes of rail delays

8.2 Track systems

8.2.1 Lagging indicators

Delays

The delays attributed to the permanent way on the Blackwater system are shown in Table 8.1 below.

Table 8.1: Blackwater system – permanent way delays

Permanent way delays	Delay (minutes)	Normalised delay (min/billion NTK)
Delays due to track maintenance and defects	24,923	1,082

Delays caused by the track maintenance and defects in the Blackwater system can be broken down into below two categories:

- 843 minutes per billion NTK attributable to track defects
- 239 minutes per billion NTK attributable to track maintenance and repair.

Derailments

Derailments in the Blackwater system in FY 2016 are shown in Table 8.2. Similar to the Goonyella system, there are not many main line derailments and the largest delay impact was a single derailment caused by a rollingstock failure on 29 September 2015.

Table 8.2: Blackwater system – derailment summary

Date	Location	Incident Summary Ds	Total Delay (minutes)
29/09/2015	Grantleigh – Tunnel (main line)	Train lost air. Train confirmed derailed at 67 km. Track reopened at 1318 hrs.	23,384
25/10/2015	Callemondah (Yard)	Ballast train derailed both wheels of the lead bogie 2 departure road.	0
28/10/2015	Blackwater (Siding)	4 wagons derailed in ER4 Blackwater.	122
6/01/2016	Bajool (Loading)	Train derailed at Bajool.	0
10/01/2016	Bajool (Loading)	Ballast train derailed in Port Alma leg.	545
9/02/2016	Boonal – Bluff (Main line)	Track machine derailed at the 178.100 km Boonal-Bluff Down road.	2,465
10/02/2016	Boorgoon Balloon (Loading)	Rear locomotive derailed.	3,397
25/02/2016	Golding (Unloading)	Golding Pit 1. 22nd wagon lead bogie and 25th wagon rear bogie.	640
3/03/2016	Callemondah (Yard)	86th and 87th wagons derailed.	0
8/03/2016	Raglan (Siding)	Derailment of locomotive in Raglan siding.	0
8/06/2016	Golding (Unloading)	3 wagons derailed on the departure side of unloading pit.	2,238

Defects

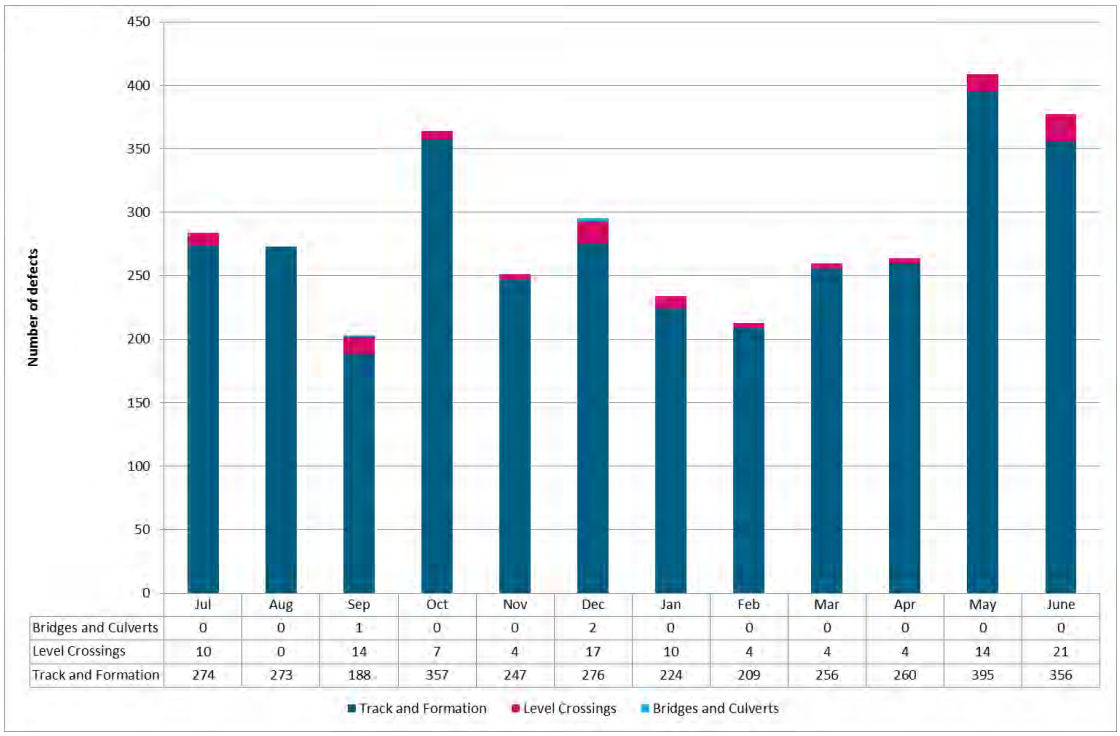
The percentage increase in average number of monthly track and formation defects per track kilometre is 73.7% since the FY 2102 assessment. This is shown in Figure 8.5 and Figure 8.6.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Avg.
FY 2012 *	181	146	100	110	115	158	127	225	152	133	129	44	143
FY 2016	253	252	174	330	228	255	207	193	237	240	365	329	249
% Difference	40%	73%	74%	200%	99%	61%	64%	-14%	56%	81%	182%	642%	74%

* Source: (Evans & Peck 2013, p.189)

Figure 8.5: Blackwater system – track and formation defects for FY 2012 and FY 2016



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bridges and Culverts	0	0	1	0	0	2	0	0	0	0	0	0
Level Crossings	10	0	14	7	4	17	10	4	4	4	14	21
Track and Formation	274	273	188	357	247	276	224	209	256	260	395	356

Figure 8.6: Blackwater system– monthly track and structures defects

8.2.2 Site visits

The Blackwater system is 994 km long and carries coal from as far west as Springsure to the RG Tanna Coal Terminal (RGTCT) in Gladstone and Wiggins Island Coal Export Terminal (WICET) north of Gladstone. The Blackwater system is duplicated from east of Burngrove. This duplicated track is bi-directional. The Blackwater system is electrified and carries both diesel and electric traffic.

The Blackwater system was constructed throughout the last century and electrified in the 1980s. There was recently a major upgrade to increase capacity to be able to service the first loader at the WICET.

The track is in satisfactory condition with some areas showing the impacts of age and traffic.

The Cooling Channel Bridge between Callemondah and the RGTCT, shown in Figure 8.7, is a critical asset on the Blackwater and Moura systems. This is the only rail crossing to this terminal. The rail and the bridge are in satisfactory condition but it is clear the rail at this site is prone to developing defects.



Figure 8.7: Track on the Cooling Channel Bridge

The horizontal alignment is constrained by an overpass immediately to the west, as seen in Figure 8.8.



Figure 8.8: One of the horizontal alignment constraints immediately west of the Cooling Channel Bridge

This overpass, and other constraints created by turnouts, leads to defects on the outside approach rail to the bridge from the west, shown in Figure 8.9. The main reason for these is that due to the critical nature of this piece of infrastructure, access for rail grinding is limited. This leads to the need to replace these rails more frequently than required by an optimal design. This bridge was original a ballasted track over the bridge and Aurizon Network has altered it to having the track fixed directly to the bridge deck. As can be seen there are still issues with rail defects, however Aurizon Network indicated that they are less frequent than defects due to top and line issues with contaminated ballast across this bridge. The horizontal alignment issues remain and a redesign and capital works would be required to address this and ease this maintenance load.



Figure 8.9: Gauge corner shelling developing on the outside approach rail west of the Cooling Channel Bridge

Figure 8.10 shows the entry and departure roads to RGTCT. The extent of top and line defects can be seen. This is partly due to the contamination from the unloading process. This is a reality of coal rail operations and is mostly mitigated by the slow speeds of trains in these parts of the network.



Figure 8.10: Entry and departure roads to RGTCT showing top and line defects

Replacement of a turnout switch and stock rail was inspected north of Gladstone, shown in Figure 8.11. Safety was clearly a priority and the site visit team was required obtain a brief from the site supervisor and to lock on before proceeding.



Figure 8.11: Turnout installation north of Gladstone at Ambrose 570.336

At this site evidence was seen of the Aurizon Network policy of taking a rail replacement back to a point where the wear on the rail is no greater than 5 mm of the rail head of the new rail, as shown in Figure 8.12.



Figure 8.12: Matching worn to new rail; difference must be less than 5 mm

At Archer a turnout identified for removal was inspected, seen in Figure 8.13. This figure clearly shows that there is minimal, if any, use of this turnout.



Figure 8.13: Turnout identified for removal at Archer 614.920

Further, Figure 8.14 shows the damage this redundant turnout causes to the rail in the vicinity of the turnout. Advisian agrees with Aurizon Network's assessment that removing this turnout loses little operational functionality but decreases the maintenance load.



Figure 8.14: Rail damage due to fixed vee turnout at Archer

Some top defects were observed in the vicinity of Rocklands at 632.387, shown in Figure 8.15. The ballast at this location appeared in reasonable shape so these defects may be caused by a weakness in the formation.



Figure 8.15: Top defects due to ballast contamination or formation failure

The ballast on the Rocklands Bridge was badly pulverised in places, shown in Figure 8.16. This can be a common problem with concrete sleepers on ballast on a concrete bridge deck. The repair is to cut and remove the rail, replace the ballast and provide ballast deck matting to reduce ballast degradation on the concrete bridge surface. Aurizon Network has scheduled this bridge for ballast replacement within the next 12 months. As discussed previously, for the Cooling Channel Bridge, the alternative of fixing the rails directly to the bridge deck can lead to problems at the approaches where the ballasted track meets track fixed to the rigid bridge deck.



Figure 8.16: Pulverised ballast on the Rocklands Bridge

Figure 8.17 below shows the Kalapa supersite. This is an important initiative to improve monitoring of the wheel profiles, among other train characteristics. They are now installed on all systems except the Moura system.



Figure 8.17: Supersite at Kalapa using Beena Vision technology

The site inspected in Figure 8.18 was reported to have top and line defects. The resurfacing had been completed here and the track appeared in good condition.



Figure 8.18: Completed resurfacing at 42.536

In interviews with Aurizon Network staff, the issue of excessive low rail wear and plastic flow on the tight curves through the hilly country near Grantleigh was discussed. Aurizon Network is analysing this particular issue by reviewing train speed, design cant and gauge. Aurizon Network believes that the curves may potentially have the incorrect cant for the actual train speed, as opposed to the design speed. In terms of gauge, Aurizon Network is investigating whether a tighter gauge will reduce the low rail wear. These investigations were not complete at the time of the CBA.



Figure 8.19: Tight curves through the hilly country at Grantleigh 71.107

Sometimes a site requires ballast replacement but the amount, location or timing means that an under cutter cannot be used. This type of operation is completed with normal civil plant with some specialised attachments for excavators. Figure 8.20 below shows such a repaired site; top, line and ballast quality looked good at this site.



Figure 8.20: Patch resurfacing and ballast replacement 103.020

A number of level crossings were inspected. Some had flange ways and others did not. Flange ways are more expensive to install but they have two advantages: firstly they lead to a tidier crossing, allowing the flow of lubrication to travel through and not get built up, and secondly they allow a rail grinder to pass. Figure 8.21 below shows a comparison between the two.



Figure 8.21: Comparison level crossing without flange way and with flange way

The Dingo level crossing is an interesting site and illustrates the challenge of working with legacy rail systems. Dingo was a major stabling and marshalling yard for the original Blackwater system; there is evidence of many old sidings in the vicinity. At some stage a road crossing was required and it seemed reasonable to place this crossing at the eastern end of these yards. However, this decision appears to have some unintended consequences: the curve immediately after the crossing appears to cater well for eastbound unloaded traffic with a cant set for 60 to 80 km/hr, as in Figure 8.22, however the loaded traffic starting from a standing start at Dingo will not reach the equilibrium speed for the curve and will be under speed leading to excessive loading on the low rail at the curve.



Figure 8.22: Unloaded train approaching Dingo level crossing (note the cant)

The evidence of this is significant plastic flow in the low rails immediately west of the level crossing, shown in Figure 8.23. There is no easy solution to this, but to try and maintain loaded trains at speed heading east may ease the potential for overloading this low rail. This introduces the complexity of applying operational above rail constraints because of the limitations of below rail infrastructure.



Figure 8.23: Plastic flow on low rail east of the Dingo level crossing

The Boonal balloon loop was inspected at 181.100. At the site a program to replace poor quality timber sleepers was in progress, shown in Figure 8.24. Boonal balloon loop was the site of derailments in FY 2016 and the timber sleepers clearly needed replacing with a number of loose dog spikes due to broken or weathered sleepers.



Figure 8.24: Timber sleeper replacement at Boonal

Boonal balloon loop exhibited scouring of dispersive soils in the cuttings. This creates a maintenance burden cleaning the drains but the capital investment of stabilising these loops is probably not warranted on a risk based assessment.



Figure 8.25: Boonal balloon loop

At Nogoa, Aurizon Network is using mixed timber and concrete sleepers, shown in Figure 8.26. As timber sleepers become unserviceable they are replaced with concrete sleepers. This is an acceptable practice in accordance with Aurizon Network standards.



Figure 8.26: Alternating timber and concrete sleepers at Nogoa 261.244

The Sandhurst Creek Bridge, shown in Figure 8.27, on the Minerva line at the far west of the Blackwater system allows rail access to only one mine. The cost/benefit of a major repair on the bridge is marginal; consequently there is a speed limit of 25 km/hr on the bridge. The top and line defects on the bridge that influence this speed restriction can clearly be seen.



Figure 8.27: Sandhurst Creek Bridge

The wheel burns shown in Figure 8.28 are more likely to be from wheel slip, as the loaded trains try to traverse the tight radius curves and steep grade out of Sandhurst Creek at slow speed. The wheel burns will create an impact which will lead to ballast breaking down, mid-hole forming, track pumping, further degradation of ballast and ponding of water, and then subsequently either formation failure, rail break or both.

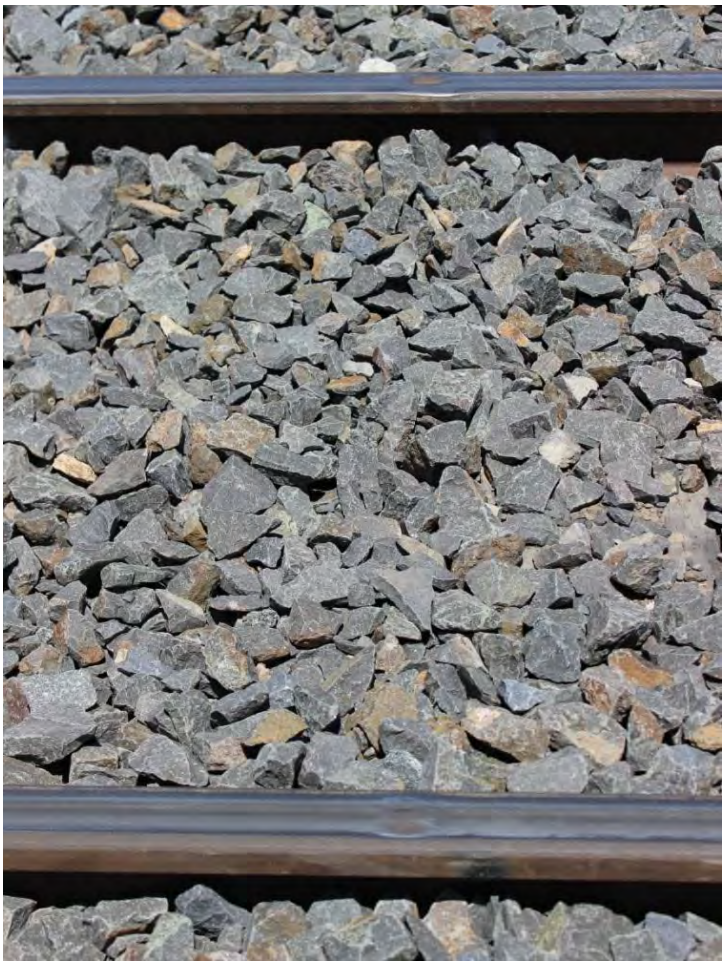


Figure 8.28: Wheel burns immediately east of the Sandhurst Creek Bridge

8.2.3 Leading indicators

The reliable BRTT and OTCI results combined with results of the site inspections and defects analysis indicate that Blackwater is generally performing well. At the west end of the line the Minerva branch is in marginal condition.

The site inspection and review of our defects indicates that Aurizon Network is aware of the parts of the track that are marginal and appears to be maintaining them to a safe level while minimising maintenance cost.

Blackwater shares with Moura and Goonyella susceptibility of requiring increased TSRs in wet weather. This could be a leading indicator of additional formation of ballast quality issues for the future.

8.3 Structures

8.3.1 Lagging indicators

Asset age

Asset ages for bridges and culverts in the Blackwater system are shown in Figure 8.29 and Figure 8.30.

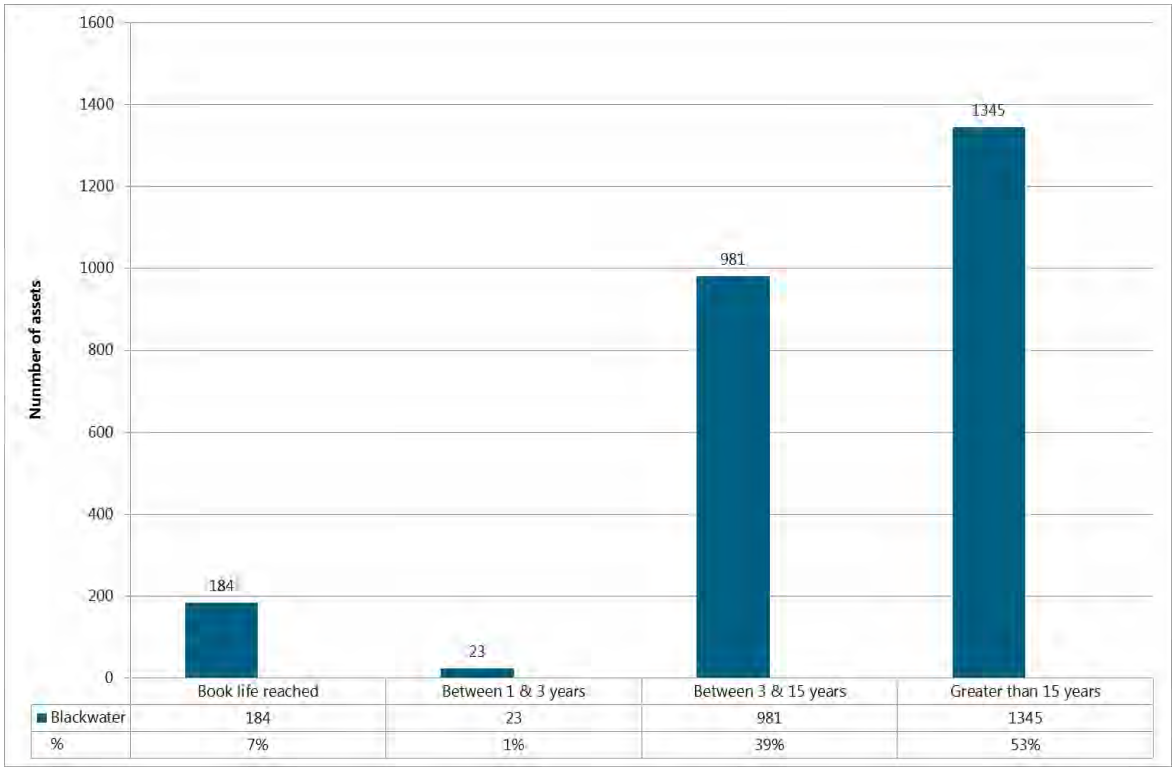


Figure 8.29: Blackwater system – bridges and culverts remaining asset book life

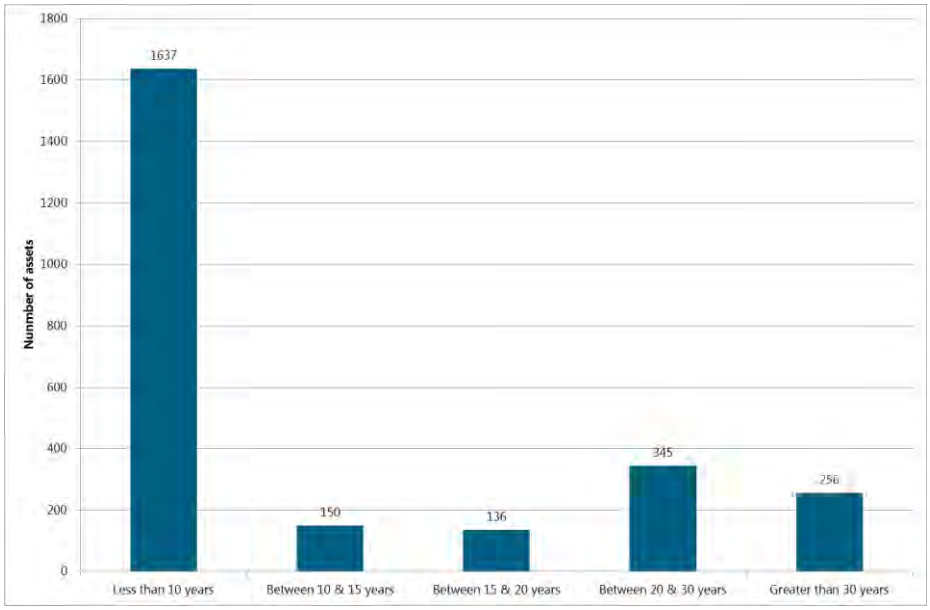


Figure 8.30: Blackwater system – bridges and culverts asset age by acquisition date

Inspections

Table 8.3 summarises the inspection work orders in the Blackwater system.

Table 8.3: Blackwater system – inspection work orders[8]

Inspection work orders	Bridges	Drains	Overall
Number of total inspections:	88	312	400
Number of late inspections:	17	193	210
% of late inspections:	19.3%	61.9%	52.5%
Average number of days late:	16.4	33.7	32.3

Delays

Table 8.4 summarises the delays due to structures in the Blackwater system.

Table 8.4: Blackwater system – permanent way delays

Permanent way delays	Delay (minutes)	Normalised delay (min/billion NTK)
Delays due to structures (bridges and culverts)	131	6

[8] The FY 2016 inspections was captured using RIMS, which had an error where inspection due dates were shown to be the 15th of each month instead of the end of the month. Aurizon Network now uses AssetAsyst which captures inspection dates correctly.

8.3.2 Site visits

The structures for the Blackwater system were generally in good condition as shown in Figure 8.31 (1.191), Figure 8.32 (93.185) and Figure 8.33 (40.600).



Figure 8.31: Rocklands Bridge (1.191)



Figure 8.32: Dawson River (93.185) overflow bridge



Figure 8.33: Grantleigh (40.600) culvert 1

The random inspection of parts of the Blackwater system identified the following issues:

- Coal fouling/corrosion
- Concrete cancer/leaching
- Propping/bracing concrete box culverts.

Coal fouling and minor corrosion was identified at the Cooling Channel Bridge shown in Figure 8.34 (2.500).

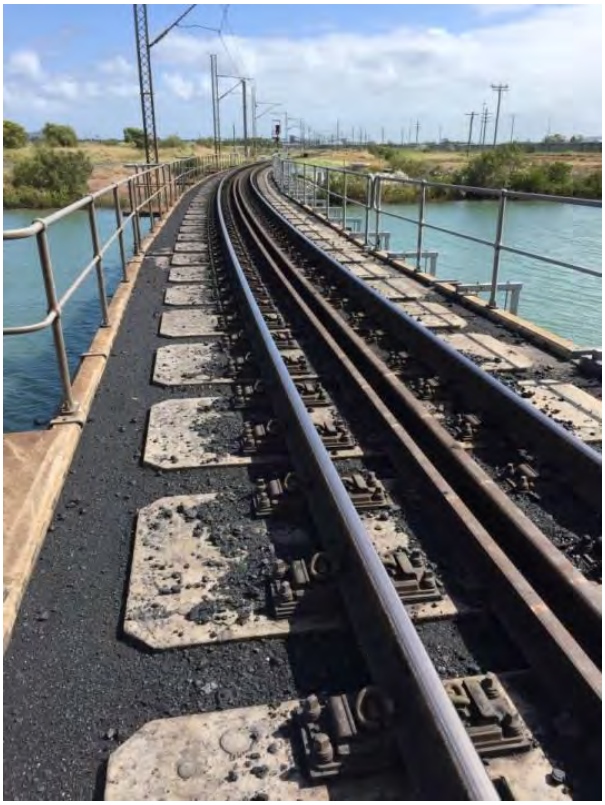


Figure 8.34: Cooling Channel Bridge (2.500)

Excess coal fouling and wet weather was found to gradually undermine the ballast substructure and consequently has created a pumping action on the Rocklands Bridge, shown in Figure 8.35 (1.191) and Figure 8.34 (2.500).



Figure 8.35: Rocklands (1.191) bridge



Figure 8.36: Dawson River (93.185) overflow bridge

Although minor, some bolts have sheared off on the guide rail as seen in Figure 8.34 (2.500) and will need to be replaced.

Concrete cancer and leaching was evident in culverts inspected as seen in the culvert in Figure 8.37 (570.366) and Figure 8.38 (47.500).



Figure 8.37: Ambrose (570.366) culvert



Figure 8.38: Westwood Yard (47.500) culvert

Retrofitting box culverts with steel bracing is shown in Figure 8.39 and Figure 8.40 (143.284). Although this works as a short term solution to maintain capacity of the culvert, other solutions should be considered.

The side effect is partial blockage of the culvert and the culvert not performing as a composite structure; however, for this case this is the most cost effective solution. This will contribute to increasing maintenance costs into the future as maintenance staff now have a confined space with restricted access to maintain.



Figure 8.39: Dingo (143.284) culvert



Figure 8.40: Dingo (143.284) culvert

Poor drainage upstream and downstream of a culvert in low lying areas, as seen in Figure 8.41 (102.108), makes it susceptible to water pooling after rain events. This allows build-up of silt and partial blockage of the culvert.



Figure 8.41: Aroona (102.108) culvert

Treatment of construction joint cracks using epoxy adhesives was evident on the Dawson River bridge piers, shown in Figure 8.42 (93.185) and on Ambrose Culvert, shown in Figure 8.43 (570.366).



Figure 8.42: Dawson River (93.185) overflow bridge



Figure 8.43: Ambrose (570.366) culvert 2

8.3.3 Leading indicators

Based on the lagging indicators the Blackwater system performed fairly well. As an ageing system with 50 to 75% of assets greater than 15 years remaining book life and high tonnages, increased maintenance will be required for all structures.

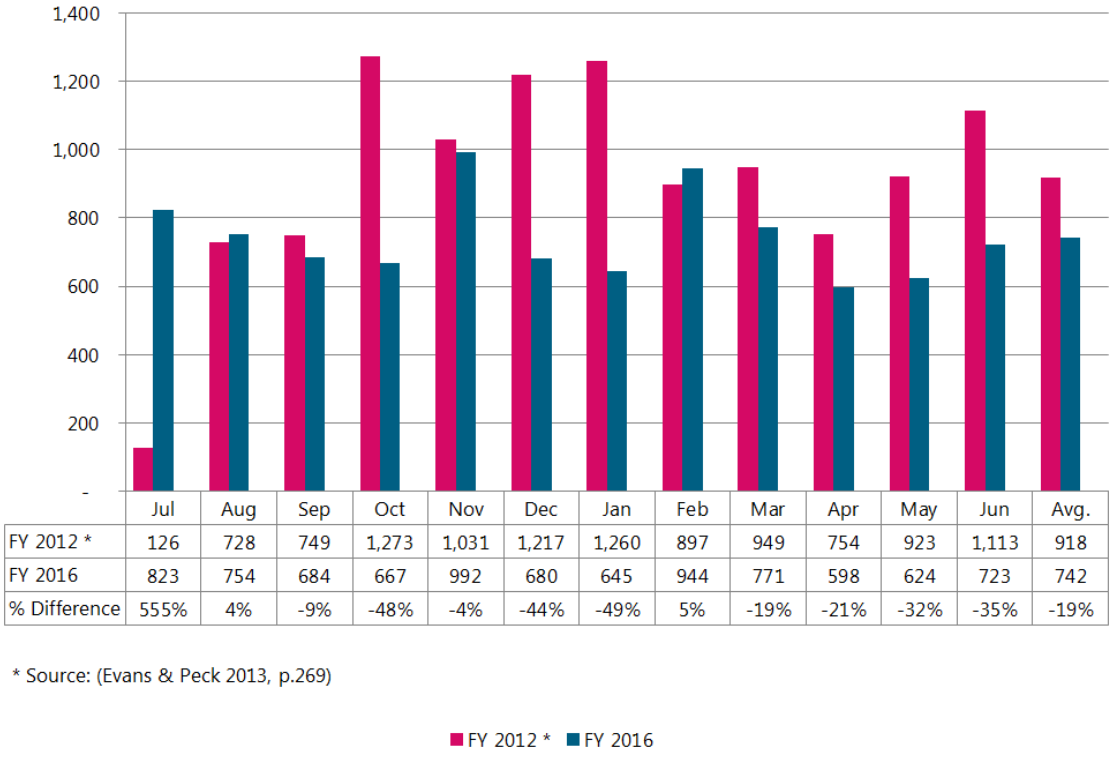
Similar to Goonyella, Aurizon Network's culvert renewal program will continue to be implemented where galvanised lined culverts will be replaced. Ongoing maintenance shall increasing however identifying new maintenance tasks continually slipped by 30 to 60 days for over half of the assets. Temporary solutions such as propping of culverts will also require ongoing maintenance to ensure integrity as well as general clearing of obstructions and vegetation.

8.4 Train control systems and telecommunications

8.4.1 Lagging indicators

Signalling faults and delays

The percentage change in number of monthly signalling faults from the FY 2012 assessment is shown in Figure 8.44.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	126	728	749	1,273	1,031	1,217	1,260	897	949	754	923	1,113	918
FY 2016	823	754	684	667	992	680	645	944	771	598	624	723	742
% Difference	555%	4%	-9%	-48%	-4%	-44%	-49%	5%	-19%	-21%	-32%	-35%	-19%

* Source: (Evans & Peck 2013, p.269)

Figure 8.44: Blackwater system – signalling faults for FY 2012 and FY 2016

The delays attributed to signalling on the Blackwater system are shown in Table 8.5.

Table 8.5: Blackwater system – signalling delays

Signalling delays	Delay (minutes)	Normalised delay (min/billion NTK)
Signalling delays	62,616	2,717

It is worth noting that there are numerous incident types causing delays within the signalling category. Breakdowns of the signalling faults and delay minutes by equipment type and element are shown in Figure 8.45 and Figure 8.46.

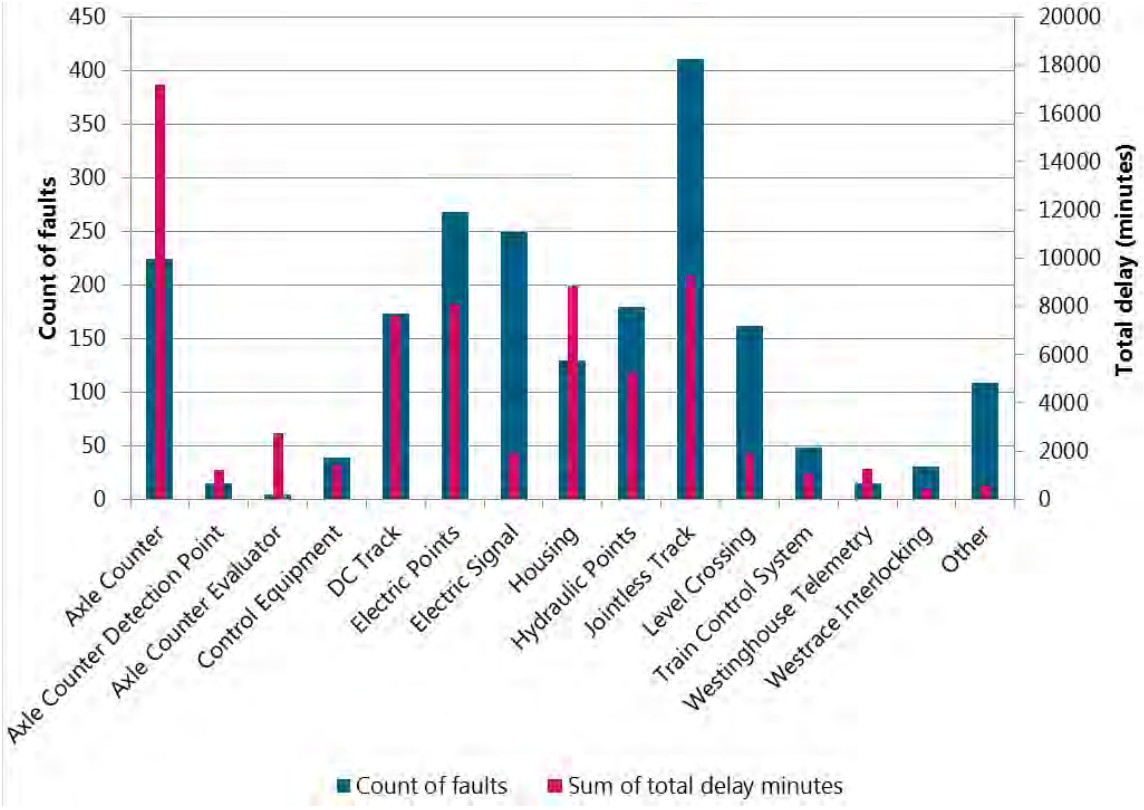


Figure 8.45: Blackwater system – signalling faults and delays by equipment type

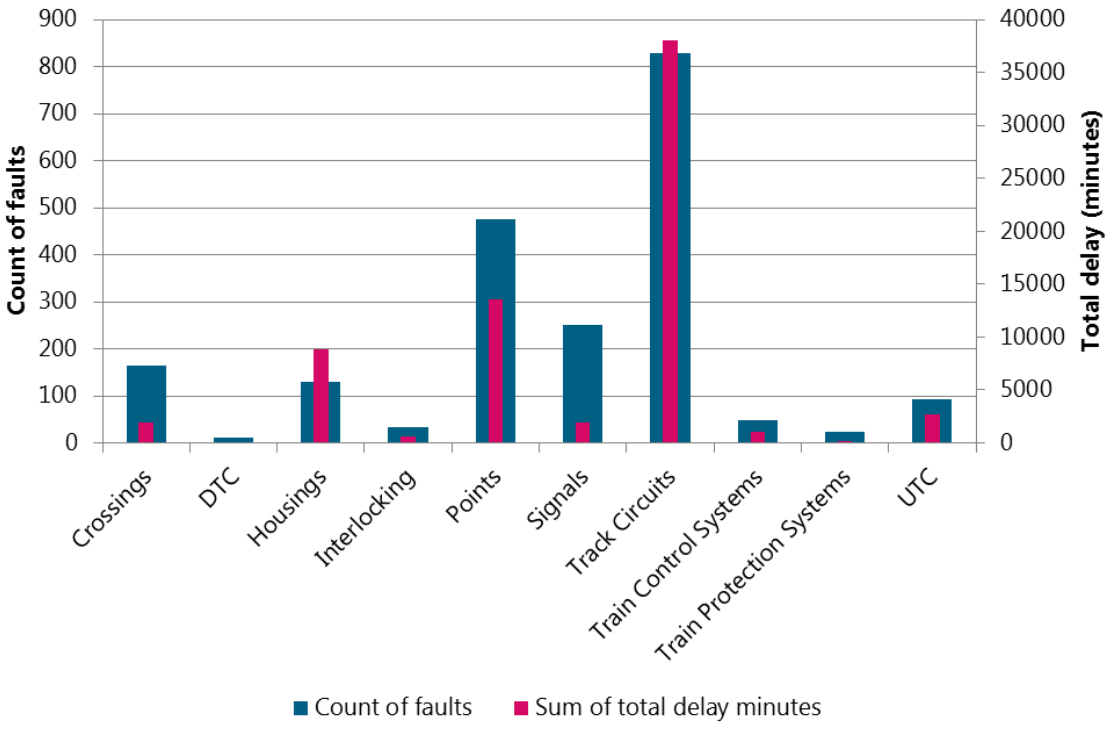
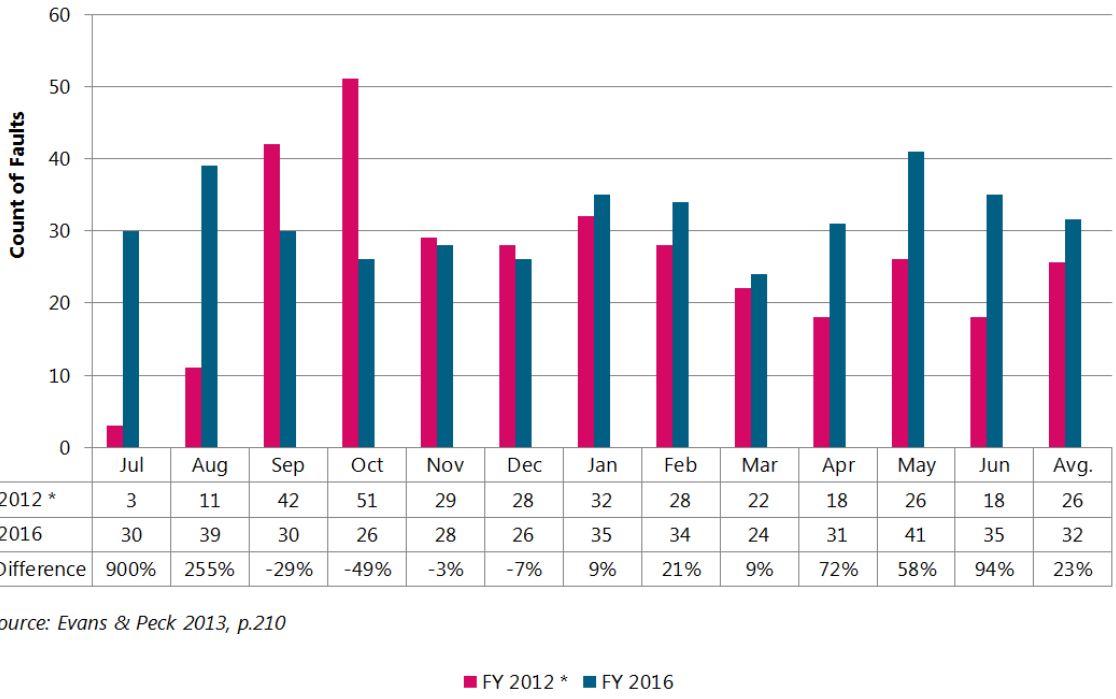


Figure 8.46: Blackwater system – signalling faults and delays by element

Telecommunications faults and delays

The Blackwater system relies on underground fibre optic wires as its primary means of communication with microwave towers providing redundancy. In some instances where there has been optical ground wire (OPGW) installed there are three levels of redundancy actively in place. As communication routes are managed by on-the-ground technicians they can change at short notice depending on requirements. In 2016 there were 120 kilometres of OPGW installed in the Blackwater system.

The percentage change in number of monthly telecommunications faults from the FY 2012 assessment is shown in Figure 8.47.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	3	11	42	51	29	28	32	28	22	18	26	18	26
FY 2016	30	39	30	26	28	26	35	34	24	31	41	35	32
% Difference	900%	255%	-29%	-49%	-3%	-7%	9%	21%	9%	72%	58%	94%	23%

** Source: Evans & Peck 2013, p.210*

Figure 8.47: Blackwater system – percentage change in telecommunications faults from 2012 assessment

The delays attributed to telecommunications on the Blackwater system are shown in Table 8.6.

Table 8.6: Blackwater system – telecommunications delays

Telecommunications delays	Delay (minutes)	Normalised delay (min/billion NTK)
Telecommunications delays	1,451	63

These are attributable to two delays. The delay of 1,436 minutes was due to a radio base failure at Gogango (February 2016) which was newly installed and failed in first 48 hours of commissioning. A refurbished base was installed to fix the fault. The delay of 15 minutes was due to UTC failure at Callemondah (no further information available).

8.4.2 Site visits

A total of 11 signalling and telecommunications sites were visited in the Blackwater system. A detailed inspection was carried out at Duaringa, with inspections of the signalling equipment room (SER), Signal DA23, Points 7A/B and track circuits 14ABT and 14BAT. Other sites visited were:

- Callemondah (Cooling Channel Bridge)
- Ambrose
- Raglan
- Rockhampton Control Centre
- Kalapa
- Grantleigh
- Dingo
- Parnabal
- Rangal to Burngrove
- Nogoa.

The first site visited in the Blackwater section was at Callemondah. This was primarily for a civil inspection of Cooling Channel Bridge, where the exit track from Gladstone Powerhouse and Clinton Balloon Loop converge to cross the power station cooling channel. This section of track acts as the exit line from the powerhouse unloader and entrance and exit from RGTCT.

Ballast in this section was completely fouled with coal dust and the axle counter heads were barely visible, although it is understood that their operation is not affected, which would be unlikely if track circuits were use in the area. Points 281A/B at the far end of the bridge was also seen to be badly contaminated and it is understood that maintenance of these points is carried out weekly to avoid failures caused by the coal dust. The situation is exacerbated by a grease applicator at the south end of the bridge, resulting in contamination being of a grease/coal dust mix, and the geometry of the curve at the south end which has a straight turnout halfway through the curve.



Figure 8.48: Callemondah fouled ballast, axle counter heads and points 281A/B

Also noted at this site was cabling with damaged protective casing and an old rail length lying on top of the leads.



Figure 8.49: Callemondah damaged track leads

During the site visit to Ambrose level crossing, the crossing was not in operation as there was a line closure for maintenance on that day. The crossing is a standard relay controlled crossing with half barriers and warning lights. The level crossing hut had suffered damage at some time, with a hole punched into the side of the hut, perhaps by a fork lift, adjacent to the test box and the end corner having been struck by a vehicle at some time.







Figure 8.50: Ambrose level crossing and damaged hut

At Raglan there is a standard relay interlocking in a concrete block building, although a new portable building has been installed nearby containing new power equipment.

A trial version of the new CSEE UM2000 track circuit receiver, now manufactured by Ansaldo, has been installed for track circuit 27BB2T. The unit is compatible with the older version CSEE track circuit equipment and has been installed in the equipment cupboard with no changes to the other external equipment. Performance is currently being monitored to assess suitability of the product.



Figure 8.51: Raglan UM2000 track circuit receiver

The network control centre is located in the main Aurizon Network office building in Rockhampton. The Rockhampton Control Centre at is based around a bespoke Queensland Rail (QR) system designed in house in the early 1990s. The system is known as Universal Train Control (UTC) in signalled territory and Direct Train Control (DTC) in dark territory. UTC/DTC provides basic screen based train and allows for through setting of routes within a control area, as well as pre-setting of conflicting routes. The Aurizon Network is covered by 15 workstations, comprising of four DTC workstations and 11 UTC workstations.

In mid-2016 Aurizon Network and GE Transportation successfully implemented GE's Movement Planner into the control centre. This provides real-time rail traffic planning and optimisation to enable freight to be moved more efficiently on the rail networks. It considers multiple factors including train schedules, traffic control systems and train movements relative to each other and then develops an optimised traffic plan for the trains throughout the network.

The control centre is backed up by a disaster recovery centre in Mackay. This was originally the control centre for the northern part of the network, before control was consolidated into the Rockhampton centre. Given the tonnages and traffic densities on the network, the remoteness of some of the locations, the length of communication links and the risk of cyclones in this part of Queensland, the retention of the disaster recovery centre is a prudent initiative.

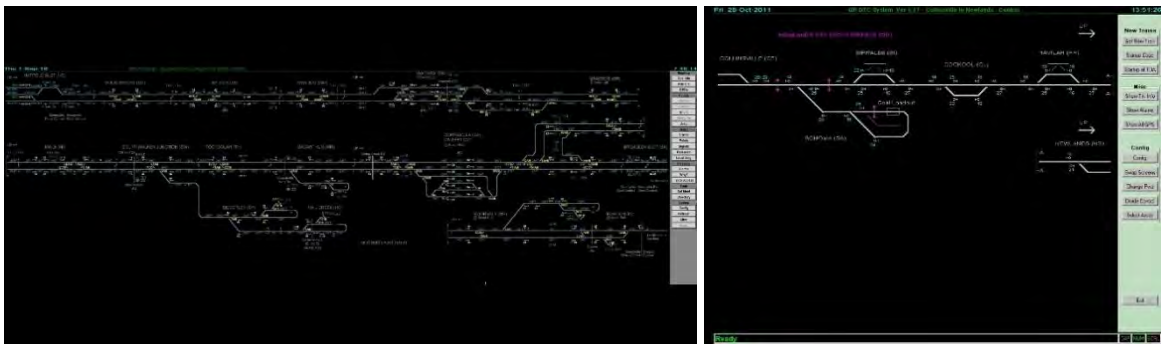


Figure 8.52: Rockhampton Control Centre screen layouts Goonyella West UTC and Newlands DTC

The control centre equipment room is on the floor below the operating floor and includes a maintenance workstation to enable fault finding and system updates.



Figure 8.53: Rockhampton Control Centre equipment room

Though not managed by the signalling and telecommunications teams, the supersite at Kalapa demonstrates Aurizon Network's commitment to providing the most up to date technology to avoid derailments and delays. The array of monitoring equipment examines vehicle profile, bogie condition, brake condition and wheel condition and also includes an in track weighbridge which is the responsibility of the telecommunications group.



Figure 8.54: Kalapa supersite array of monitoring equipment

Grantleigh is a relatively new installation with the latest style portable SER containing a Westrace computer based interlocking with relay interfaces. The SER was in excellent condition and kept very clean and tidy.



Figure 8.55: Grantleigh SER

A detailed site inspection was conducted at Duaringa, covering signal DA23, points 7A/B and track circuits 14ABT and 14BAT. Dauringa is also a recent installation comprising a Westrace interlocking in a pre-assembled portable building that was equipped and testing off site before final transportation to site, connection to pre-installed cabling and completed by correspondence and final testing.

The interlocking includes and maintenance panel to assist fault finding and system upgrades. On the outside wall of the building, is a local control panel for Edward Street level crossing, whose controls are in the SER.

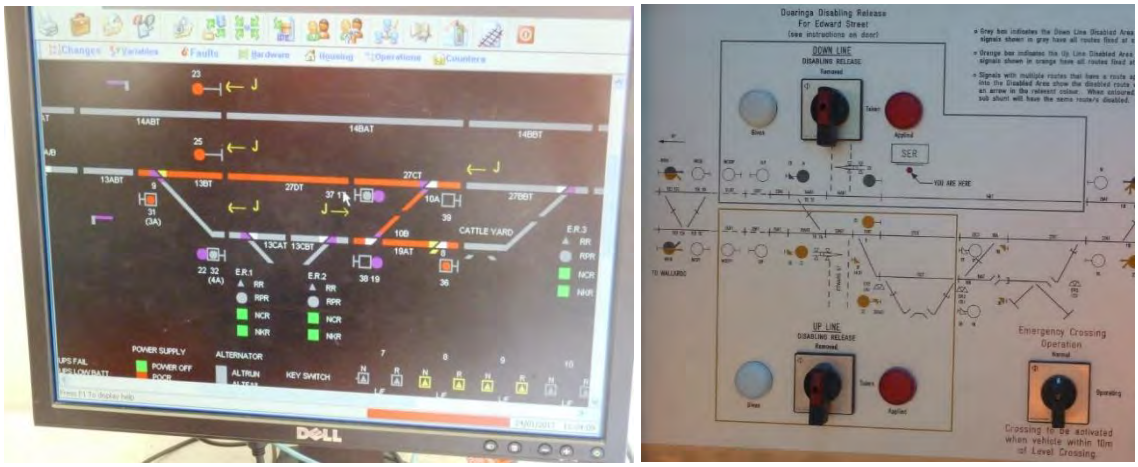


Figure 8.56: Dauringa maintenance screen and level crossing control panel

Signal DA23 is a two aspect (red/green) bi-directional signal on the down line at 104.732 km. The signal has LED lamp units which are clean and in good condition. The post is in good condition although the paint is slightly scuffed and the paint on the signal head is faded. The signal has a ladder and a partial cage which are in good condition. The tail cable is buried and is not visible.



Figure 8.57: Dauringa signal DA23

Points 7A/B lie in the up line on the Emerald side of Edward Street level crossing. The turnout is on concrete bearers and comprises the turnout switches, points 7A and the swing nose crossing, points 7B. Points 7A is operated by a Westinghouse M23 point machine with hand throw lever. The machine is a fairly old model and the paint is deteriorating, although internally it appeared clean and well maintained. Point rod and connections are in good condition, with no visible damage and point movement was smooth. Slide chair were lightly lubricated with Kluber lubricant and point roller was also fitted. The tail cable is buried and was not visible.



Figure 8.58: Dauringa turnout 7A/B, point machine 7A and points 7A switches

14ABT is an AC immune single rail DC track circuit between the glued insulated joints (GIJs) in the down line adjacent to signal DA23 and the GIJ in the down line on the Emerald side of Edward Street level crossing opposite the tips on point 7A in the up line. The feed end is in location 22/25 and the relay end is in location 7W. Tail cables are buried and were not visible, but track leads from the disconnection box to the rail are slightly frayed, but intact.

Track circuit 14BAT is a CSEE UM71stale audio frequency track circuit between the GIJs in the down line adjacent to signal DA23 and a tuned loop in the down line adjacent to shunt signal DA139 at 104.097 km. The receiver end is in location 22/25, but the transmitter end was not inspected. An impedance bond is mounted back-to-back with the receiver end tuning unit for traction continuity across the GIJs at the joints with track 14ABT. Tail cables are buried and were not visible and track leads use the traction leads from the impedance bond, which were in a fair condition and intact.



Figure 8.59: Dauringa 14ABT track circuits trackside equipment

The inspection at Dingo the focussed on Normanby Street level crossing which forms the main road between the Capricorn Highway from Rockhampton to Middlemount and Coppabella. There is a significant flow of oversize vehicles along this road, making the crossing at Dingo a prime site for OHL strikes.



Figure 8.60: Dingo level crossing large load and crossing mechanism

Over height detectors have been installed at the crossing to mitigate these occurrences. The detectors are positioned about 80 m from the crossing on the south side of the line and illuminate a large LED warning sign at the crossing if it is triggered. The crossing is also fitted with CCTV cameras to record the vehicle triggering the warning.



Figure 8.61: Dingo level crossing overheight detectors, warning sign and CCTV camera

At Parnabal we inspected one of the pivoting signals collaboratively developed with Westinghouse (now Siemens) that allow the post to be pivoted to the horizontal to permit maintenance, cleaning and change outs without the need for staff to work at height and minimising the dangers of contacting the overhead.



Figure 8.62: Parnabal pivoted signal post

Parnabal is in an area that was duplicated in recent years. The area has been equipped with Siemens axle counters throughout, including through the two crossovers, avoiding the need for GRJs and impedance bonds.



Figure 8.63: Parnabal Siemens axle counter evaluator, connection box and counter head

Between Rangal and Burngrove a stop was made primarily for the civil team to examine reported rail head wear. The track circuited lineside equipment was noted to be in a very poor state at this site. This is the location of the tuned loop between two CSEE UM71 track circuits, 23AT and 23B1T. The tuning units and the mid loop coil were seen to be missing their covers and it appeared as if the tuning units had been burned at some stage. It is to be assumed that the units are still operational as the track leads seems to have been replaced.



Figure 8.64: Rangal to Burngrove Burned CSEE UM71 Trackside Equipment with Missing Covers

A short stop at Nogoa, the junction with the Springsure Branch, enabled a visual inspection of signalling equipment. The points at the Springsure Branch junction, points No. 8, were inspected and are in generally good condition. The turnout is fitted with a Westinghouse M23 machine with hand throw lever. When the points were operated, they moved smoothly. Also noted in the area was a damaged CSEE tuning unit cover and a number of track circuit leads in average condition.



Figure 8.65: Nogoa Points No. 8, Damaged Tuning Unit Cover and Squashed Track Lead

8.4.3 Leading indicators

Signalling delay minutes have decreased since FY 2012 from 129,305 to 62,616 minutes in FY 2016. This decrease of 53% in overall delay minutes corresponds to a 19% decrease in the number of signalling faults.

FY 2016 track circuit faults caused more than half of all signalling delays (55%) with FY 2012 circuit faults representing 37% of all signalling delays. Similar to Goonyella system, the percentage of delays attributed to track circuits has increased, however the delay minutes have decreased from 48,060 to 38,054.

Delays due to point faults were the second largest contributor to signalling delays. After equipment failure, the main reasons for point failure were obstructions, lubrication and adjustment issues. Despite the simple nature of these failure types, their performance is still an improvement on FY 2012 results with delay minutes decreasing by 11,980 minutes.

Telecommunications delays increased since FY 2012 from 824 minutes to 1,451 minutes in FY 2016. In FY 2016 one single delay of 1,436 minutes was attributed to a radio base failure which had been installed less than 48 hours prior. Aside from this single delay, telecommunications in the system are performing well and there are no other anticipated maintenance issues.

8.5 Traction distribution and power supply systems

8.5.1 Lagging indicators

Autotransformer oil analysis exceptions

Many of the Blackwater autotransformers are relatively new due to the track upgrade program that was running near the time of the last assessment. In addition to this Aurizon Network was renewing older units which were displaying corona induced gassing.

In the FY 2012 assessment 15% of the autotransformers were found to have exceptions. This was 14 out of 96 autotransformers that were in the system at that time. Since this time the number of autotransformers has increased to 130 due to track duplications.

As was the case for Goonyella, all the autotransformers had oil samples analysed in November 2016. Out of the 130 results, 19 were highlighted as unsatisfactory by Aurizon Network. This would represent 15%, however after review by Advisian using the acceptance criteria from the FY 2012 assessment with a small compensation applied relative to normal aging, the number with serious problems was reduced to 7 which represents only 5%. There were some units, whilst showing some indications of developing problems, strictly speaking under the FY 2012 criteria would be considered satisfactory. Therefore in reality we believe there has been a substantial improvement in the autotransformer condition in Blackwater based on what Advisian considers to be valid acceptance criteria. Nevertheless, Aurizon Network now appears to be applying more stringent standards.

Similar to Goonyella, the main issue is hydrogen and methane gassing. The gas ratios suggest that corona discharge is the source of the problems. Overheating is indicated in three of the units. Only one autotransformer showed high moisture content and a low breakdown voltage.

Feeder transformer oil analysis exceptions

The Blackwater system now has 25 feeder transformers. This has been expanded from 13 in the FY 2012 assessment due to the track duplication program. These all had oil analysis conducted in November 2016. There were no exceptions highlighted by Aurizon Network and the Advisian review also agrees there are no exceptions. Almost half the transformers are relatively new and it is apparent that the original units are being well maintained by Aurizon Network. In FY 2012 there were two transformers at Rangal (T15 and T17) that were showing voltage breakdown exceptions. The moisture content was also found to be over the limit. There are no issues with these transformers at present. The breakdown voltages in exceeds 70 kV and the moisture content of the oil is 5 ppm in both cases.

Contact wire wear

Aurizon Network has conducted surveys of the overhead contact wire wear at 80 locations throughout the Blackwater system during 2013 to 2016. The analysis of this data shows that the average wear was only 0.9 mm, as shown in Figure 8.66.

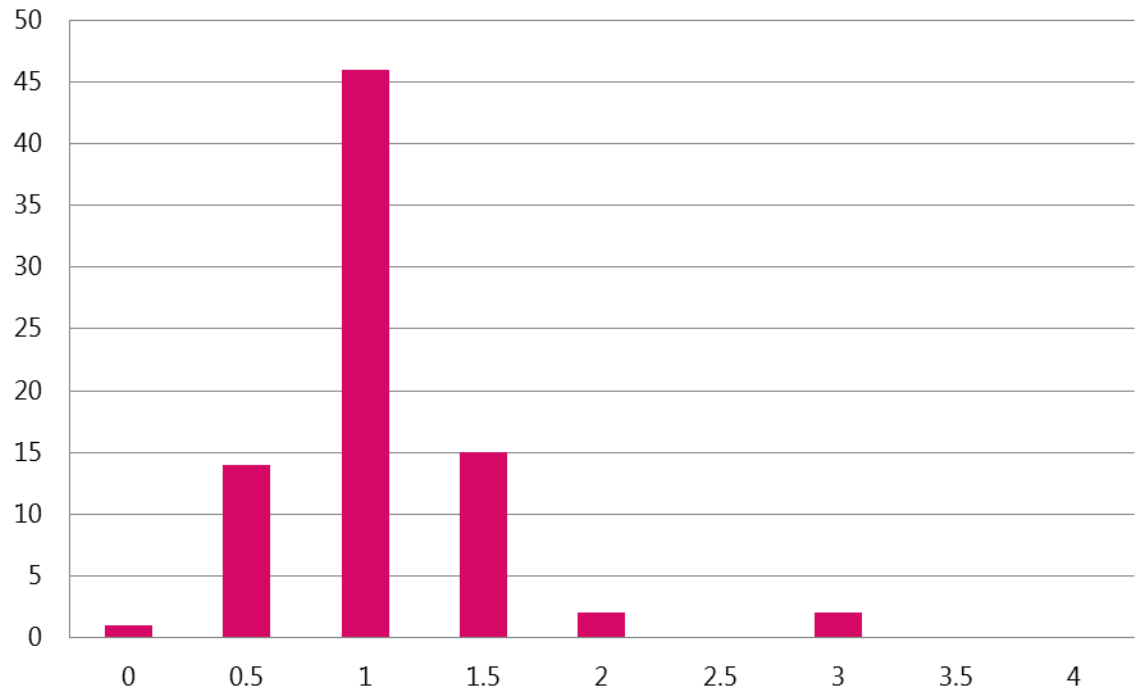


Figure 8.66: Blackwater system – contact wire wear

The wear limit that gives a 33% (35 mm^2) area reduction is 4.06 mm. When measured, this translates to a contact wire height of 8.28 mm as illustrated in Figure 8.67 (the original conductor is 12.34 mm in diameter).

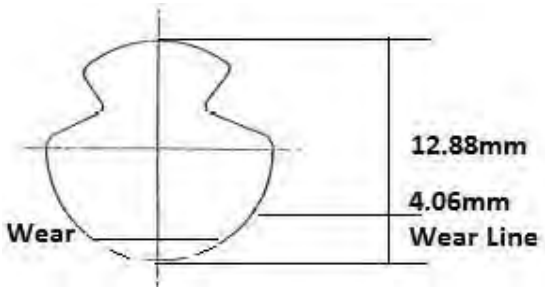


Figure 8.67: Blackwater system – contact wire cross section

Therefore in reality, the actual wear on average is much less than what has been projected by Aurizon Network. Some of this contact wire will have been replaced due to dewirements over the years, which will explain its good condition. Nevertheless, the remaining lifetime, based on just the average wear, could be considered to be at least another 60 years.

There are no areas in Blackwater that are showing wear near the limit of 4.06 mm. The most severe wear appears to be in the Raglan-Marmor area with a value of 2.7 mm.

Delays

Delays attributed to overhead line (OHL) and power supply are shown in Table 8.7.

Table 8.7: Blackwater system – OHL and power supply delay

OHL and power supply	Delay (minutes)	Normalised delay (min/billion NTK)
Damage/Failure/Malfunction of OHL equipment	4,273	185
Power supply – trips (overcurrent)	1,770	77

The total annual delay minutes attributed to the overhead contract system in FY 2016 for Blackwater was 4,273 minutes. Once normalised to the 20.1 billion NTK handled by Blackwater in FY 2016 it becomes 213 min/billion NTK.

The monthly delay minutes are shown in Figure 8.68.

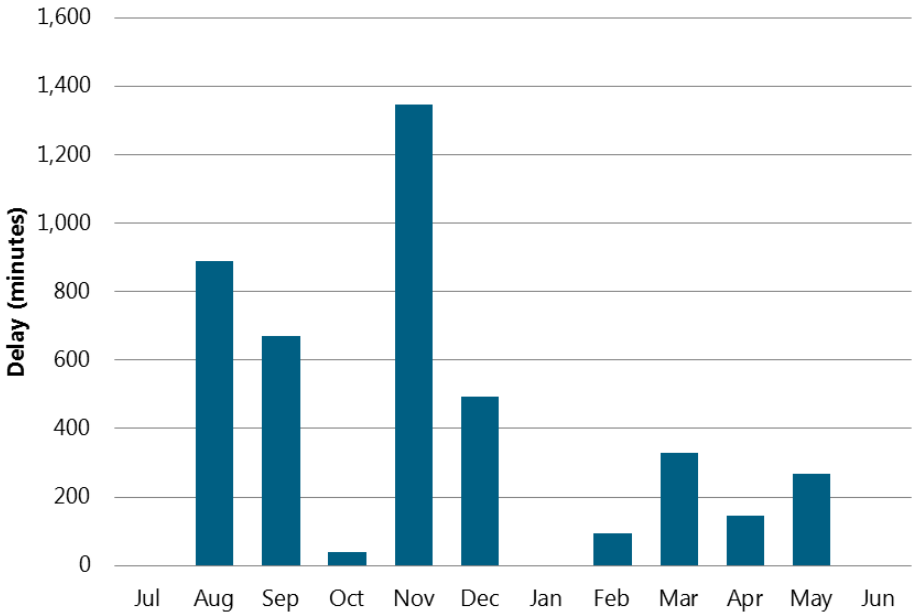


Figure 8.68: Blackwater system – delay minutes due to the overhead contact system

For the Blackwater overhead contact system, as illustrated in Figure 8.69 the system loss focus in terms of downtime hours has been on track sectioning.

In the previous assessment for FY 2012 the normalised delay for Blackwater was 3,607 min/billion NTK. Therefore, there has been a significant improvement.

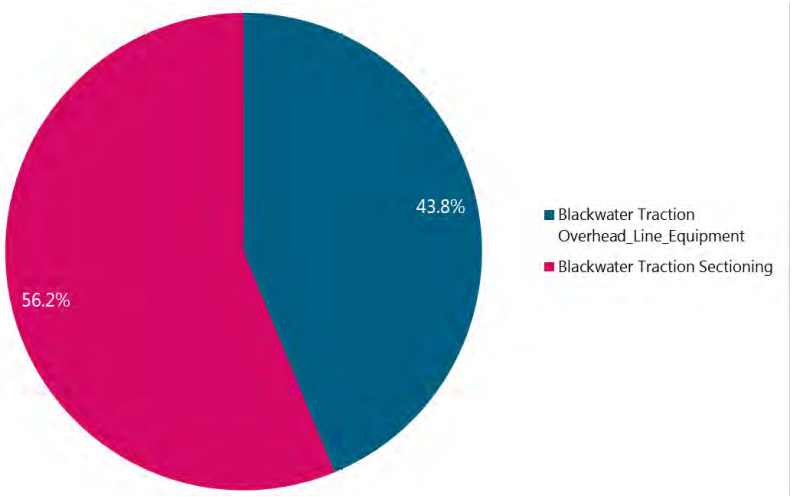


Figure 8.69: Blackwater system – maintenance focus

Dewirements

Dewirements for the Blackwater system in FY 2016 are shown in Table 8.8.

Table 8.8: Blackwater system – dewirement records

Date	Location	Description	Details
13/11/2015 3:41	Callemondah - Mt. Miller	Overhead trip	EF42 and EK15 reported double trip on up and down roads.
19/04/2016 16:16	Umolo - Parnabal	Overhead trip	EF24 reported trip.

Figure 8.70 shows that dewirements for the Blackwater system has been generally decreasing in recent years.

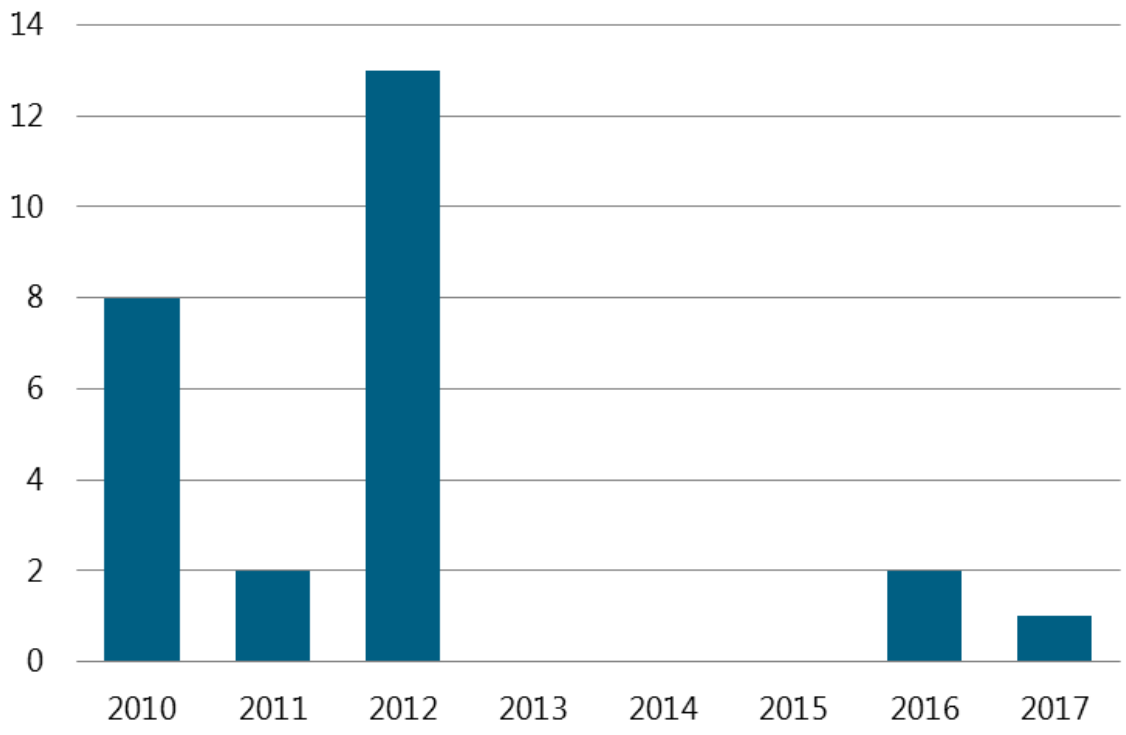


Figure 8.70: Blackwater system – count of overhead dewirements

8.5.2 Site visits

Over the period Monday 23/2/2017 to Wednesday 25/02/2017, Advisian comprehensively inspected Aurizon Network's traction power (TP) and OHL distribution network in the Blackwater rail corridor from Callemondah yard through to German Creek track sectioning cabin (TSC). Advisian was accompanied by the power section supervisor and the district traction engineer responsible for that area.

During the site visits the agenda for the locations inspected was set by Advisian with constraints on what was inspected only set by the time available for inspection, the time required to travel to inspect certain sites and electrical and rail safety issues. Access was readily provided to all areas requested. The attending senior Aurizon Network staff had the necessary keys, access permits and knowledge to answer all questions. This allowed for an open and honest appraisal of the electrical asset.

Inspections were conducted using four check sheets which covered: feeder stations, TSCs and track condition units (TCUs), autotransformer sites and OHL sections. The site inspection sampling was as follows:

- 9 of the 11 feeder station sites (82%)
- 8 of the 13 TSC/TCU sites (62%)
- 8 of the approximate 29 autotransformer sites (28%)
- 4 randomly selected OHL sections.

The feeder stations not visited in the Blackwater system were Struan Road FS and Dingo FS, due to time constraints. Struan Road is located at 50 km along the Rolleston branch line which represented a prohibitive travel time by road (two hour round trip) relative to the schedule. Also the Rolleston FS assets are relatively new. The Struan Road FS uses static frequency converters (SFCs). This is new technology that uses power electronic converters rather than a 132/50 kV transformer. They have the advantage of not requiring a static var compensator to allow connection the 132 kV network.

There were several common issues identified throughout the feeder station sites, including:

- Fire extinguisher inspections are out of date. Fire detection equipment where fitted is not connected to fire suppression systems and experiences spurious alarms
- Some autotransformer silica gel dryers were approaching replacement or were contaminated by oil. Silica gel free dryers are being trialled at a number of sites but these have not gained favour
- At some locations signage is starting to fade
- Fencing is generally in good condition, however there is an issue at Callemondah
- At most feeder stations the emergency exit lights are not working
- Corrosion is evident on battery terminals. This appears to be difficult to clean off when the batteries are located within the building. Terminals should be coated with a battery terminal protector product
- Vegetation control and removal of dead vegetation from feeder station surfaces is improving but an ongoing struggle.



Figure 8.71: Comparison old and new feeder station circuit breaker layout

The new feeder stations in the Blackwater system are: Raglan FS, Wycarbah FS, Duaringa FS and Bluff FS. These are in very good condition with only minor issues identified.

The Duaringa feeder station has both harmonic filters cut out due to the failure of the large filter inductor. However, Aurizon Network is only operating AC traction locomotives in this area which have low harmonic current draw. The requirement for filtering is greatly reduced or possibly eliminated. Aurizon Network currently has a study running to reassess the necessity for the harmonic filters in Blackwater due to the change in rollingstock technology that is now operating. Whilst cut out filters would historically have been a large issue, due to the changed operating conditions Advisian is not concerned about this condition.



Figure 8.72: Damaged section cut out of large filter inductor, Duaringa feeder station



Figure 8.73: Harmonic filter at Duaringa feeder station

The auxiliary supply backup isolation transformer and power conditioners were either disconnected or due for disconnection due to an overheating and fire risk. This was worse in Blackwater than Goonyella due to the larger number of new feeder stations and TSCs in Blackwater.



Figure 8.74: Disconnected auxiliary power equipment Raglan feeder station

The new feeder station cable pits, where the XLPE underground cables come up under the feeder station buildings, more often than not contain water. This is due mainly to defective pumps or the pumps not being controlled adequately.



Figure 8.75: Water in cable pit under main building at Duaringa feeder station

The older feeder stations built in the mid-1980s have poor ground surface. This is an issue of electrical safety. The design and maintenance of the surface condition is to ensure the lowest risk of step or touch potential to staff working within the feeder station compounds. At most sites the surface is a combination of stone, decomposed granite, coal dust and dying or dead vegetation. At some sites to overcome this issue at the bottom of isolation switches a grounded earth mat on the top of the stone has been installed. The approach to electrical safety due to surface condition should be consistent across the feeder stations. Having said this, although poor in some areas, vegetation control in the older feeder stations is significantly better in the Blackwater system compared to the FY 2012 audit. The poisoned biomass, although mainly dead, still remains a risk when forming part of the ground surface.



Figure 8.76: Surface condition inside electrical compound, Rangal feeder station



Figure 8.77: Poor surface condition in front of autotransformers at Callemondah feeder station

Other issues with older feeder stations include:

- The battery terminal conditions are poor
- There is rusted guttering which in some cases is falling off
- External lighting is not working in some locations
- There is broken or badly fitting concrete cable duct covers
- Some auto isolators are cut out pending review
- The emergency exit lighting rarely works
- At Callemondah FS the fence is in poor condition.

TSCs and TCUs suffer from similar issues to the feeder stations with the more remote TSCs being in the poorest condition.

In the Blackwater system, Burngrove TCU appears neglected however work is scheduled to reconfigure the autotransformer connections and improve the site. The OHL that this TCU supported from Burngrove to Emerald will remain permanently disconnected and this section was not inspected during this condition audit.

At Red Rock the following maintenance requirements were identified:

- Signage is faded
- Vegetation control needed
- Lighting not working
- Battery corrosion evident
- Building in poor condition
- Surge arrestor blow out devices missing
- Current transformers appear to be tracking across the surface.



Figure 8.78: Red Rock TSC surface condition inside electrical compound



Figure 8.79: Red Rock TSC surface condition inside electrical compound

At Yan Yan some temporary wiring to battery charger which is not likely to be compliant with the AS 3000 wiring rules.

The autotransformer sites pose little risk to train operations. Most autotransformer sites are now able to be disconnected from the OHL if faulty; it appears that only a few sites remain to have isolators installed. Again the new sites are in good condition with installed bunding and the control building outside the transformer enclosure. Some older remote autotransformer sites suffer from similar issues as the feeder stations and TSC with:

- Poor vegetation control
- Corroded battery terminals
- Faded signage
- Minor oil leaks
- An additional environmental issue at the older sites is the lack of transformer bunding.

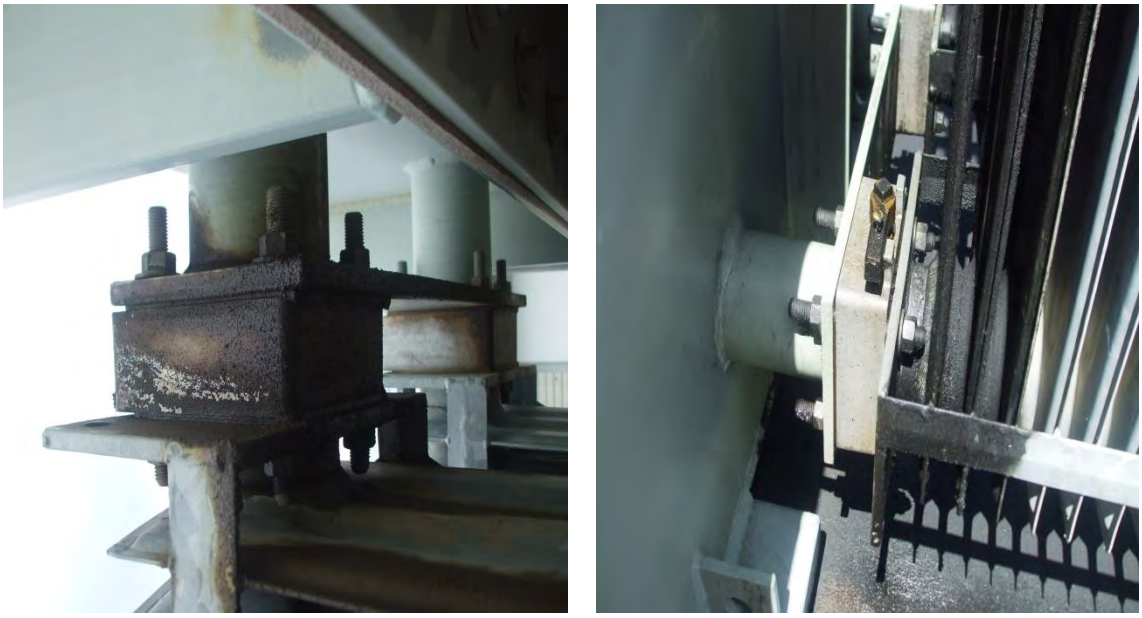


Figure 8.80: Typical of minor autotransformer oil leaks at Tx to heat exchanger butterfly valve interface

In general the new TSCs and the track sectioning yard at Kinrola are in very good condition and the older TSCs do not pose any risk to train operations but do need some general maintenance.



Figure 8.81: New track sectioning layout at Kinrola

There has been a big effort in recent times to ensure the autotransformers are in a satisfactory condition by changing out any that show poor electrical or dissolved gas results. Other than some units with dark transformer oil and some contaminated or end of life silica gel the autotransformers physical appearance and maximum operating temperature parameters were reasonable.

The overhead contact wire is in good condition and where issues were identified either these are known or plans are in place to address them. The occupational crossing height gauges at many locations were checked against the specification and found to be satisfactory. The occupational crossing height gauges were checked at a number of locations against the specification, the only height gauge not conforming to the specification was the crossing at Yan Yan which was low. This crossing is likely only used by railway personnel as it is clear that the property it was meant to service has not been accessed by this crossing for a very long time.

The following OHL items were inspected at each site and were found to be in good condition:

- Masts
- Droppers
- Drapes
- Insulators
- Connections and suspension clamps
- Wind stays
- Contact wire
- Catenary wire
- Feeder and earth wires
- Hinged fittings
- Steady arms and steady arm to registration tube connection
- Mid-point anchors
- Stagger.

There were minor OHL issues with the following:

- Arrestor blow out devices missing (plastic plug)
- Section insulators having some contamination
- Bird nests in masts
- Surface corrosion of cantilever assembly (upper arm, strut and registration tube)
- Disconnected motorised isolators
- Some neutral sections had minor arcing on the arc tips or contamination on the insulator (all earth connections to the central neutral section earthed point were in good condition).



Figure 8.82: Bird nest in unmodified mast near supersite

The issue of surface corrosion of the cantilever assembly occurs mainly along the coast at Callemondah yard to Raglan.

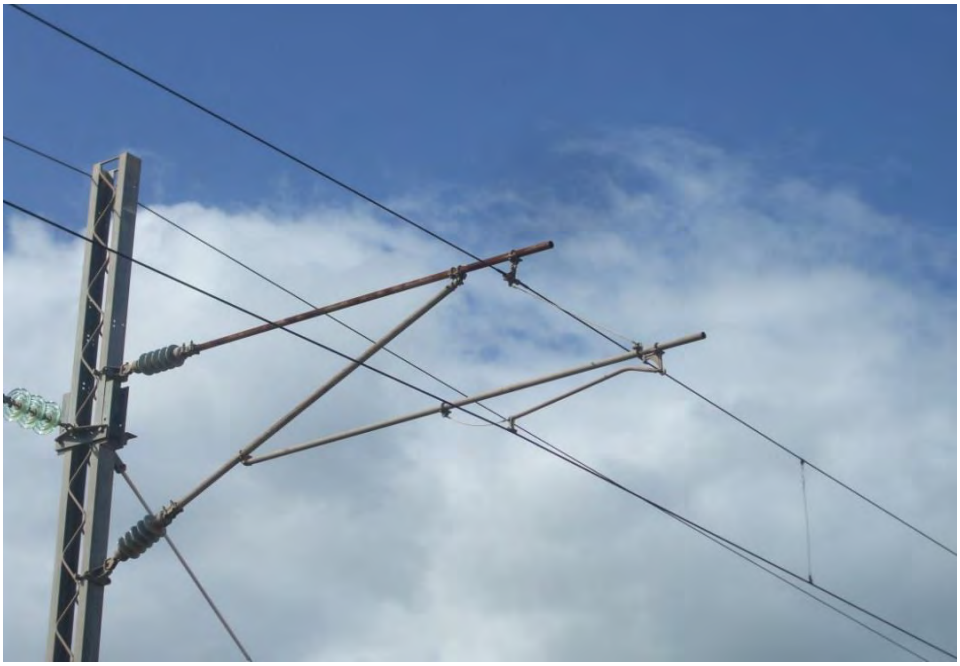


Figure 8.83: Typical surface corrosion on upper arm leaving Callemondah yard

The bird nest issue is being addressed through mast modification, with a substantial number of the masts now modified. In general this modification has been a great success however there are some modified masts with bird nests.



Figure 8.84: Bird nest in mast with modification

In the Blackwater system, the along track movement appears to be in need of attention and in some cases will need resetting.

The requirement for the full complement of motorised isolators is currently under review and a number will likely be withdrawn from service.

Currently there is significant redundancy with the power supply network and most issues can be addressed by switching to bypass faulty components. This has enabled a high level of reliability. Some of the older feeder stations are showing the signs of their age Aurizon Network is currently investigating shutting down some of the older feeder stations. In Blackwater these will be Dingo FS and Rocklands FS. The Rocklands supply may be substituted by Wycarbah FS and Raglan FS feeding through Kabra and Bajool TSCs respectively. The Dingo supply may be substituted by Bluff FS and Duaringa FS feeding through Umolo and Wallaroo TSCs. They have become redundant due to the introduction of AC traction which does not suffer from the same voltage drop issues that the DC traction technology produced. As a consequence, the investment in maintaining some of the older feeder stations is being considered.

The OHL is well maintained and observations during the site visit reveals that the electrical network is in reasonable condition and is an improvement over the FY 2012 assessment.

8.5.3 Leading indicators

Scheduled and unscheduled electrical system work orders

The scheduled and unscheduled work orders have been analysed based on the allocated downtime. This gives a comparative indication of the effort being put into scheduled preventative maintenance as opposed to unscheduled failures. The graph shown in Figure 8.85 covers the downtime for both traction power and the overhead contact system in Blackwater. It can be seen that the scheduled downtime was 285 hours compared with only 14 hours of unscheduled downtime which covers responding to corrective faults. Most downtime has been associated with scheduled work on sectioning which includes track switches, neutral sections and section insulators. This effort appears to have been beneficial since there has been minimal unscheduled downtime for sectioning. Also, there has been 17 hours invested in scheduled preventative maintenance on transformers for which there has been no unscheduled downtime recorded.

As shown in Figure 8.85 most of the unscheduled corrective downtime has occurred due to OHL equipment. This category has a greater exposure to environmental factors which are out of Aurizon Network's control (e.g. birds, snakes, lightning strikes, etc.), and issues resulting from the rollingstock interface.

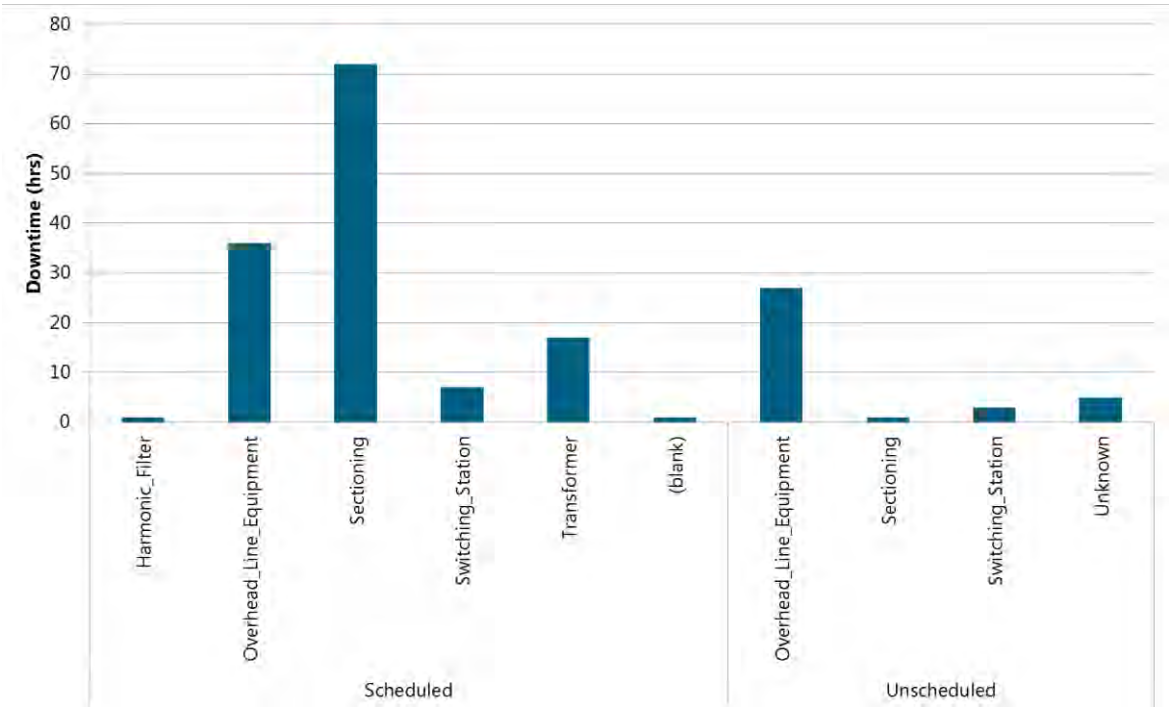


Figure 8.85: Blackwater system – scheduled and unscheduled downtime by equipment

Figure 8.86 shows a further breakup of the total work order downtime showing the equipment where the effort is being directed. The three dominate equipment areas are autotransformers, overhead exceptions and section insulators. There remains a significant number of older autotransformers which Aurizon Network is gradually dealing with based on condition. Given this appears to be almost completely scheduled work this appears to be a successful strategy. Aurizon Network has been focusing on renewal of suspect section insulators due to a significant failure that occurred in FY16 at Jilalan. A new improved section insulator is being deployed where required on a scheduled basis.

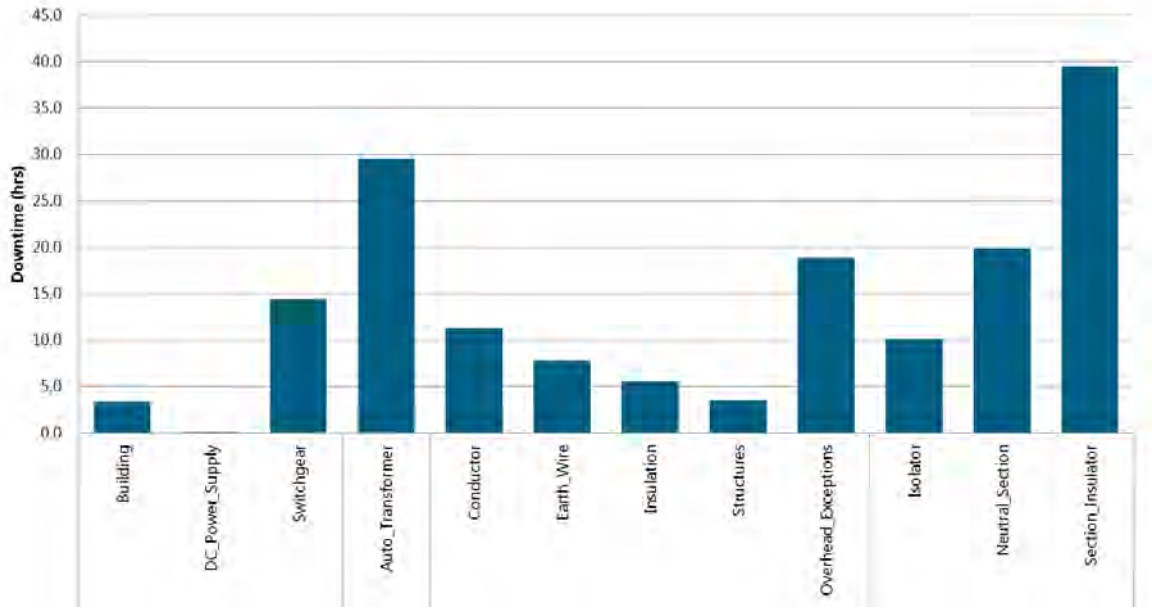


Figure 8.86: Blackwater system – total downtime by equipment

The overhead exceptions category is an output from the track recording car (TRC) data. Responding to these exceptions has been a significant activity for Blackwater. The main relevant information the TRC provides is the contact wire stagger. Stagger which is out of bounds can result in the wire running off the pantograph and catching as it returns. The wire is subsequently pulled down as the droppers are knocked off, resulting in a dewirement. Given dewirement levels are improving and are low for Blackwater in FY 2016, this demonstrates that Aurizon Network's response to this issue is satisfactory. Towards the future, the favourable ratio of scheduled to unscheduled downtime indicates that the good results being achieved will likely continue.

Autotransformer refurbishment replacement policy – preventative maintenance

The original Tyree autotransformers have historically suffered from partial discharge problems. It is thought this may be due to a design issue. Aurizon Network has in the past refurbished the autotransformers based on condition indicated by the dissolved gas in oil levels. However, the current refurbishment scope does not address the original design problem. Therefore, after refurbishment the partial discharge problem persists. It is not feasible to refurbish the autotransformers for a second time.

The Aurizon Network autotransformer asset policy states that the minimum design life of an autotransformer is 25 years. Figure 8.87 shows the age analysis for Blackwater autotransformers. There are essentially two groups of autotransformers: original units purchased in 1985 and those purchased from 2000 through to 2012. There are 80 units that fit into the latter category. This leaves 90 older units. However, as only 130 units in service, only 50 out of the 80 are actually deployed. There will be 30 old units which are either condemned or spares. These 50 would have already had one refurbishment and therefore will require replacement over the next five years. The transformer oil analysis results indicate that 7 will require replacement in the next 12 months. Aurizon Network is identifying the units that require replacement based on condition, using oil testing and analysis. The Aurizon Network policy states that autotransformers greater than 15 years in age shall have more frequent scheduled maintenance. However, the oil sampling interval is maintained at 12 months.

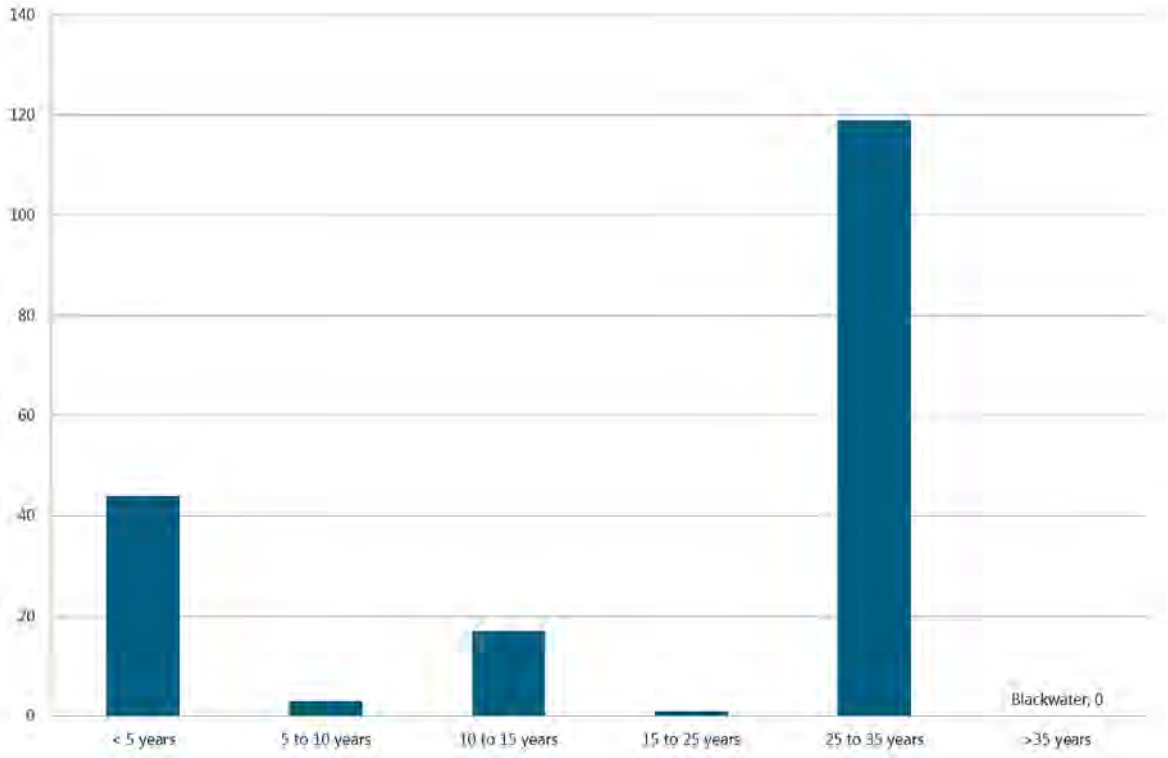


Figure 8.87: Blackwater system – autotransformer age by acquisition date

Aurizon Network has shown it is managing the autotransformer aging. In the last assessment, there were 120 units that required refurbishment before FY 2017. This task appears to have been largely completed. Going forward the program will be renewal based on condition. Advisian is confident that going forward Aurizon Network is managing the autotransformer aging in a satisfactory manner.

Table 8.9 shows a summary of the current autotransformer condition status.

Table 8.9: Blackwater system – autotransformer condition status

Total Number in FAR	Installed Number	Age <15 years	Age >25 year in service	Condemned or Spares	Number to be replaced in next 5 years	Number requiring Replacement in next 12 months
170	130	80	50	30	50	7

Traction distribution faults

Aurizon Network has conducted analysis of the electrical system faults in Blackwater from calendar year 2011 to 2015, from Aurizon Network's Yearly Fault Report 2015. The previous assessment indicated there were 639 faults in FY 2012. This only included faults associated with feeder station protection operations. This is consistent with the electrical section faults in Aurizon Network's report. For Blackwater there has been a slight decline in the electrical section faults from 2011 through to 2015. The feeder station faults have however been significantly increasing. The faults associated with feeder stations are attributed to equipment failure within the feeder station rather than the electrical sections. Further review of the Aurizon Network data suggests that the sharp increase is mostly due to faults at the new Struan Road feeder station that uses static frequency converters. Struan Road which was commissioned in late 2014 had 40 faults in calendar year 2015. This is almost three times that of the other highest failure rate at Wycarbah which is also a new feeder station. Our understanding is that the Wycarbah faults have been the result of harmonic filter issues. The Struan Road SFC is a more complex technology compared to the conventional feeder station. Being a power electronic converter, it has many protective features which may be activated leading to a fault. These protective functions may come into play due a number of reasons including; 132 kV grid instabilities and railway system integration issues generating control instability. These interactions are very complex and take time to resolve. Advisian's expectation is that as the control system settings and algorithms are refined these faults will diminish.

Whilst there have been significant faults associated with harmonic filters in the Blackwater system, Aurizon Network is currently evaluating a plan to switch these off. This is potentially viable due to the exclusive use of AC traction locomotives in Blackwater. The harmonic current emissions from the AC traction locomotives are almost insignificant compared to the DC traction locomotives. Removing this equipment from the system will reduce the faults and maintenance and also reduce the energy loss.

Aurizon Network has examined the annual electrical section faults and normalised them to the electrified track kilometres for each system. For Blackwater where there is approximately 1000 km of electrified track, the normalised electrical section faults are consistently near 0.67. This represents 600 to 700 faults per annum. This is consistent with the previous FY 2012 assessment where it was found that there were 639 electrical section faults. The majority of these were attributed to environmental influences such as wildlife or storms. Because environmental influences dominate these electrical section faults, and the fact that the track kilometres has expanded over the period due to the electrification of the Rolleston branch line and network track duplications, the normalised value does not significantly change. The consistent value is a good leading indicator that the condition of the overhead system will not be deteriorating in the medium term to an extent that it is having a tangible effect on the normalised fault numbers. In absolute terms the normalised electrical section fault figure is consistent with a well operated and maintained system. The typical recognised benchmark figure is one fault per annum per track kilometre for electrified railways. For Blackwater, Aurizon Network is well below this figure.

The stable electrical section normalised fault levels are being achieved due to good maintenance practice where the preventative maintenance effort is substantially exceeding the corrective maintenance and corrective faults. This maintenance regime demonstrates that it is likely that Aurizon Network will maintain the system reliability into the medium term.

Also of importance is that Aurizon Network is now analysing the data and presenting it in a useful format. This is a distinct improvement over what was seen in the FY 2012 assessment.

Advisian has analysed the electrical section faults based on distance protection and Delta I protection operations. These will account for the vast majority of short circuit faults attributed to the electrical sections. This was done for the FY 2016 period. There were 619 electrical section faults in the period with a high number in March 2016. The majority of these were associated with trips at Rangal feeder station. It is possible this anomaly is also associated with the high fault rate on the Struan Road Feeder Station and the necessity to feed from Rangal via the Kinrola track sectioning yard when the SFC fails. This is a long feed and could be prone to false tripping when trains are at the end of the line.

The 619 electrical section faults will still translate to a normalised figure of 0.62 faults per annum per track kilometre which is consistent with the historical levels and is a good result in terms of typical benchmark.

These leading indicators show that in the medium term the frequency of faults in Blackwater will be maintained or possibly reduced due to the high level of preventative maintenance that is being executed.

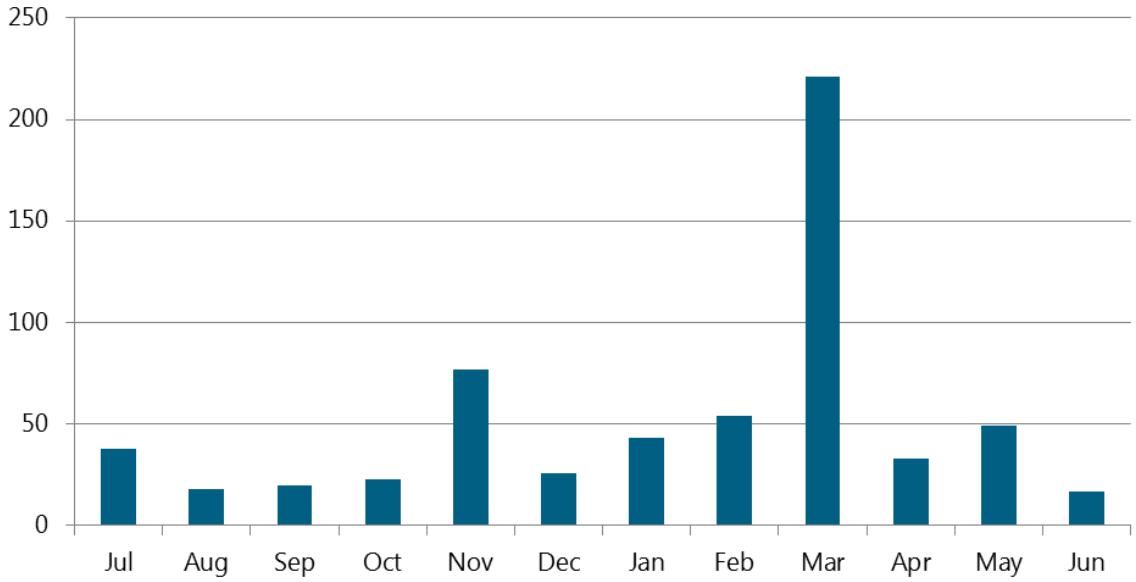


Figure 8.88: Blackwater system – number of feeder station trips by month

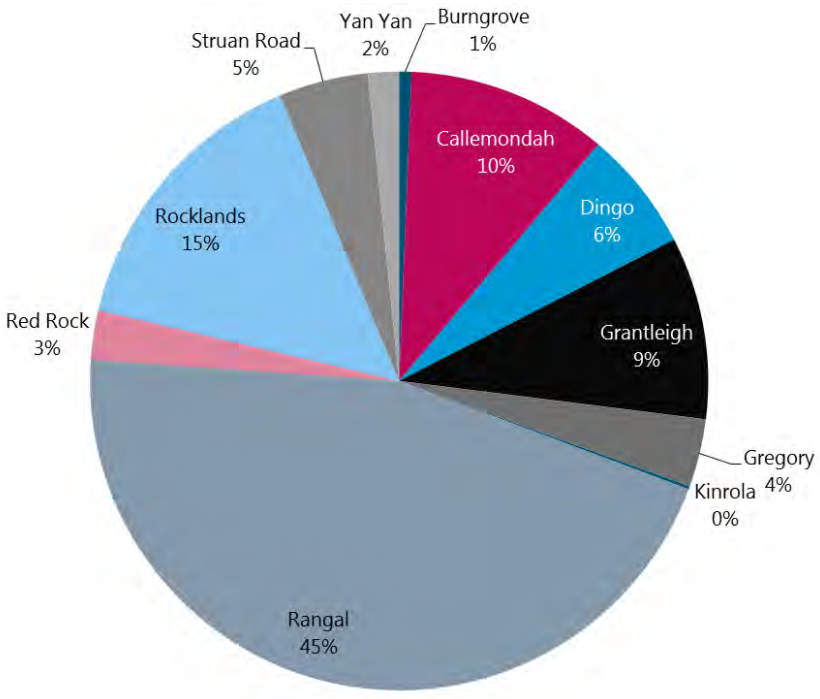


Figure 8.89: Blackwater system – distribution of feeder station trips

Circuit breaker health

Aurizon Network has conducted comprehensive circuit breaker testing in Blackwater at the older feeder stations. Circuit breakers at TSCs were not inspected in Blackwater. The older switchgear uses the following circuit breakers:

- Type – vacuum bottle
- Rated voltage – 55 kV
- Rated short circuit breaking current – 12.5 kA
- Nominal contact resistance – 23 μΩ
- Number of breaks per phase – 2 (2 phases)
- Close coil – 48 V DC
- Mechanism – spring
- Trip coil – 48 V DC spring winding motor voltage – 48 V DC.

Aurizon Network uses the ISA CBA 2000 HV circuit breaker analyser and micro-ohm meter to assess the circuit breaker condition and operation. This unit measures the following parameters:

- Current level in closure coil at close
- Current level in trip coil at trip
- Contact resistance
- Opening time
- Closing time.

In addition, Aurizon Network also quantifies the following:

- Wear or 'burn-off' of the contacts
- Total number of operations
- Physical condition based on observation.



Figure 8.90: Circuit breaker wear/'burn-off' indicator

Each of these attributes is given a rating from 5 to 1 where 5 is poor and 1 is excellent and is meeting the required performance or parameter specifications. The number of operations varies considerably from site to site due to the particular operational profile and electrical section fault propensity.

In Blackwater, Aurizon Network inspected 58 circuit breakers in feeder stations. The feeder stations and TSCs that were covered are as follows:

- Callemondah FS
- Dingo FS
- Gregory FS
- Grantleigh FS
- Rocklands FS
- Rangal FS.

Only the older feeder stations were selected for testing since the newer feeder stations are assumed to be still in very good condition.

Figure 8.91 shows the scores for circuit breakers in Blackwater with 1 being excellent and 5 being poor.

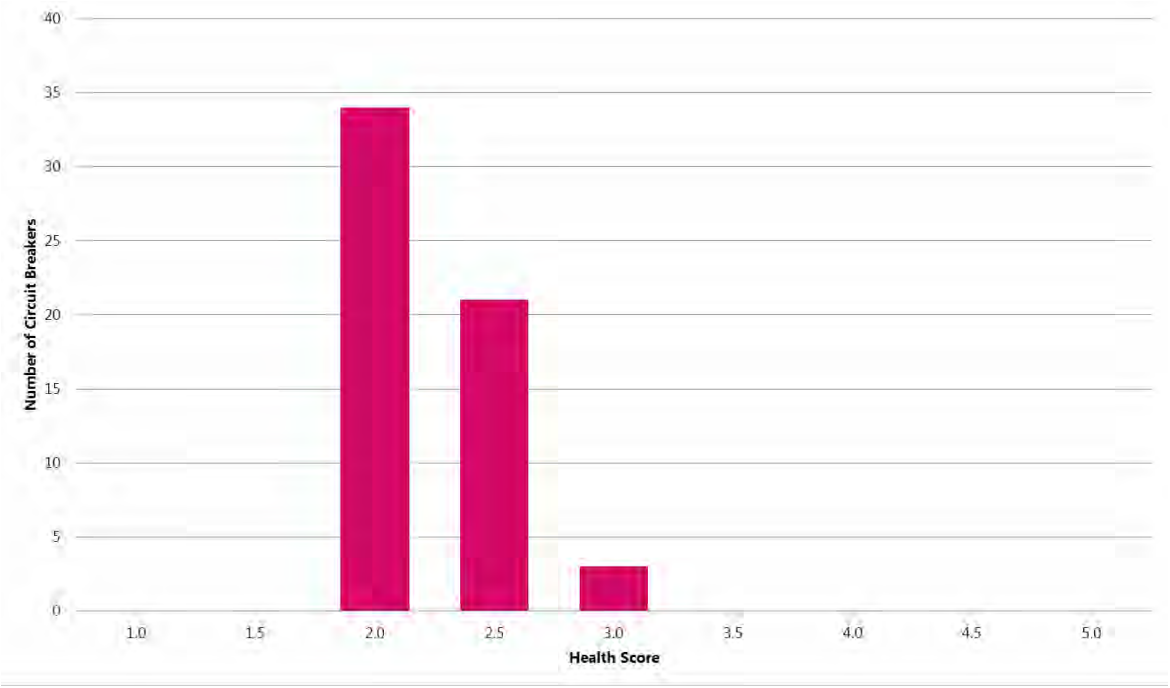
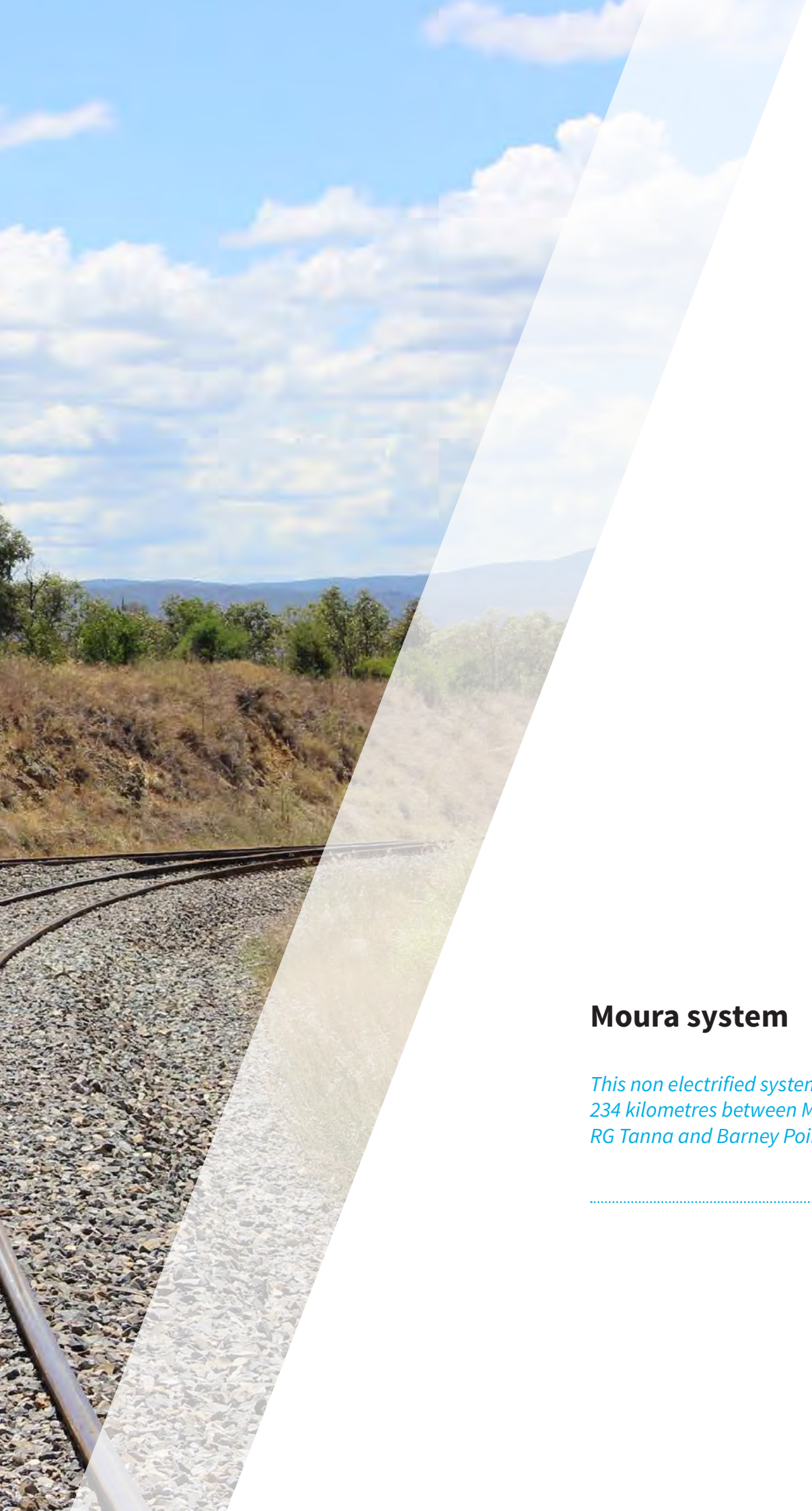


Figure 8.91: Blackwater system – circuit breaker health score

The majority (58%) the circuit breakers have scored 2.0 with 1 being a perfect score and 5 being the lowest. There are 36% of the circuit breakers that have scored the lower value of 2.5. Three circuit breakers were inferior to the rest with a score of 3. It is considered that these three may require replacement in the next five years. However, in general it can be considered that these circuit breakers are still in reasonable condition despite their age. The largest issue with them will be obsolescence since the vacuum bottles are not likely to be available as spare parts.

Aurizon Network's Yearly Fault Report 2015 showed that there were eight circuit breaker faults in Goonyella, which is relatively insignificant compared with the 584 electrical section faults which are largely caused by environmental effects and rollingstock operational issues. The failure profile between both the Blackwater and Goonyella systems is very similar. Therefore, Advisian considers the old circuit breakers will continue to provide similar reliability to historical levels in the medium term.





9

Moura system

This non electrified system connects the 234 kilometres between Moura and the RG Tanna and Barney Point Coal Terminals.

9.1 Operational KPIs

Below Rail Transit Time (BRTT)

The Moura system has achieved BRTT targets for all but one month in FY 2016. The results are shown in Figure 9.1 below.



Figure 9.1: Moura system – BRTT

Overall Track Condition Index (OTCI)

The Moura system's OTCI is within the threshold range and trending downwards in FY 2016. The results are shown in Figure 9.2 below.

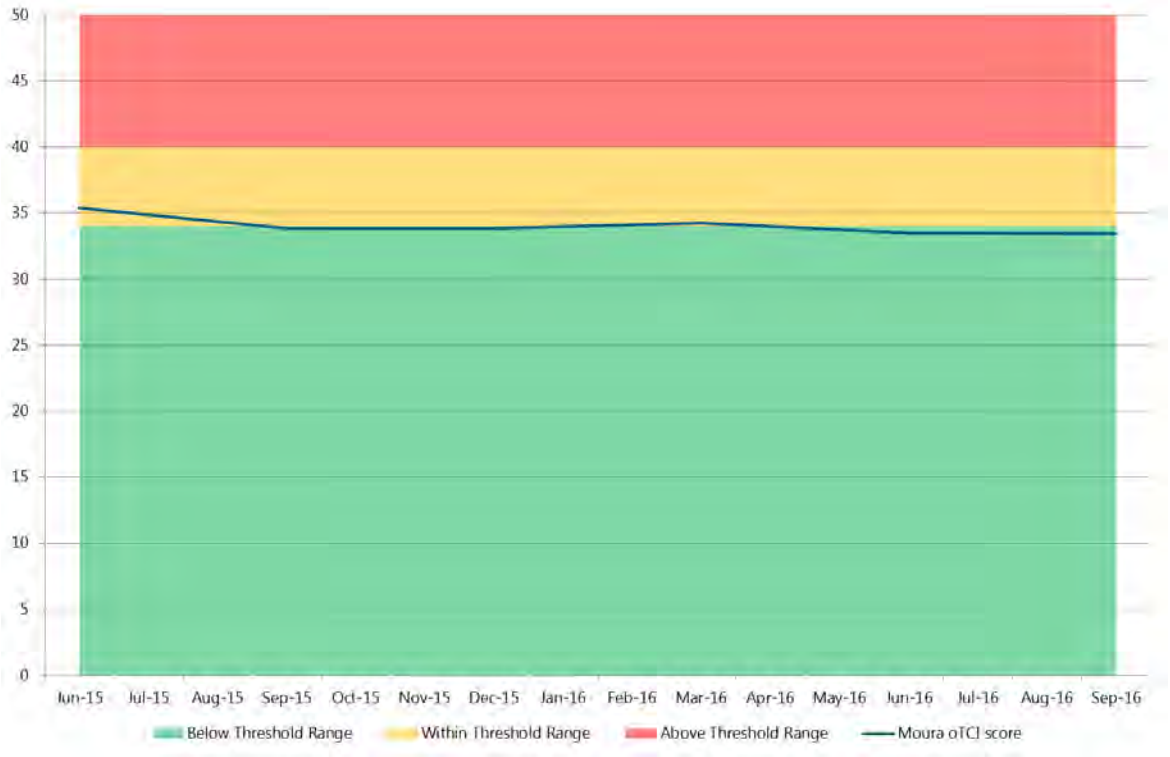


Figure 9.2: Moura system – OTCI

Speed restrictions

In the Moura system in FY 2016, 74.3% of days were recorded to have a weighted section run time (WSRT) performing better than section run time (SRT) targets, as shown in Figure 9.3. There is a correlation with this track and its performance in wet weather.

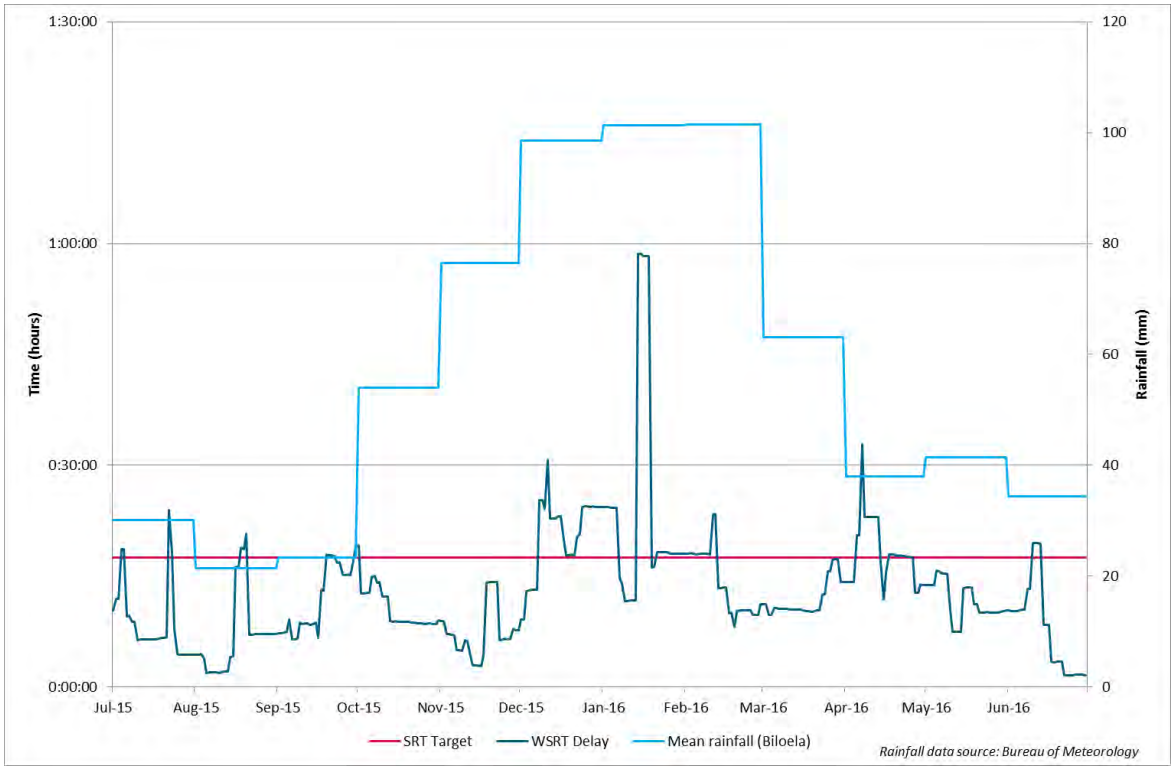


Figure 9.3: Moura system – WSRT

Delays

The detailed causes of below rail delays in Moura are shown in Figure 9.4.

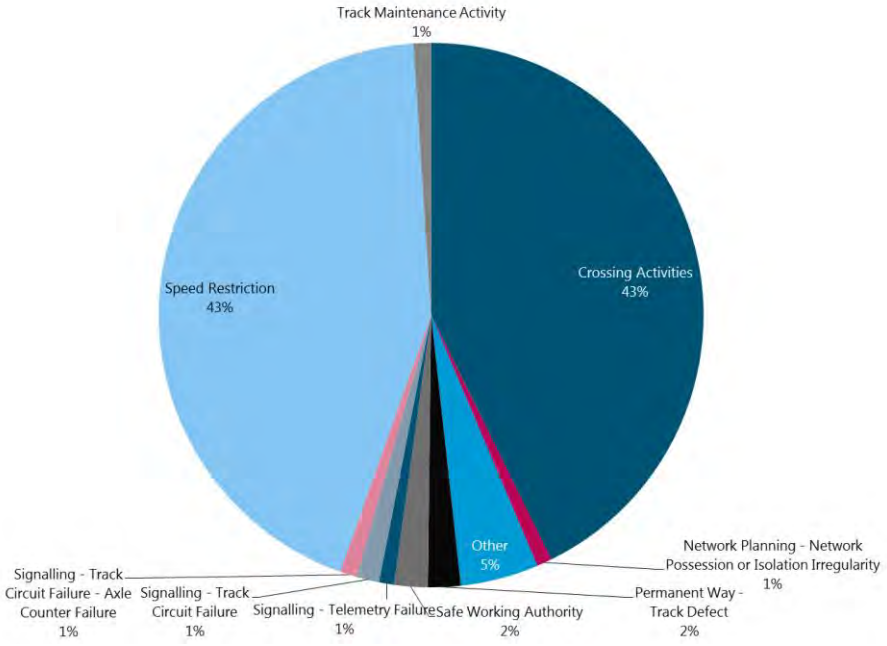


Figure 9.4: Moura system – specific causes of rail delays

9.2 Track systems

9.2.1 Lagging indicators

Delays

The delays attributed to the permanent way on the Moura system are shown in Table 9.1 below.

Table 9.1: Moura system – permanent way delays

Permanent way delays	Delay (minutes)	Normalised delay (min/billion NTK)
Delays due to track maintenance and repair	4,418	2,229

Delays caused by the track maintenance and repair in the Moura system can be broken down into below two categories:

- 1,720 minutes per billion NTK attributable to track defects
- 509 minutes per billion NTK attributable to track maintenance and repair.

Derailments

Derailments in the Moura system in FY 2016 are shown in Table 9.2.

Table 9.2: Moura system – derailment summary

Date	Location	Incident Summary Ds	Total Delay (minutes)
4/06/2016	Gladstone QAL SDG - Unknown	DERAILMENT: 9SL8 had derailed in the private siding at the QAL unloading facility. Rear bogie of the 42nd wagon, VNSQ46088 derailed. Investigation completed. Wagon rerailed and no track damage found.	278

Defects

The percentage increase in average number of monthly track and formation defects per track kilometre is 148.8% since the FY 2102 assessment. This is shown in Figure 9.5 and Figure 9.6.

It is worth noting the increase in defects reported between FY 2012 and FY 2016. Advisian suggests this is a combination of the impact of the heavier 26.5 tal traffic on the original 20 tal alignment and more rigorous reporting processes by Aurizon Network implemented over the last four years.

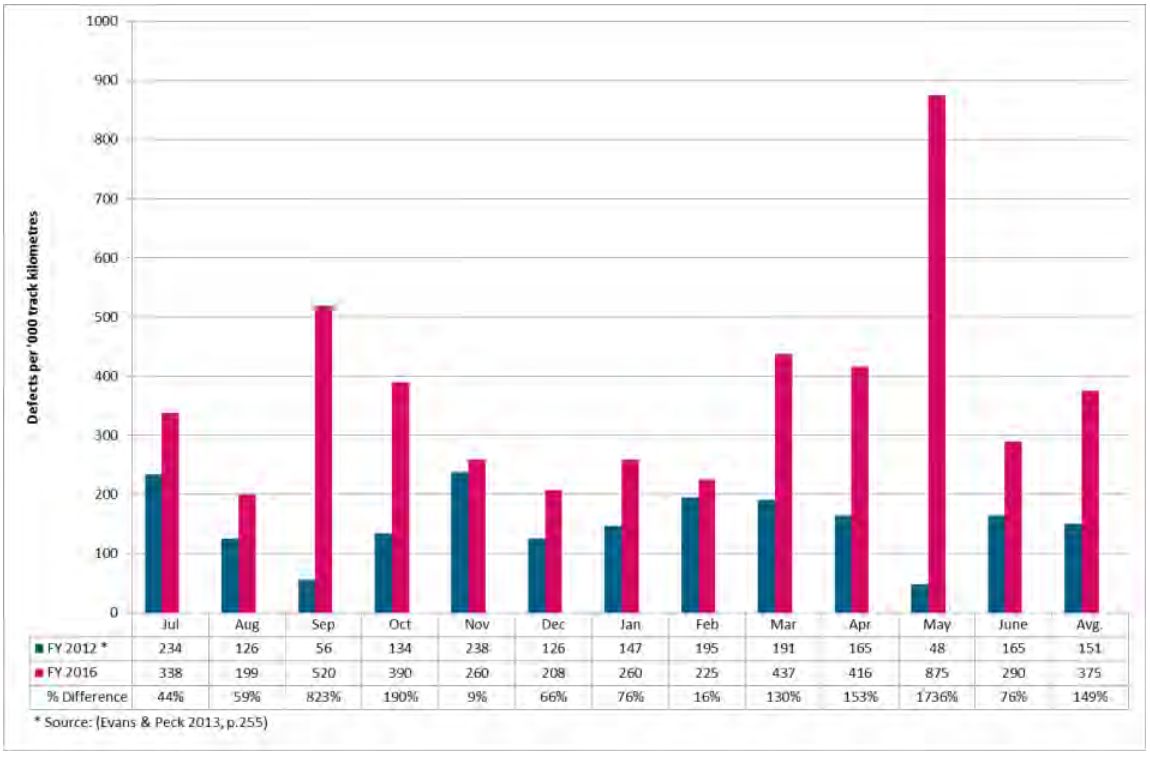
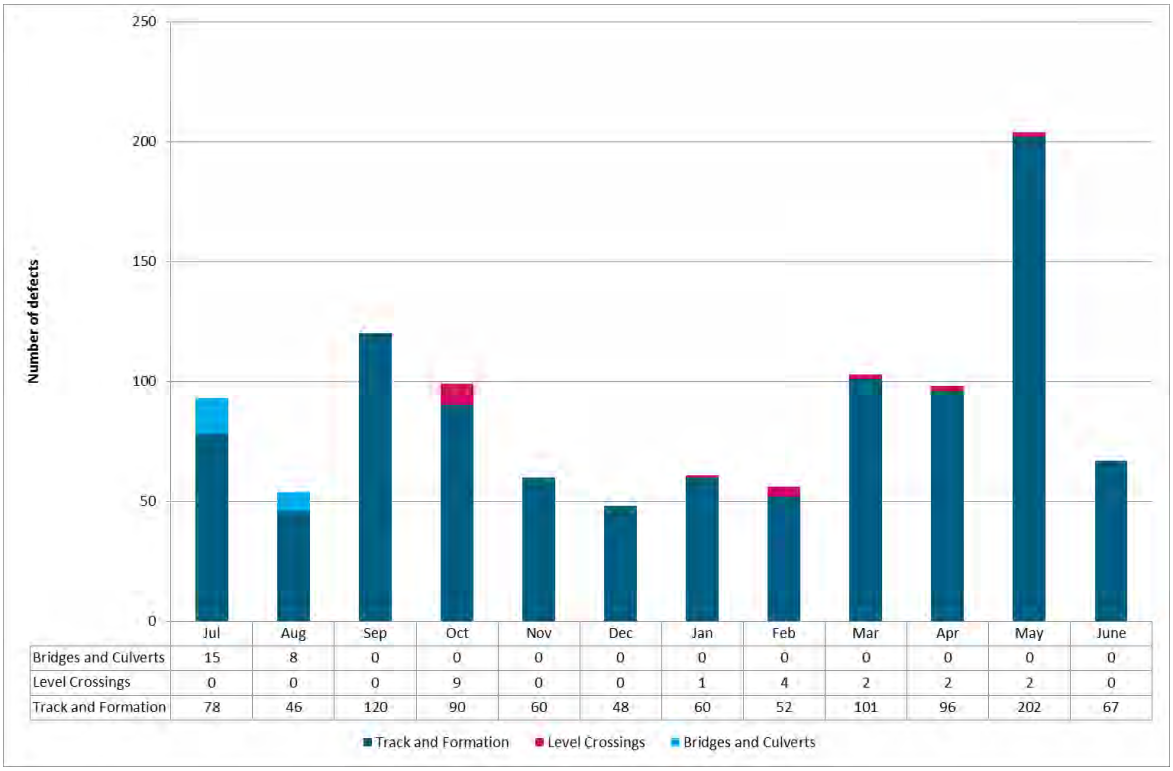


Figure 9.5: Moura system – track and formation defects for FY 2012 and FY 2016

Figure 9.6 shows that in relative terms track defects are more common than bridges, culverts or level crossings.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bridges and Culverts	15	8	0	0	0	0	0	0	0	0	0	0
Level Crossings	0	0	0	9	0	0	1	4	2	2	2	0
Track and Formation	78	46	120	90	60	48	60	52	101	96	202	67

Figure 9.6: Moura system– monthly track and structures defects

9.2.2 Site visits

The inspection team visited a resurfaced length of track at approximately 47.300, as shown in Figure 9.7. Visual inspection indicated that ballast, top and line and formation were all satisfactory. Speed restrictions were still in place as this work was completed recently.



Figure 9.7: Resurfaced track at 47.300 km

A series of tight curves was investigated between 99.300 and 100.300, shown in Figure 9.8. These curves exhibited greater table wear at the low rail, 15 mm, than the high rail, 10 mm. Plastic flow and gauge face shelling on the low rail indicated that the design cant may be excessive for the actual train speed.



Figure 9.8: Plastic flow and gauge shelling at tight curves at 99.300.

This site also had major earthworks to repair damage by flooding, shown in Figure 9.9.



Figure 9.9: Flood damage repair

A number of sites were inspected at Boundary Hill:

- Reballasting to hold light track on timber sleepers in place, shown in Figure 9.10
- Poor quality sleepers and fasteners at the balloon loop, shown in Figure 9.11
- Evidence of ballast pumping due to contaminated/deteriorated ballast, shown in Figure 9.12.



Figure 9.10: Reballasted track at Boundary Hill.



Figure 9.11: Poor quality sleepers at Boundary Hill Balloon Loop.



Figure 9.12: Contaminated ballast and pumping at Boundary Hill.

The Boundary Hill site has 47 kg/m standard carbon rails on timber sleepers. This indicates that much of the infrastructure here is the original 1980s installation. The wear on these original rails is low, with around 2 to 3 mm table wear, indicating that even 47 kg/m rail under some circumstances such as slow traffic and low tonnages can last a long time. The issues at Boundary Hill are deteriorating sleepers and contaminated ballast.

Figure 9.13 is a standard Aurizon Network monument at the Boundary Hill loop.



Figure 9.13: Aurizon Network standard monument

At Boundary Hill balloon loop near Annandale, Aurizon Network has removed a redundant turnout to reduce the maintenance load. Figure 9.14 below shows the location of the removed turnout; now reconfigured to be straight track.



Figure 9.14: Removed redundant turnout at Boundary Hill.

At 143.100 many sleepers damaged by a derailment were observed. The sleepers were still sound and Advisian assesses that it is reasonable for Aurizon Network to keep them in service.



Figure 9.15: Sleepers damaged by derailment at 147.000

The Moura loading loop is the oldest and original loading loop on the Moura system. It was constructed in 1978. The rail is the original 47 kg/m carbon steel rails. It does appear that at some stage the original timber sleepers have been replaced by concrete FIST sleepers.

Figure 9.16 below shows the loading loop. There are clear differences between the entry road on the right and the exit road on the left. The top and line on the entry road is in good condition whereas the top and line of the exit road is in poor condition. The entry road ballast is in good condition whereas the exit road is heavily contaminated by coal fines and in poor condition. This comparison shows the impact ballast contamination has on track stability and consequently top and line.



Figure 9.16: Poor top and line at Moura Loop

The rails on the exit road are badly damaged with evidence of plastic flow and wear, as seen in Figure 9.17 and Figure 9.18. Aurizon Network currently manages this with speed restrictions on this track.

The remaining life of the Moura mine is uncertain and Aurizon Network is reluctant to invest capital in reconstructing this loop for an uncertain future. In this case, however, Aurizon Network has little choice as the track is marginal for operations and must be reconstructed. It is being managed via increased inspections, reduced cant and reduced speed, and is to be rebuilt in the next 12 months.



Figure 9.17: Plastic flow on low rail at Moura Loop



Figure 9.18: Plastic flow on heavily worn rail at the Moura Loop

9.2.3 Leading indicators

Aurizon Network's focus is to keep Moura operational and safe at minimum cost. This is being achieved.

The significant increase in defects reported of 148%, and the susceptibility of the track to increasing TSRs with wet weather indicate that the maintenance load on this track in terms of ballast and formation quality could increase. There may need to be asset renewal projects if enough certainty with mine production warrants these.

9.3 Structures

9.3.1 Lagging indicators

Asset age

Asset ages for bridges and culverts in the Goonyella system are shown in Figure 9.19 and Figure 9.20

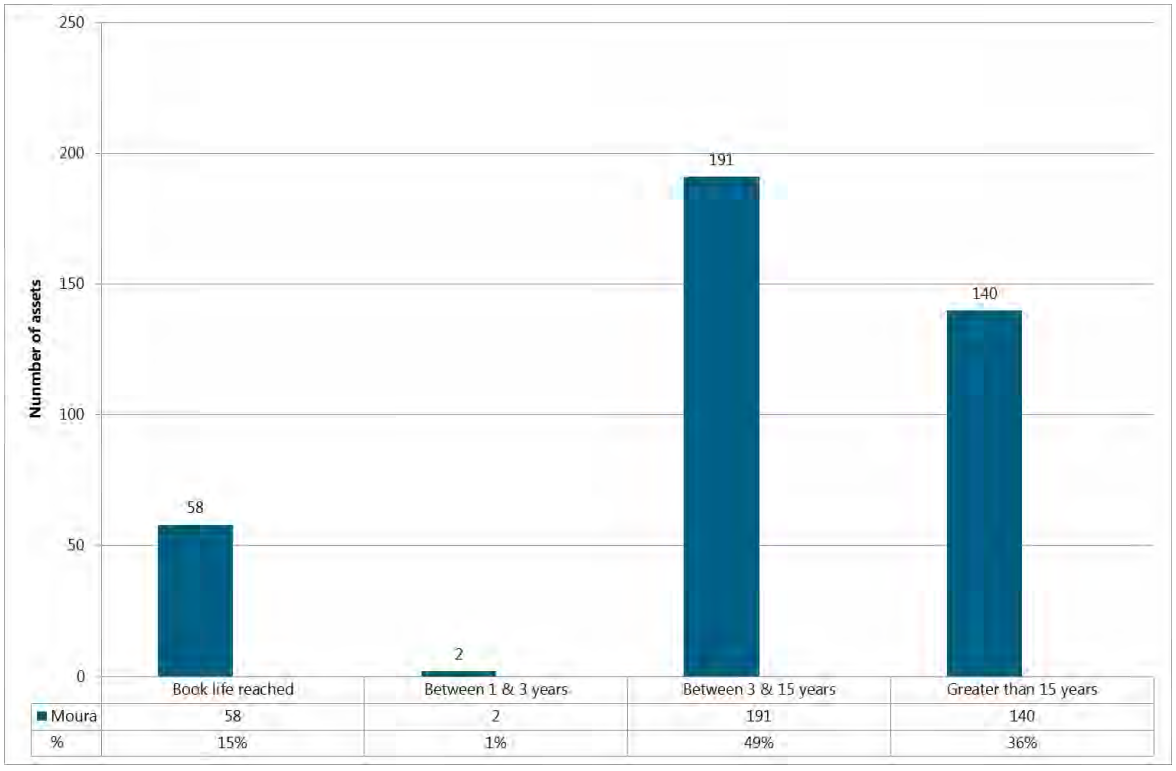


Figure 9.19: Moura system – bridges and culverts remaining asset book life

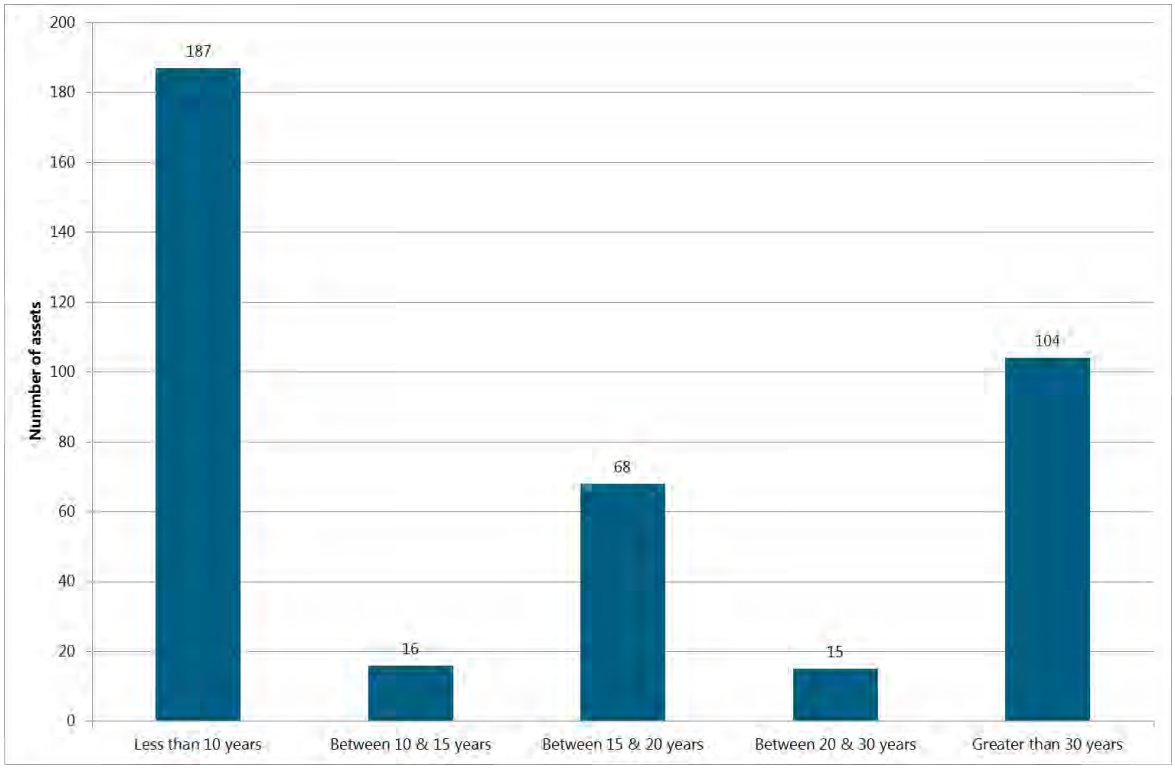


Figure 9.20: Moura system – bridges and culverts asset age by acquisition date

Inspections

Table 9.3 summarises the inspection work orders in the Moura system.

Table 9.3: Moura system – inspection work orders[9]

Inspection work orders	Bridges	Drains	Overall
Number of total inspections:	42	472	514
Number of late inspections:	26	292	318
% of late inspections:	61.9%	61.9%	61.9%
Average number of days late:	15.8	20.6	20.2

Delays

No delays due to structures were reported for the Moura system in FY 2016.

[9] The FY 2016 inspections was captured using RIMS, which had an error where inspection due dates were shown to be the 15th of each month instead of the end of the month. Aurizon Network now uses AssetAsyst which captures inspection dates correctly.

9.3.2 Site visits

Some of the structures on the Moura system are life expired. This is particular the case for the corrugated iron culverts, seen in Figure 9.21. Aurizon Network is either replacing these assets or, where possible, lines them to extend their life, shown in Figure 9.22.



Figure 9.21: Life expired corrugated iron culvert



Figure 9.22: Culvert internally relined to extend life

9.3.3 Leading indicators

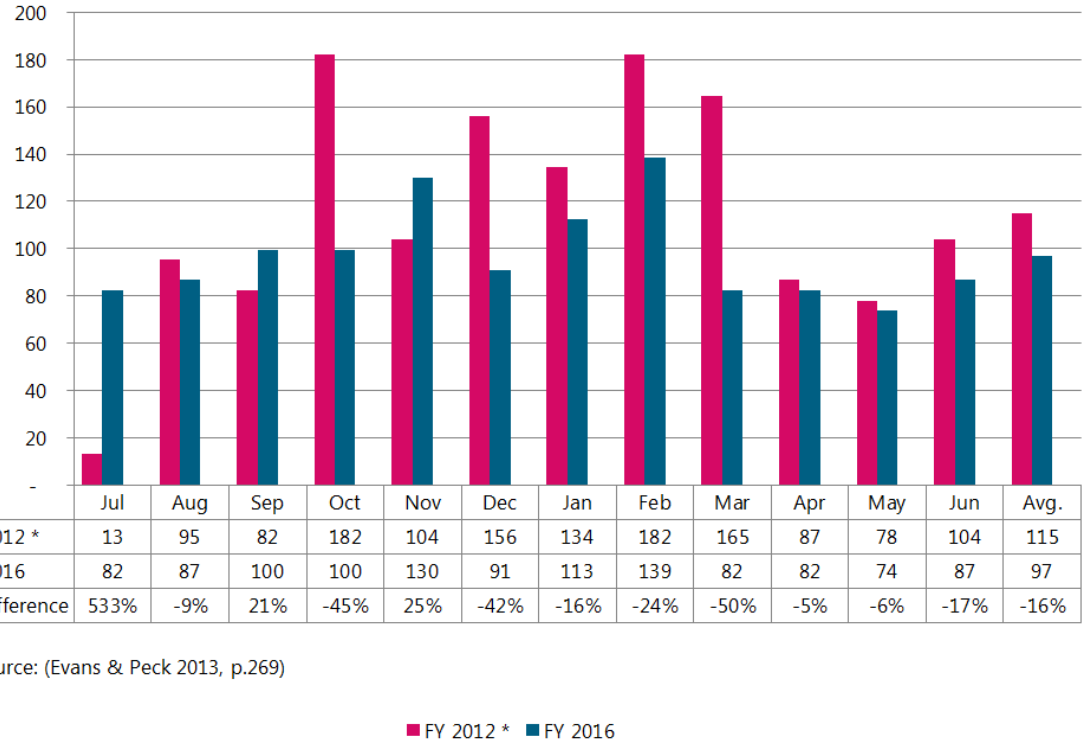
Based on the lagging indicators, the Moura system performed well. As the oldest system with 25 to 50% of all assets having greater than 15 years remaining book life, ongoing maintenance will be required for both bridges and culverts. Inspections were undertaken as required in the allotted time frame suitable to keep the track performing with lower tonnages compared to the other systems.

9.4 Train control systems and telecommunications

9.4.1 Lagging indicators

Signalling faults and delays

The percentage change in number of monthly signalling faults from the FY 2012 assessment is shown in Figure 9.23.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	13	95	82	182	104	156	134	182	165	87	78	104	115
FY 2016	82	87	100	100	130	91	113	139	82	82	74	87	97
% Difference	533%	-9%	21%	-45%	25%	-42%	-16%	-24%	-50%	-5%	-6%	-17%	-16%

* Source: (Evans & Peck 2013, p.269)

Figure 9.23: Moura system – signalling faults for FY 2012 and FY 2016

The delays attributed to signalling on the Moura system are shown in Table 9.4.

Table 9.4: Moura system – signalling delays

Signalling delays	Delay (minutes)	Normalised delay (min/billion NTK)
Signalling delays	8,637	4,357

Breakdowns of the signalling faults and delay minutes by equipment type and element are shown in Figure 9.24 and Figure 9.25.

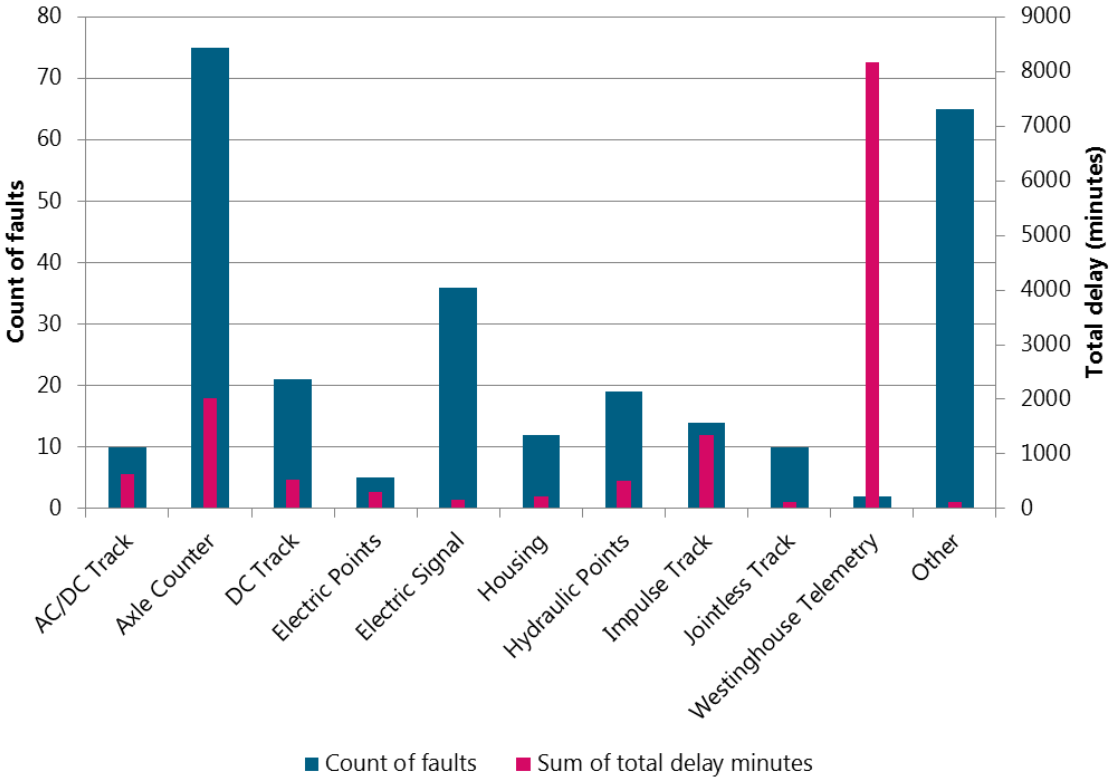


Figure 9.24: Moura system – signalling faults and delays by equipment type

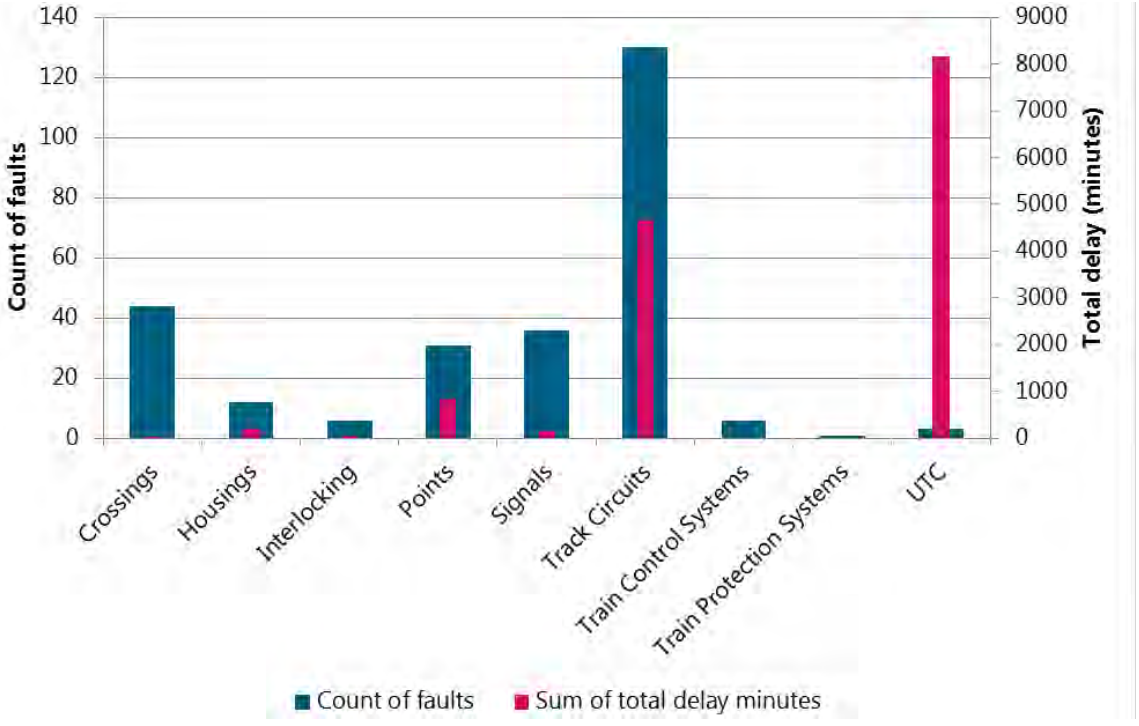
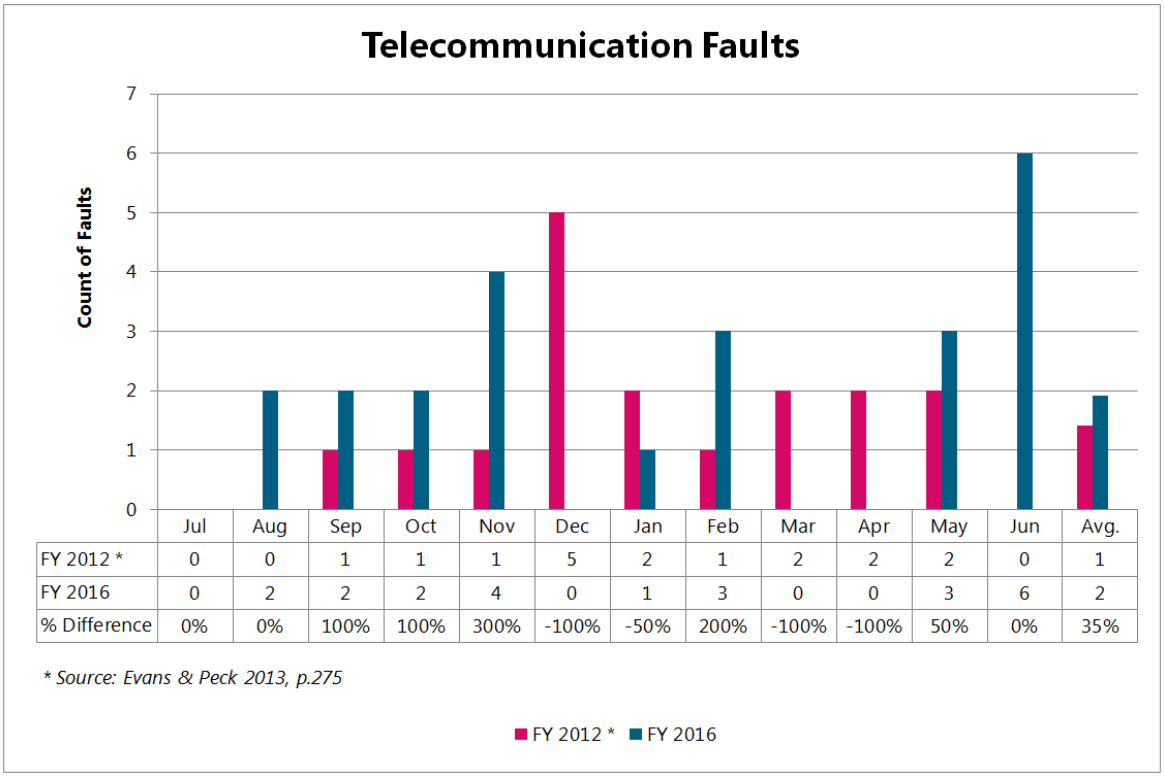


Figure 9.25: Moura system – signalling faults and delays by element

Telecommunications faults and delays

Moura has a different communication link design from the other three systems. It does not have any fibre optic cabling and relies on long-range microwave links and sub-rate (UHF) radio links.

The percentage change in number of monthly telecommunications faults from the FY 2012 assessment is shown in Figure 9.26.



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Avg.
FY 2012 *	0	0	1	1	1	5	2	1	2	2	2	0	1
FY 2016	0	2	2	2	4	0	1	3	0	0	3	6	2
% Difference	0%	0%	100%	100%	300%	-100%	-50%	200%	-100%	-100%	50%	0%	35%

** Source: Evans & Peck 2013, p.275*

Figure 9.26: Moura system – telecommunications faults for FY 2012 and FY 2016

The delays attributed to telecommunications on the Moura system are shown in Table 9.5.

Table 9.5: Moura system – telecommunications delays

Telecommunications delays	Delay (minutes)	Normalised delay (min/billion NTK)
Telecommunications delays	628	316

The 628 minute delay occurred in September 2015 and was caused by a card failure in the transmission system (telemetry failure).

9.4.2 Site visits

Moura still has a number of incandescent type signals, as shown in Figure 9.27 and Figure 9.28. These units are serviceable and do not require replacement with LED.



Figure 9.27: Incandescent signal at Boundary Hill



Figure 9.28: Incandescent signals at Annandale

A turnout installation at Annandale, shown in Figure 9.29, was inspected. The points mechanism was refurbished and in good condition.



Figure 9.29: New points on timber sleepers at Annandale

Also at Annandale were examples side by side of the older style four bolt glued insulated joint (GIJ) beside the newer six bolt style GIJ was inspected. The six bolt style handles any potential pumping of the track better than the four bolt style.



Figure 9.30: Older style four bolt GIJ and new style six bolt GIJ at Annadale

9.4.3 Leading indicators

Since the FY 2012 assessment signalling delay minutes have increased from 9,805 to 14,114 minutes in FY 2016. The largest contributor to signalling delay for FY 2016 is universal train control (UTC), accruing 8,176 minutes over three incidents. In FY 2012 there were no delays associated with UTC faults. Aurizon Network should seek to address the delays caused by the UTC (Westronic S2) faults as they appear to be isolated incidents that may be easily resolved. Removing the delays caused by the UTC, FY 2016 signalling delays would be significantly less than those of FY 2012, indicating an improvement in delay minutes.

Telecommunications delays have increased from 85 minutes (FY 2012) to 1,283 minutes (FY 2016). This is a concern when taking into account net tonnes hauled over the Moura system which decreased slightly from 13 mtpa in FY 2012 to 11 mtpa in FY 2016. Telecommunications delays were due to cabling faults in radio bases and control card failure in microwave links. Aurizon Network should look into telecommunications faults in the Moura system.

9.5 Traction distribution and power supply systems

The Moura system has only 13 kilometres of electrified track near Callemondah yard. The remainder of the network is not electrified.