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Aurizon Network Maintenance and Renewal Strategy and Budget

Confidentiality and Disclaimer

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This document is the Maintenance Strategy and Budget and Renewals Strategy and Budget as such terms are defined in Aurizon Network's UT5 Access Undertaking dated 19 December 2019 (Undertaking) and has been prepared for the purposes set out in the Undertaking. It is only to be used for those purposes and is otherwise commercial in confidence.

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GUIDING PRINCIPLES

Our operations are designed and managed to appropriately balance cost, reliability and rail infrastructure performance (each in the long and short term) to ensure customers' contracted positions are delivered in a safe and sustainable way through the following three principles:

1. Coordinated and Integrated Closures

Required maintenance and renewal works are coordinated with ports and mines to minimise impacts on the supply chain. The strategy is aimed at fewer, but longer duration, closures and maximising maintenance and renewal works during those closures. Planned maintenance activities outside of closures are designed to minimise impacts on the supply chain.

2. Asset Reliability

Assets will be renewed based on condition and will be inspected, maintained and replaced to minimise unplanned failures and to be fit for purpose.

3. Cost Effective

Maintenance activities are carried out in a way which balances cost, reliability and performance (each in the long and short term) each in respect of the Rail Infrastructure.

COMMITMENTS FOR FUTURE RIG ENGAGEMENT

Through the development and consultation of the initial FY21 RIG process both Aurizon Network and RIG members have identified opportunities to improve the engagement and information for consideration of future year submissions.

Aurzion Network makes the following commitments to the RIG;

- To work collaboratively with the RIG in developing a quarterly reporting framework that provides relevant information on the actual performance of scope delivery and costs incurred against plan across the maintenance and renewals task
- To develop and negotiate with the RIG agreed performance metrics that provide indication of the effect of the application of the approved strategies on the performance of the rail networks.
- To Provide additional information on the scope development of the ballast undercutting project and options for determining the efficient delivery of the defined scope
- To provide information of on the value drivers and underlying cost assumptions that drive the maintenance and renewal forecasts

Aurizon Network will work through the above commitments in the period post the FY21 Strategy approval process and prior to the lodgement of the FY22 RIG submission.

INTRODUCTION

Alignment to 2017 Access Undertaking test
(UT5, Draft Amended Access Undertaking approved by the Queensland Competition Authority (QCA) on 19 December 2019)

This paper has been developed by Aurizon Network to provide the Rail Industry Group (RIG) Aurizon Network's Maintenance and Renewal Strategy and Budget for each rail system in the Central Queensland Coal Network (CQCN).

This paper has considered and actioned RIG proposed inclusions and amendments arising from RIG review of the draft strategy submitted to RIG November 29, 2019.

The RIG will consider the proposed Maintenance and Renewal Strategy and Budget and request RIG members to approve via the voting process outlined in Section7A.11 of UT5.

Deliverables of the Maintenance and Renewal Strategy

This paper consists of:

- The maintenance scope and budget for each system for Financial Year (FY) 2021 and a forward forecast of spend FY22-25
- The renewal scope and budget for each system for FY21 and a forward forecast of spend FY22-25
- Detail of the application of the maintenance and renewal strategy on each asset class
- Detail of historical unit rate performance for the largest asset renewal and maintenance products
- Additional information communicated to the RIG post the submission of the Draft Maintenance and Renewal Strategies (Appendix 11)

EXECUTIVE SUMMARY

The application of the maintenance and renewal strategies across the coal systems drives a scope requirement which is translated into a budget. Historic and forecast data provide an estimate of cost, scope and required track access.

The estimated forecast cost for maintenance and renewal scope for each of the four coal systems are detailed in Appendices 1 to 8.

Maintenance and renewal costs against prior years and the UT5 Final Decision are summarised in the tables below.

There has been no change to the maintenance and renewals scope or forecast from the draft Strategy presented by Aurizon Network in November 2019

Maintenance Budget

System ($m)	FY18 Actual	FY19 Actual	FY20 UT5 FD	FY21 UT5 FD	FY21 Budget
Newlands[2]	$12.2	$13.8	$13.6	$14.4	$13.7
Goonyella	$52.2	$57.0	$60.1	$61.1	$56.9
Blackwater	$61.3	$64.0	$62.2	$62.8	$59.1
Moura	$14.7	$11.8	$11.2	$11.6	$12.5
TOTAL	**$140.4**	**$146.7**	**$147.2**	**$149.8**	**$142.2**
Depreciation on Ballast Cleaning[3]	$5.8	$5.0	$8.1	$8.0	$6.5

Table 1. Maintenance cost budget per system FY21

To compare across years, the Maintenance Budget table excludes Ballast Undercutting which is a renewal activity from FY20 onwards however the depreciation on Ballast Undercutting plant is set out at the bottom of the table as this amount forms part of the Maintenance Cost allowance under the UT5 DAAU

Renewal Budget

System ($M)	FY18 Actual[HD(1]	FY19 Actual	FY20 Forecast	FY21 Budget
Newlands	$17.0	$15.3	$20.5	$21.4
Goonyella	$96.9	$74.9	$115.3	$113.5
Blackwater	$98.4	$87.4	$91.3	$116.1
Moura	$15.8	$20.5	$15.9	$15.4
TOTAL	**$228.1**	**$198.1**	**$243.0**	**$266.4**

[2] While the UT5 DAAU contains individual Reference Tariffs and Allowable Revenues for the Goonyella to Abbot Point Expansion (GAPE) it is not a geographically distinct coal system. The scope of the GAPE project included significant infrastructure upgrades to Rail Infrastructure in the Newlands system and this infrastructure is utilised by all GAPE and Newlands Train Services. Similarly, all GAPE Train Services utilise all existing Newlands system infrastructure. As a result, Newlands and GAPE are treated as a single system for this report. From a pricing perspective, GAPE Train Services continue to pay for the QCA-approved cost of GAPE Project infrastructure within the Regulated Asset Base (RAB) whereas forecast maintenance costs will be allocated between GAPE and Newlands users

[3] Under the UT5 DAAU, Aurizon Network recovers the depreciation of ballast undercutting plant within the maintenance cost budget

Table 2. Asset renewal cost budget per system FY21

For presentation purposes Ballast Undercutting is represented in the asset renewal table for the period FY18 forward. Prior to FY20 this product was treated as a maintenance activity.

It should be noted, the value of asset renewal activities represented in table 2 reflects the capital expenditure Aurizon Network expects to incur in a given year. By comparison, capital expenditure submitted for inclusion in the Regulated Asset Base (RAB) as per Schedule E of the 2017 Access Undertaking is on an 'as commissioned' basis. As a consequence, the value of capital expenditure reflected in the Renewal Strategy and Budget may vary from the annual capital expenditure claim submitted to the QCA in line with Clause 7A.11.6 of the Access Undertaking

ASSET MANAGEMENT CONTEXT

Aurizon Network is the Asset Manager and Rail Infrastructure Manager (RIM) of the Central Queensland Coal Network (CQCN). The CQCN comprises the Newlands, Goonyella, Blackwater and Moura rail systems. As outlined in footnote [2] for the purpose of this report, all GAPE infrastructure is considered part of the Newlands system.

In the role of RIM, Aurizon Network is legally required to provide effective management of the rail infrastructure for which it has statutory or contractual rights to use and provide access. Aurizon Network is required to maintain RIM accreditation and apply a Safety Management System (SMS) that is approved by the Rail Safety Regulator.

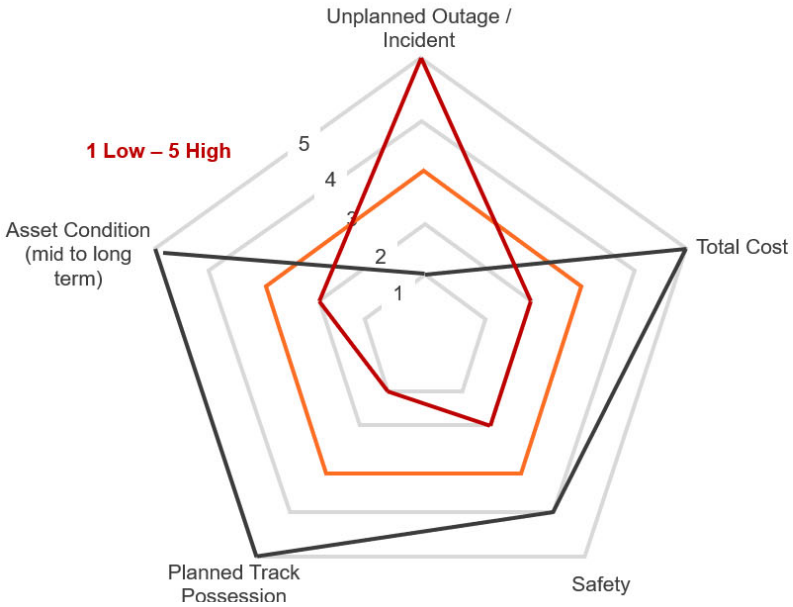
The role of asset management is to manage assets through their lifecycle balancing key variables, principally:

- **Safety** – maintaining assets to meet the requirements of the SMS and ensure the safety of workers (both internal and external), rail operations and public interfaces;
- **Customer** – maintaining and operating a safe and fit for purpose rail network capable of meeting the contracted Access Rights;
- **Track Occupancy (Planned Track Possessions)** – managing time required on track to deliver required works;
- **Cost** – managing expenditure required to undertake maintenance and renewal activities;
- **Incident Risk** – managing asset condition to mitigate the risk of rail incidents such as derailment or collision that could result in serious injuries or fatality or cause significant throughput disruption and recovery cost; and

- **Mid and Long-term asset condition** – investing to deliver sustained performance of the rail infrastructure. The consequence of condition change is an increase or decrease in unplanned delays caused by non-performance of the rail infrastructure.

These variables are interrelated, movement of one variable will affect one or more of the other variables. Aurizon Network's maintenance and renewal strategies seek to maintain a balanced approach across the variables.

This interrelationship of moving the level of investment variable is represented in the graphic and table below:



Element	High	Low
Asset Condition	Increased quality	Decreased quality
Incident Risk	More unplanned possessions	Less unplanned possessions
Cost	Higher cost	Lower cost
Safety Performance	Increased safety performance	Decreased safety performance
Planned Possession	More planned possessions	Less planed possessions

Balanced Investment
Decreased Investment
Increased Investment

Figure 1: Trade off's to be considered in Asset Management while delivering capacity of Access Rights

MAINTENANCE AND RENEWAL STRATEGY

The detailed application of Aurizon Network's maintenance and renewal strategies is provided at Appendix 9. This includes the triggers for intervention, inspection and renewal as well as details of the latent condition of the rail infrastructure driving the strategies.

Maintenance Strategy

Maintenance of rail infrastructure is the inspection, testing, recording of faults and subsequent adjustment or repair of the asset.

There are a wide variety of assets that make up the rail infrastructure. These assets wear through use or movement, such as tonnage amounts over a rail section, movements of mechanical parts, or through obsolescence, either as a result of operating systems no longer being supported, a reduction in availability of spare parts or advances in alternate technologies.

Assets degrade at differing rates due to their construction materials and their location.

To manage this variability Aurizon Network applies several maintenance approaches to inspect, measure deterioration and respond to issues or disruption due to asset condition.

Maintenance Approach	Description	Assets Applied to	Maintenance Activity
Condition or Tonnage based intervention	Maintenance programmed to occur once a usage threshold is met. Maintenance can be programmed ahead of time due to forecast traffic movements	Rail, turnouts and ballast,	Rail grinding - of both track and turnouts to return the rail profile to design and remove any miro faults Track Resurfacing - of both track and turnouts to maintain track to the design geometry and ensure track alignment
Planned Inspection and Service (Preventative Maintenance)	Periodic inspection of assets to understand condition and identify items that may cause a future fault Period of inspection is known and can be planned	Rail, sleepers, turnouts, ballast, formation, culverts and bridges	Track Geometry Recording – specialised track vehicles to measure geometric characteristics of track alignment Ultrasonic Rail Testing – non-destructive testing to identify internal rail faults On Track Inspection – road rail vehicle inspection of the rail corridor Structures inspection – inspection and testing of critical elements of the structures to measure and track condition
		Signals, interlockings, level crossing protection, optic fibre, standby power system,	Control Systems planed periodic inspection and minor servicing . Includes function testing, signal alignment testing, battery testing, cleaning and security check.

Maintenance Approach	Description	Assets Applied to	Maintenance Activity
		SCADA system, radio system	
		Switching transformers, overhead line equipment	Electrical planed periodic inspections and minor servicing. Includes condition testing, oil sampling, switch testing and wire wear measurement
Planned Corrective Maintenance	Planned rectification of faults found from inspections or remote monitoring Period to rectify is dependent on the severity of the fault or risk to operations	Rail, sleepers, turnouts, ballast, formation, culverts and bridges	Rail joint maintenance – rail welding. Rail plating and lifting and lining rail joints Maintenance Ballast – small section ballast repair / replacement, removal of mud holes and squats Sleeper cluster management – spot insertion of sleepers to repair damaged sleepers, sleeper testing, fastening repairs and sleeper respacing Rail stress adjustment – rail stress testing and adjustment to manage compression and expansion of the rail Top and line resurfacing – hand track tamping and small machinery tamping Structures repairs – minor concreting works, kerb repair, walkway repair, bridge drain cleaning General earthworks maintenance – embankments and cutting repair, drain cleaning and access road maintenance
		Signals, interlockings, level crossing protection, optic fibre, standby power system, SCADA system, radio system	Control Systems general maintenance and component repair.
		Switching transformers, overhead line equipment	Electrical general maintenance and component repair
Reactive Maintenance	Immediate remedy of faults that have disrupted operation of the rail network	Rail, sleepers, turnouts, ballast, formation, culverts and bridges	Rail repairs – immediate repair of broken rails or failed welds Derailment and collision repair – infrastructure requiring replacement as a result of a train derailment or collision

Maintenance Approach	Description	Assets Applied to	Maintenance Activity
			Formation repair – rectification of track formation that has failed due to a slip or shear. Mud Hole Removal – saturated formation sections dug out and repaired to maintain track alignment
		Signals, interlockings, level crossing protection, optic fibre, standby power system, SCADA system, radio system	Communication failure response – rectification of a brake in the telecommunication chain across the CQCN. This can be a fibre optic breakage, microwave radio fault or digital radio issue Wayside equipment alarm response - investigation as to the trigger of an alarm such as a dragging equipment detector or bearing acoustic detector Power failure response – rectification of mains power to signalling and wayside equipment. Solar and generator provide immediate power but for limited periods
		Switching transformers, overhead line equipment	Dewirement repair –infrastructure requiring replacement as a result of a Dewirement Trip investigation – to understand the cause of electrical trips and to remedy fault ahead of re-energisation Transformer replacement – in the event of a transformer letting go or failing it is switched out to maintain the integrity of the electrical network

Table 3. Asset maintenance approaches

To the extent possible, Aurizon Network seeks to deliver the required maintenance tasks in a manner that is consistent with the Maintenance Objectives.

The maintenance plan for assets is set as per the relevant Asset Policy but can be altered dependant on its performance or position in the asset lifecycle.

The maintenance strategy is utilised to identify the preventative maintenance requirements. It is based on achieving the appropriate level of asset availability at the most efficient cost of ownership, through the asset life cycle, which will best meet the business requirements of the customers using the assets. This is the concept of Reliability Centred Maintenance where unplanned response or intervention is kept to the minimum, balancing cost and Deliverable Network Capacity.

The maintenance strategy applied is a standard, widely accepted approach to the maintenance of both fixed and linear assets.

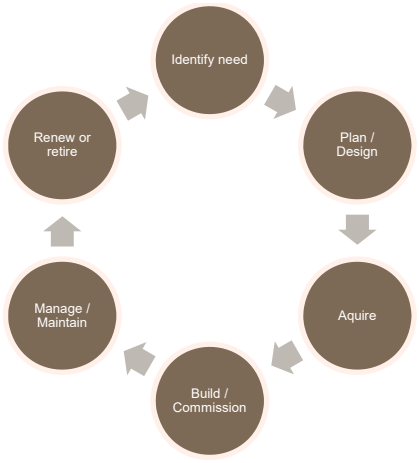


Figure 2. The asset lifecycle

Renewal Strategy

Renewal of railway infrastructure is the removal of an asset from service that is life expired or obsolete and replaced or reconfigured with the modern-day equivalent asset.

Through maintenance inspections and targeted condition reviews, Aurizon Network determines the condition of assets across the CQCN. This condition is ranked on a spectrum from new asset through to an asset no longer performing its design function.

The location of an asset and its criticality to system operations differs across each system and each track section within a system. As such, each track section is assigned a location criticality ranking. This ranking is a combination of parameters, including the proportion of total of system tonnes railed across each track section and the required lead time for executing asset renewals in the event of a failure.

By understanding asset condition and asset criticality, all identified scope can be ranked and prioritised to target those assets that are most in need of renewal. This process, as identified in figure 3 below, of prioritisation is completed in Aurizon Network's Scope Priority Model (SPM).

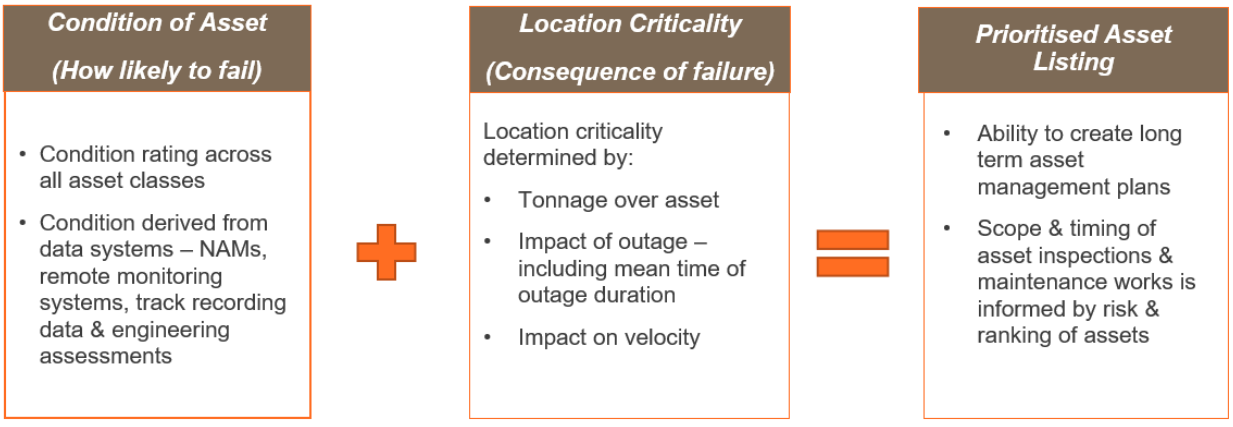


Figure 3. Asset Renewal Prioritisation Approach

Once scope is identified and prioritised through the SPM, Aurizon Network will undertake the following activities:

- Ascertain the scope that must be completed to adhere to the safety and regulatory requirements for railway operations. Scope and cost are assessed in balance with consideration for capacity requirements and alignment with port closures and other outages;

- Consider renewals that are aligned to long term asset strategies and are necessary to avoid asset failures;
- Consider scope that could potentially be deferred but can be delivered within the closure plan defined by the scope identified in paragraphs 1 and 2 and provides benefit in renewing over deferring; and
- Consider the additional maintenance holding costs of deferring scope identified through the SPM (including additional inspections or temporary speed restrictions), risk of failure and consequential impacts of failure if deferred to balance the cost, reliability and performance and impact to the Deliverable Network Capacity determine when the renewal should be completed.

The use of the SPM allows Aurizon Network to compare all assets against common parameters. This ensures that the assigned capital funding is allocated to the assets that most require renewal.

Interrelationship between Maintenance and Renewal Strategies

The asset management approach manages assets through the lifecycle, from defined requirements through design, build, maintain and renew/dispose.

The maintenance and renewal strategies identified above are interrelated and support each other.

Figure 4 below illustrates the relationship between capital and maintenance costs, asset condition and the risk of asset failure. This is a typical pattern for an asset that wears through usage, e.g. turnouts.

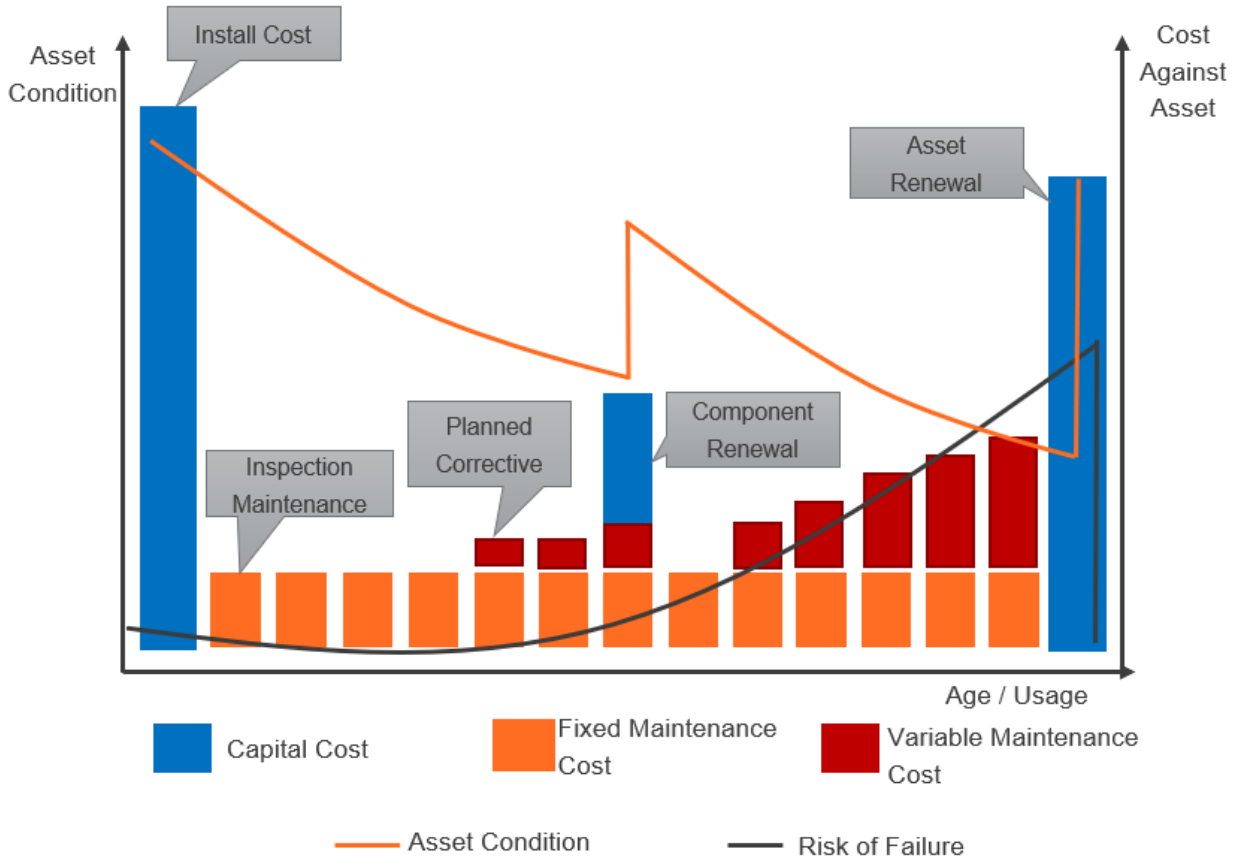


Figure 4. Maintenance and renewal activity effect on asset condition and failure risk.

Track Possession Strategy

Aurizon Network's intent is to adopt an integrated approach to planning asset renewal and maintenance activities coordinated with other parts of the supply chain.

Maintenance and renewal works are conducted using a variety of track possession approaches including the following:

- As part of an integrated possession – where renewal and maintenance works are required in a section or across a system. These are combined into an integrated closure to enable maximum works to be completed. The timing of these closures is coordinated where possible with other supply chain participants.
- In-between train services – smaller tasks undertaken in a safe and controlled manner on track whilst no trains are present or by utilising unused train paths.
- In the shadow of other activities – activity is completed in sections by taking advantage of trains not operating in that section due to renewal or maintenance activity that is occurring in another sections.
- In a single line possession – work completed on one track in a duplicated section whilst the other track is kept operational.
- As a dedicated possession – rail section closed to all traffic and works undertaken to conduct renewal activities or maintenance. This is coordinated to have the minimum impact on the operation of train services.
- As a scheduled rail service – track recording car, high rail inspections, movement of rail plant.
- As nil access required – works completed outside the danger zone whilst the railway is operating, for example culvert inspection, fencing, vegetation control etc.

Asset Management and Planning Systems

The application of maintenance and renewal strategies is managed via several established technology systems that are proposed to be further enhanced to better inform investment and access decisions.

NAMS

The Network Asset Management System (NAMS) is a series of interrelated systems and activities that work together to provide a digital representation of the asset life cycle. NAMS has and continues to be developed and delivered across four main stages, to support the delivery of the maintenance and asset renewal strategies:

- Data Acquisition - Condition data through planned maintenance inspections and service and automated data capture via track recording, rail grinding survey, wayside equipment readings and rail ultrasound recordings
- Transaction – Data gathered drives work requirements for planned corrective maintenance and scheduled renewal works. Work is transacted via a SAP interface.
- Decision – the data flowing from inspections and other data collection is utilised to analyse asset condition trend, prioritise renewal scope requirements and review interventions under the planned inspection and tonnage-based maintenance.

- Application and Feedback – Information derived from analysis of data and completion of works is fed back into the data acquisition processes. The insights gained from analysis drive better condition knowledge and allows for advanced planning and resource management.

The system is guided by the Asset Standards and Polices and underpinned by a complete master data suite across all assets, as highlighted in Figure 5 below.

Agreed tonnage forecast, intervention rates from standards and calculated expected asset engineering life are analysed against the actual asset condition trend to develop the long-term maintenance and renewal requirements across each system.

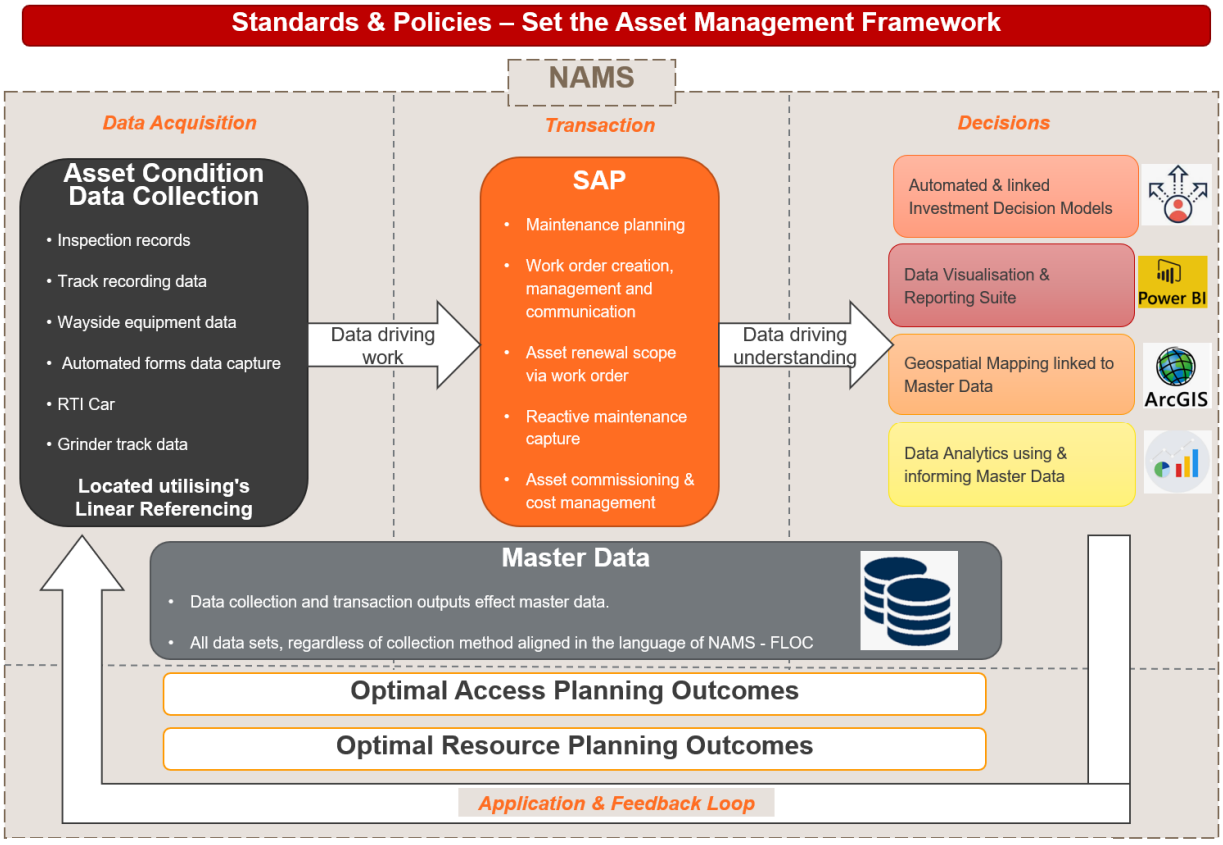


Figure 5. Network Asset Management System (NAMS)

In this proposed FY21 strategy a further investment in NAMS is highlighted. Currently the NAMS system is operating as a maintenance work management system, planning and assigning identified and planned works. The final investment in NAMS is introducing treatment of renewal expenditure works to NAMS so that renewal and maintenance works are in the one works management system. This will allow for analytics on NAMS master data to drive better investment decisions and complete the alignment of all works managed in a single system with visibility to the asset manager, possession planer and works executor.

The completion of the NAMS system will address a number of data and historical cost tracking issues raised by the QCA's consultant GHD, in the UT5 submission process. Further detail is provided in Appendix 10. Aurizon Network has invested in NAMS to capture and manage cost and scope data.

Advanced Planning and Scheduling

Aurizon Network is implementing an Advanced Planning and Scheduling system (APS) to modernise the planning and scheduling of access on the CQCN.

APS is transforming the way Aurizon Network undertakes planning and scheduling by modernising the way we plan and schedule onto a single platform that interfaces with NAMS. APS is critical for enabling the Network planning and scheduling teams to deal with the modern complexities of increasing traffic volumes over an expanding and interconnected CQCN. APS will enable forecasting, planning and scheduling by utilising statistical algorithms to determine scheduling solutions based on the constraints determined by business processes and deliver optimised planning and scheduling solutions for our customers.

APS enables quicker and more effective and efficient responses to customers' needs, through:

- Increased capability to deal with growing operational complexity and traffic volumes
- Timely updates to customers across various operational and planning horizons with up-to-date reporting to assist with train service allocations
- Scenario capability to quickly develop multiple plans and work with customers to agree on implementing the best plan

Asset Management Innovations

Aurizon Network is at various stages of developing further innovations to better understand asset performance in real time, informing the maintenance and renewal strategies, including through:

- Esri GIS – visual representation of the network on a Geographic Information System (GIS) mapping tool to allow for desktop site analysis and works planning reducing the need for field-based inspections
- Automated Track Inspection – mounted track recording equipment on rail operators' trains lessoning the reliance on dedicated track runs which will free up train paths for coal carrying services in addition to increasing the data points available for analysis
- Rail profile review – changes to the wheel and rail profiles to prolong the life of rail in curves and reduce grinding frequency
- Digital forms – transferring of data captured via asset inspections seamlessly into the management systems and live linking data to assets removing the administrative burden of data entry
- Remote Temperature Monitoring – measurement of rail and ambient temperatures across the network in real time allowing for more targeted application of heat related speed restrictions during summer months
- Identification and verification of location via GPS – Using differential GPS to confirm location of track workers to most accurately position them for track protection Plant and people separation – use of sensors and AI to reduce probability of serious injury or fatality through failure to maintain separation of track workers and plant in the rail corridor

Targeted advancement in management and decision and safety systems will allow Aurizon Network to further monitor the condition and performance and safety of the rail infrastructure to adapt maintenance and renewal strategies to manage for total expenditure efficiency within available possessions.

System Characteristics and Effect on Maintenance and Renewal Scope

Each of the four coal system in the CQCN have individual characteristics that have some effect on the maintenance and renewal works required in these systems.

Goonyella System

- Civil Assets – The civil assets in the Goonyella system see the highest tonnage of the four coal systems and the highest train density. The Great Dividing Range crossing at Black Mountain is a significant rail crossing with high grades and tight cures resulting in significant train dynamics and inertia forces applied to the rail, sleeper and formation assets.

- Control System Assets – A significant amount of the control system assets in the Goonyella system are the original 1980's infrastructure from initial installation. These assets are beyond their nominal service life and are reaching a point where they will not meet their safety function of train separation.

- Electrical Assets – Like the control system assets, the majority of electrical assets are from the original installation during the Goonyella Electrification project. The assets nearest the ports see significant corrosion due to the costal environment. The Goonyella system has more overhead line equipment than the Blackwater system.

Total tonnage and train density, along with the significant range crossing, result in maintenance and renewal activity in the Goonyella system being very similar to that in the Blackwater system, even though it is a smaller system by distance. Due to the concentration of train movements, the Goonyella system has the highest volume of activities triggered by tonnage.

Blackwater System

- Civil Assets – Unlike the Goonyella system, the Blackwater system was not built as a heavy haul coal network. As a result, there are sections of formation and structures that date back to the late 1800's. In addition to this change of purpose, the rail alignment traverses significant sections of low-lying floodplains and black soil which result in formation and track alignment issues during periods of wet and very dry weather.

- Control System Assets – The completion of the Wiggins Island Rail Projects and the Blackwater Duplications in the early 2010's has resulted in a significant upgrade of the telecommunications, wayside and train protection systems throughout the system. However, there are some aged control system assets particularly west of Tunnel. The interlockings in Callemondah yard were installed in the 1970's and train detection track circuits where installed in the 1980's and are nearing end of life.

- Electrical Assets – The condition of these assets are comparable to those in the Goonyella system as they were installed during the 1980's Main Line Electrification Project. There were 4 new feeder stations installed in 2012.

Blackwater is the largest system by track distance and is also the oldest system. These conditions, combined with variable sub soils conditions, result in the higher track resurfacing and formation renewal activity than other coal systems.

Newlands

- Civil Assets – The GAPE project built a 65km greenfield connection between the Goonyella and existing Newlands Systems in 2012. This project also upgraded the pre-existing Newlands system from 20 tone axle load to 26.5 tonne. These upgrades included rail replacements, formation strengthening and structure renewal. Current activity is centred around the sections that were not upgraded in 2012.

- Control Systems Assets – This asset class was also modernised during the GAPE project and is the only fully digitised control system. Like the civil assets, these upgrades are intermixed with aged assets. For control systems, these aged assets include the section of non Remote Controlled Signalling (RCS) controlled track between the Newlands Junction section and Collinsville.

The non-upgraded sections of the Newlands system attract the majority of the maintenance and renewal activity given these assets are aged and there are sections of 53kg rail and fist fastener sleepers associated with the original 20 tone axle load operations.

Moura System

- Civil Assets – Like the Blackwater system, sections of the Moura system are located on black soils leading to formation and alignment issues when wet or very dry. The system has tight radius curves on Mount Rainbow and several large sized original constructed corrugated metal pipe culverts inside large embankments.

- Control System Assets – Processor based interlockings installed in the 1990's are now life expired and, whilst operating, will require attention in the coming years. There is no optic fibre linkage in the Moura system with telecommunications carried by the microwave radio system, as a result there is limited back up communication paths in the event of microwave failures.

The Moura System is the smallest of the systems with regard to both tonnage and distance. The system has some geographical challenges with track access and alignment. It traverses black soil plains, a large range crossing and has poor drainage on the plateau west of Mt Rainbow. The system has been managed fit for purpose given the tonnage and as such has seen suppressed investment in recent years.

PROPOSED FORECAST SCOPE AND COST BUDGET

Network maintenance and renewal asset scope is driven by the guiding principles of the proposed Asset Maintenance and Renewal Strategy, to employ integrated planning and focus on cost effective asset reliability. This section will outline key maintenance and renewal scope considerations and provide FY21 forecast scope and budgeted cost as well as a 4-year outlook for investment.

The application of the maintenance and renewal strategies across the coal systems drives a forecast scope requirement that is cost budgeted using historic and forecast data. This provides a forward budget of cost, scope and required track access. The scope is not driven by or designed to fit a prescribed budget.

The maintenance and renewal scope for each of the four coal systems and associated budget are detailed in Appendices 1 to 8.

A detailed review of the application of the maintenance and renewal strategies to each asset type is provided in Appendix 9

Maintenance and renewal costs against prior years and the UT5 Final Decision are summarised in the tables below.

Maintenance Budget

System ($m)	FY18 Actual	FY19 Actual	FY20 UT5 FD	FY21 UT5 FD	FY21 Budget
Newlands	$12.2	$13.8	$13.6	$14.4	$13.7
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Table 3. Maintenance cost budget per system FY21

Renewal Budget

Table 2. Asset renewal cost budget per system FY21

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Newlands	$17.0	$15.3	$20.5	$21.4
Goonyella	$96.9	$74.9	$115.3	$113.5
Blackwater	$98.4	$87.4	$91.3	$116.1
Moura	$15.8	$20.5	$15.9	$15.4
TOTAL	**$228.1**	**$198.1**	**$243.0**	**$266.4**

Table 4: FY21 Cost budget per system

The following graphic shows actual and forecast maintenance and renewals budget spend against actual and forecast tonnage across the CQCN for the period FY18 to FY25. Over this period total expenditure is decreasing as a trend at a rate of c.1% year on year whilst tonnage across the CQCN is increasing at a trend of c.1% to 1.5% a year

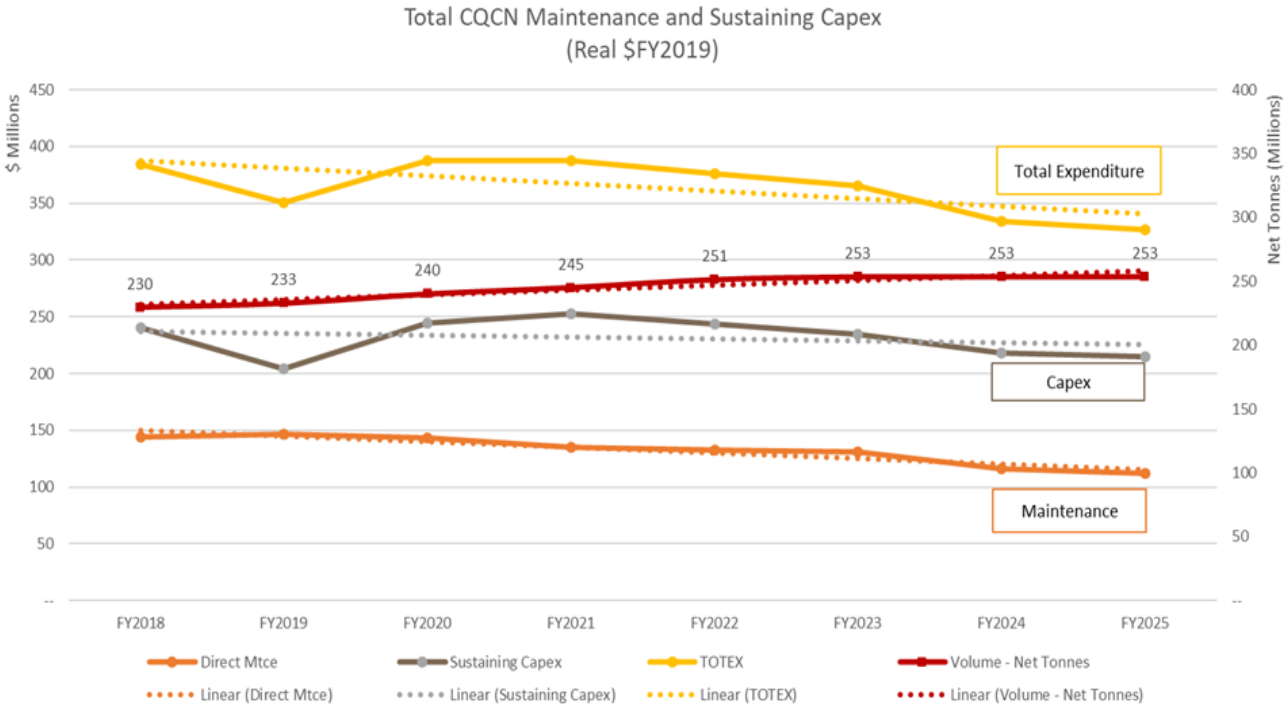


Figure 6: Total CQCN Maintenance and Sustaining CAPEX (Real $FY19)

Major maintenance and renewal categories

This section provides a description of the key maintenance and renewal categories (in terms of proposed budgeted spend), identifies benefits of completing the works, the risks mitigated and the maintenance or renewal trigger.

Maintenance Categories Products

Key maintenance categories include:

Categories	Description	Benefits and Risks Managed	Maintenance Trigger	FY21 Budget
Resurfacing	Fleet of plant used to restore the geometry of the track and turnouts by lifting and lining to the appropriate level and alignment and compacting the ballast underneath the sleeper This fleet is also utilised to complete tasks within the renewal program and ballast undercutting program, these costs are assigned to those activities and not in the FY21 budget	• Maintaining track alignment mitigates the need for temporary speed restrictions applied as a risk control prior to component renewal or full asset renewal.	Triggered by tonnage over a rail section • Track resurfacing: 50 million gross tonnes (MGT) • Turnout resurfacing: 80 MGT Also applied to remedy geometry faults identified through rail inspections and track recording car	$20.9m
Rail Grinding	Specific plant that grinds rail in track and turnouts to remove micro cracks and small surface faults from the rail, restoring a profile that spreads the contact band, and positions it for better wheel set tracking around the curves.	• Removes micro and small faults in the rail surface that if not treated can result in rail failure or breakage. • Prolongs the life of the rail (further extended through use of rail lubricants)	Triggered by tonnage over a rail section or curve • Straights: 40 MGT • Curves 1001m to 2500m radius: 20 MGT • Curves less than 1000m radius: 10 MGT • Turnouts: 40 MGT	$17.5m
General Track Maintenance	Encompasses the planned corrective maintenance effort, responding to faults identified by drivers, track inspection, specific asset inspection, and Track Recording and Rail Flaw	• Faults managed via the NAMS system to align required works to minimise impact on capacity	• Planned corrective dependant on fault severity and time to remedy	$49.2

Categories	Description	Benefits and Risks Managed	Maintenance Trigger	FY21 Budget
	Detection inspections. Activity can be planned according to the severity and the time period for fault/fault remedy of the identified fault. Fault severity ranges from : • Immediate - Track closed until repair completed • Y1 – repair required within 1 year of identification	• Faults managed to mitigate against infrastructure failure leading to unplanned outages • Localised depots responding to infrastructure faults to reinstate operability of the network in a controlled manner	• Planned rectification works on identified faults to return equipment to working condition • Blackwater North Coast Line (NCL) – 4 times per year • Blackwater – Central Line Mainline, Branches, Balloons and Passing Loops – 2 times per year • Goonyella – Mainline, Branches, Balloons and Passing Loops– 2 times per year • Moura and Newlands mainline, passing loops and branches – 2 times per year • Ultrasonic Testing Track every 10MGT • Rail Flaw Detection Manual - Track and Turnouts	
Other Civil Maintenance	Ballast Undercutting Minor Activities on Track and Turnouts. Ballast Undercutting Minor Track is a corrective maintenance activity to replace the fouled ballast and mud holes from beneath the sleepers for a length of track up to approximately equal or less than 40 sleeper bays (as a guide).	• Identification of faults not visible via person inspections allows for fault rectification in a controlled manner prior to the fault resulting in a failure • Undercutting Minor Activities Spot repair mudholes and small areas of ballast fouling which cause track defects and increase the risk of derailment and remove TSRs.	• corrective ballast undercutting activities dependant on defect severity and time to remedy	$6.9m
Structures and Facilities Maintenance	Periodic inspection of bridge and culvert structures to monito asset condition and performance	• Trend of condition allows for component or renewal works to be forward programmed given the wear rate of the assets	• Ground based bridge decks – every 2 years • Scaffolded inspection – every 10 years	$5.6m

Categories	Description	Benefits and Risks Managed	Maintenance Trigger	FY21 Budget
		• Faults managed to mitigate against infrastructure failure leading to unplanned outages	• Under group pile exam – every 10 years • Underwater Inspection – every 4 years	
Signalling and Telecommunication Maintenance	Inspection and maintenance that is regularly performed on the signalling asset to lessen the likelihood of it failing. Performed whist the asset is in place and working so that it does not break down unexpectedly.	• Faults managed to mitigate against infrastructure failure leading to unplanned outages	• Time based – planned periodic inspection and repair activities Planned rectification works on identified faults to return equipment to working condition	$23.3m
Trackside Systems Maintenance	Inspection and maintenance that is regularly performed on the wayside equipment assets to lessen the likelihood of it failing. Performed whist the asset is in place and working so that it does not break down unexpectedly.	• Faults managed to mitigate against infrastructure failure leading to unplanned outages	• Time based – planned periodic inspection, servicing and repair activities • Planned rectification works on identified faults to return equipment to working condition	$2.1
Electrical Overhead Maintenance	Inspection and maintenance that is regularly performed on the electrical substation and overhead line assets to lessen the likelihood of it failure. Performed whist the asset is in place and working so that it does not break down unexpectedly.	• Faults managed to mitigate against infrastructure failure leading to unplanned outages	• Time based – planned periodic inspection and repair activities • Planned rectification works on identified faults to return equipment to working condition	$9.0m
Other General Maintenance	Asset Management and Inventory Management	• Inventory is held and managed at specific location across the network so as materials required for recitation works are available	• Critical spares determined by lead time to obtain parts, level of supplier support and availability of materials / component	$7.7m

Table 5: FY21 maintenance products by budgeted spend

General track maintenance and corrective signalling maintenance encompasses most of the planned corrective maintenance effort, responding to faults fault identified by track inspection, specific asset inspection and rollingstock operators. Activity can be planned according to the severity and the time period for fault remedy of the identified fault. Possessions required to remedy faults may be:

- Emergency Possession: A Possession required to rectify a serious fault with the Rail Infrastructure that Aurizon Network (acting reasonably) considers dangerous to any person, or where severe speed restrictions have been imposed affecting the scheduled Train Services of Railway Operators and that Aurizon Network, complying with the Possession Protocols, will use reasonable endeavours to carry out within seven days after the detection of the fault giving rise to the need for that Possession.

- Urgent Possession: a possession

    - required to correct problems that Aurizon Network (acting reasonably) considers potentially dangerous to any person, or property;
    - notified to Access Holders less than twenty-one (21) days in advance of taking effect; and
    - that Aurizon Network, complying with the Possession Protocols, will use reasonable endeavours to carry out between seven (7) days and three (3) Months after the detection of the fault giving rise to the need for that Possession.

- Planned Possession: A Possession that may adversely impact upon the operation of Train Services and is notified to Access Holders at least twenty-one (21) days prior to taking effect and, for clarity, includes Maintenance Work.

Due the variability of the actual maintenance task for other activities, a clear definition ahead of the fact is not possible to assign a scope measure prior to a year, similarly the definition of a unit rate in the absence of scope is also problematic. As such no scope or unit rate is shown against these products. The estimated forecast is typical with prior years budgets for these products taking into account tonnages across the network compared to prior years, general cost increases and efficiency and productivity improvements.

Maintenance Unit Rates

Aurzion Network tracks unit rate performance for products that are repeatable and scoped to review performance and set forward forecasts.

Category	Historical and Forecast Unit Rate				Commentary
Track Resurfacing ($ per Km)	FY18	FY19	FY20F	FY21	FY18 unit rates were lower due to new fleet with a reduced component charge out required in that year.
	$6,725	$7,615	$7,759	$7,854	
Turnout Resurfacing ($ per location)	FY18	FY19	FY20F	FY21	Increased rate since FY18 due to increased spend on components.
	$7,778	$8,208	$8,783	$8,983	
Rail Grinding ($ per Km)	FY18	FY19	FY20	FY21	FY19 rate was higher on lower mainline kilometres due to a reduction in track time leading to 6% higher cost.
	$3,595	$3,844	$3,668	$3794	
Turnout Grinding ($ per location)	FY18	FY19	FY20	FY21	The unit rate is expected to remain steady following achievement of efficiency gains in FY19.
	$5,765	$5,309	$5,320	$5,350	

Table 6: FY21 maintenance products, historical unit rate

The maintenance unit rates in the table above represent total category costs against total CQCN scope. Unit rates do vary between systems, for example, the FY21 rate per unit in Blackwater for turnout resurfacing is $8,127 for 173 turnouts opposed to $14,970 for 21 turnouts in Newlands. These fluctuations are attributable to:

- The number of assets being maintained per system – mechanised plant has a significant fixed cost and the unit rate is a function of these fixed costs against the number of work task being completed in a system
- Travel requirements – variable costs related to machine travel time requirements from home station to system of work or when moving between systems.

Asset Renewal Categories

Key renewal categories:

Category	Description	Benefits and Risks Managed	Renewal Trigger	FY21 Budget
Ballast	Over time ballast becomes fouled through degradation, sub soil contamination and coal dust. Ballast undercutting removes these contaminants from the ballast to restore drainage and load distribution requirements. Ballast fouling is managed via the following approaches dependant on the location of the fouling: • Ballast Undercutting Machine - excavating the fouled ballast from beneath the sleepers by a dedicated ballast cleaning consist, • Ballast Replacement as part of a formation repair or track upgrade – ballast can be replaced as part of the formation repair or track upgrade activity. • Ballast Undercutting Turnouts - excavating the fouled ballast and mud holes from beneath a turnout by minor mechanised equipment such as an excavator • Bridge Ballast Roll Out – due to the width, height and environmental constraints on bridges fouled ballast on bridges is completely removed and new ballast added.	Restores the drainage and load management properties of the ballast moving water away from the formation and spreading loads across the track structure to reduce the risk of formation issues leading to track geometry faults	Ground Penetrating Radar (GPR) provides a measure of ballast fouling severity comparative to prior GPR runs. This provides both degradation rate and level of fouling. Scope is determined based on the most fouled locations or those showing the greatest degradation matched to the production of the Undercutting fleet.	$67.1m

Category	Description	Benefits and Risks Managed	Renewal Trigger	FY21 Budget
Rail Renewal	Replacement of rail in a section of track due to rail fatigue (increased fault rates) and/or wear outside of Aurzion engineering standard. Rail renewal includes rail stressing to match the tension of the track with the surrounding railway reducing risk of rail misalignment (buckles) and rail breaks	• Renewing rail in a planned way reduces rail breaks and rail faults that would otherwise lead to unplanned delays • Reduces derailment risk related to rail break or rail misalignments	The timing of renewal is dependent on the weight of the rail, its location in track (loaded / unloaded, on straights or curves) and rail compassion (head hardened, standard carbon on through hardened) Network utilises a rail wear data base to identify future years renewal requirements based on rail wear against standard to determine the required renewal intervention	$60.7m
Turnouts and Component Renewal	Turnouts (sometimes called Switches) allow trains to move between tracks in duplicated sections, as well to allow entry and exit from passing loops and to move from the main line into spurs and balloon loops. A turnout is a combination of civil assets being the steel rail and sleepers and Control Systems Assets being the points motors, rodding and electronics	• Component renewal extends the life of the turnout • Full renewal re-life's assets and maintains operability of turnout providing operational flexibility	Renewal - Condition and location of assets and degradation rate Component – items within the turnout that require renewals based on asset component condition	$17.2m
Sleeper Renewal	Sleepers (or ties), along with sleeper clips, hold the rails to gauge and alignment. There is a variety of sleeper types across the CQCN with most being 60kg concrete. Other sleepers are lower Kg's or apply older styles of sleeper and rail fastening (clips). In sidings and older track sections there are both timber and steel sleepers.	• Reduction is track alignment issues relating to gauge and rail twist leading to temporary speed restrictions or unplanned delays. • Reduces derailment risk cause by loss of gauge or rail twist	Sleepers are condition scored based on weight, material and condition. The sleeper renewal program is renewing aged underweight sleepers with the 60kg concrete standard	$11.7m
Structures Renewal	Structures are bridges and culverts that allow for the flow of water through the rail formation or for access under the track Bridges are located at large hydrological water flows (rivers, creeks etc) Culverts are located at low points allowing overland flows through the track infrastructure.	• Renewal of assets prior to failure to reduce unplanned delays or safety risks associated with structure failures • Strategy to review hydrology in renewal locations to reduce number of culverts.	Structures are inspected and assigned a condition rating and allotted a location criticality. Structures are then ranked based on condition and location scores	$22.9m

Category	Description	Benefits and Risks Managed	Renewal Trigger	FY21 Budget
Control Systems Renewals	Control Systems assets are the physical and digital assets that provide, train control, telecommunications and wayside monitoring systems. These assets provide the capacity multiplier for the track assets, that is they allow for the safe movement of more train services over the track structure. The main classes with in the control systems grouping are: - Train control Systems: signalling system, level crossing active protection, interlockings and point motors - Telecommunications: the data network required to connect assets to train control, includes the optic fibre network, digital radio and microwave radio systems - Wayside Systems: assets in the rail corridor that provide a level of monitoring and alarming to protect track and overhead assets	Train control: • Ensure the continuity of the train control systems and provides incremental improvement to the operability of the system Telecommunications: • Reduce telecommunication outages due to fibre faults and data flow interruptions • Ensure the integrity of the safe working systems • Ensure the track side equipment faults are being reported for cation Wayside systems: • Allows for real time monitoring across the 2600 km network to identify out of tolerance or non-controlled rollingstock interface issues and stop or reduce the impacts	Unlike Civil assets, the trigger for the renewal of Control System assets is predominantly driven by the age of the asset along its life cycle. These assets do not necessarily wear with tonnage, and often don't show degradation until the point of failure. Obsolescence of data systems or components is also a key trigger for asset renewal.	Train Control $2.3m Telecoms $22.6m Wayside Assets $19.7m
Electrical Renewals	Blackwater and Goonyella systems are electrified, enabling the operation of electric rollingstock. The traction system comprises two main asset groups, - Overhead Line Equipment (OHLE) - infrastructure distributes traction power to trains on the system - Traction Substations - stations provide a means of connecting to the high voltage transmission network (Powerlink or Ergon) and converting	OHLE • Renewal of components cross the 2000km of OHLE to reduce the instances of faults causing disruptions and cancelations. Traction substations • Managing the risks associated with the control of high voltage electricity	Like Control systems assets renewal is driven by the age of the assets against their lifecycle, they do not wear with the passage of trains and don't show high levels of degradation ahead of failure Major renewals of traction substation assets will be required in line with the downstream renewals by the 132kv suppliers. Aurizon Network is working closely with these third parties to	OHLE $5.5m Power Systems (Traction Substation) Subs) $6.3m

Category	Description	Benefits and Risks Managed	Renewal Trigger	FY21 Budget
	the transmission voltage (132kV or 275kV) down to 50kV for the traction system All the traction substations which were built as part of the main line electrification in the 1980s are nearing the end of their service life. Aurizon Network is employing best-practice asset management techniques to further life-extend this infrastructure. In parallel with this Aurizon Network is actively investigating modern technology alternatives to traditional substations which would allow for more cost-effective electrification topologies. It is likely that future renewals of traction substations will employ these new technologies.		understand the timing and impacts to the Aurizon assets	

Table 7: FY21 asset renewal products by budgeted spend

Asset Renewal Unit Rates

Aurizon Network tracks unit rate performance for the renewal of major products to review performance and set forward forecasts.

Product	Historical and Forecast Unit Rate				Commentary
Ballast ($K per Km undercut)	FY18	FY19	FY20	FY21	The FY20/FY21 unit rate increases are due to increases in ballast freight cost, and in FY21 partly due to increased cost of components for the commissioning of the new ballast undercutter. The new ballast undercutter is designed and planned to deliver scope at an improved rate so that for relatively the same unit rate scope can be delivered with 27% lower track time utilisation.
	407	418	435	439	
Track Upgrade ($/K)	FY18	FY19	FY20	FY21	Track Upgrade renews total track structure at a single site (sleepers, rail, fastenings and in some locations ballast) maximising the efficiency of asset renewal activities by only mobilising to site once. The unit rate for a combined track upgrade project in FY21 is forecast to be $1,344K/KM against a combined unit rate for separate rail upgrade and a sleeper upgrade of $1,718K/KM. Track Upgrade works are only undertaken where all track elements require replacement. The lower unit rate in FY20 was due to a targeted efficiency from the FY19 year. This FY20 base rate has been carried into FY21 however have been offset by increases in costs of sleepers and materials freight costs.
	1,335	1,389	1,225	1,344	

Rail Renewal ($K per Km re-railed)	FY18: 439 FY19: 466 FY20: 411 FY21: 411	The Rail Renewal unit rate is forecast to remain steady in FY21 at lower unit rates that FY18 and FY19 due to efficiencies in planning and combining sites for renewal .
Sleeper Renewal ($K per km sleepers)	FY18: 893 FY19: 894 FY20: 788 FY21: 896	The Sleeper Renewal Program targeted efficiencies in FY20 however This base unit rate has been carried into FY21 however have been offset by increases in costs of sleepers and materials freight costs.
Optic Fibre Renewals	The telecommunications fibre asset was installed in 1980s and has not seen a significant renewal in recent years, hence no unit rate comparison possible. Estimated cost is derived from early market engagement. This asset is operating beyond its design life and requires replacement. This optical fibre asset renewal will take place in FY21 and FY24.	
Structures Renewal	Culvert sites are estimated individually based on the type, number, length of culvert and accessibility to the site. Similarly, bridges are estimated based on type of bridge, length and specific renewal work identified to extend the life of the bridge. Aurizon is using sleeving technology where suitable to reduce track possession requirements for renewal works and reduce costs while extending the life of existing culvert locations.	
Turnout Renewal	Sites are estimated individually based on turnout angle (size), rail, ballast, formation or drainage works required as well as signalling (point machines and interlocking changes) and electrical works required at site.	

Table 8: FY21 asset renewal products, historical unit rate

ASSUMPTIONS TO PROPOSED SCOPE FORECAST AND COST BUDGET

Aurizon Network's proposed FY21 Maintenance and Renewal scope, cost and track access requirements are based on the following strategic assumptions:

- Tonnages – UT5 Final Decision revised to 245mt;
- References to historical data refer to the application of the unit rates for key scope items as at 1 July 2019 to the forward year scopes with no escalation;
- Maintenance costs provided in the document are direct costs only;
- All budgets and forecasts are for coal traffic only with no costs included relating to non-coal traffic;
- All GAPE infrastructure is considered part of the Newlands system as has been the practice adopted under previous Undertakings;
- All asset renewal activities represented reflect the capital expenditure Aurizon Network expects to incur in a given year. By comparison, capital expenditure submitted for inclusion in the Regulated Asset Base (RAB) is on an 'as commissioned' basis. As a consequence, the value of capital expenditure reflected in the proposed Renewal Strategy and Budget may vary from the annual capital expenditure claim submitted to the QCA in line with Clause 7A.11.6 of the 2017 Access Undertaking;
- Under the UT5 DAAU, Aurizon Network proposes to recover the depreciation of ballast undercutting plant within the annual direct maintenance cost allowance.

INTEGRATED CLOSURE HOURS IMPACT

Forecast Closure Hours

Aligned to our guiding principles, Aurizon Network plans asset works to be integrated, cost effective and to target asset reliability and safety requirements of the rail infrastructure. Maintenance and renewal works are coordinated with ports and mines to minimise impacts on the supply chain. Planning aims to achieve fewer but longer duration closures together with maximising renewal and maintenance works during those closures.

The integrated approach, using a variety of track possession approaches balances priorities through:

- Scope driven closures;
- Supply chain balanced integrated works, aligned to ports and mines;
- Consideration for seasonality and customer demand requirements (i.e. reduced activity at the end of financial and calendar years);
- Consideration of supply chain operating paradigms including cross system demand.

Blackwater System

Planned integrated closures, branch closures and BCM

Blackwater	2020						2021						
(Hours)	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
System Closure	38	36	60		36		36		36	36	60		338
BCM – Inside System closure[4]			60		36		36		36				168
BCM – Central West			39	87	110	92	61	174	89				652
BCM – Bluff to Burngrove					82								82
BCM – North Coast Line			16				57						73

Goonyella System

Planned integrated closures, branch closures and BCM

Goonyella	2020						2021						
(Hours)	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
System Closure	60	36	36		36		12	36		36	48		300

Branch Line Closure – Gregory		36						60				96
Branch Line Closure – Nth Goonyella	52					56					52	160
Branch Line Closure – Blair Athol							54					54
BCM – Inside System closure	112	72							36	48		268
BCM – Goonyella Mainline	173	134	111						33	114		565
BCM – Coppabella to Wotonga		39	3					78				120
BCM – Gregory		5	8							51		64
BCM – Nth Goonyella								39	68			107

Moura System

Planned integrated closures, branch closures and BCM

Moura	2020					2021						
(Hours)	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
System Closure		72						36				108

Newlands System

Planned integrated closures, branch closures and BCM

Newlands	2020						2021						
(Hours)	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Total**
System Closure				108						38			146
BCM – Inside System closure				108									108
BCM – Mainline				4									4

Aurizon Network is preparing an addendum to this paper that will detail the development of the overall Access Strategy including

- The alignment of Network integrated closures and port closures

- Alignment with other interfaces
- Location and movement strategy of the Ballast Undercutting Machine
- Branch line closures

Details of all activities included within the Access Strategy are available on the CQCN ASSET ACTIVITY Power BI located at https://app.powerbi.com/groups/me/apps/68ac9546-ea00-422e-bed2-591bded0e001/reports/b72c8779-6578-432a-ae98-873c63fa9dec/ReportSectionf3b3689802aecca9c80a.

MAINTENANCE AND RENEWAL IMPACTS TO SUPPLY CHAIN OUTSIDE INTEGRATED CLOSURES

Effective asset management has the task of balancing work with impact on Deliverable Network Capacity. Aurizon Network is very aware that the safe operations of train services over the rail infrastructure whilst providing appropriate levels of Deliverable Network Capacity are the primary objectives. Additional maintenance and renewal work that occur outside of integrated closures are planned to balance Deliverable Network Capacity in each system. Additional planned works that occur outside of integrated closures and the principles to planning these works are detailed in the following section and discussed in Appendix 9.

Mechanised Maintenance and Renewal

Mechanised maintenance and renewal activities that are completed outside of integrated closures are managed to minimise the impact to Deliverable Network Capacity and to achieve the work requirements for the assets. Mechanised maintenance activities are outlined in the following table.

Task	Requirement	Planning Principle
Ballast Undercutting (Ballast scope is delivered inside and outside of closures, with highest impacted locations completed within closures)	Activity required to remove foreign elements from the track ballast to maintain track drainage and load distribution properties	Planned activity to deliver identified scope on a cyclic basis to affect a system for only a limited period of the year Pre and post works conducted outside track closure to minimise on track time Ballast scope is delivered inside and outside of closures, with highest impacted locations completed within closures
Rail Grinding	Reestablishment of rail profile and removal of rail faults	Planned activity with frequency rates defined in track standards. Frequency is dependent on the track alignment, i.e. more grinding on curves then straights. Plan based on when track sections will reach usage triggers
Track Resurfacing	Return track profile to required geometry for the safe and efficient operation of rollingstock over the rail infrastructure	Planned task triggered by usage Planned corrective maintenance task to rectify identified faults Planned as part of renewal activities where the track has been worked on
Road Runs	On rail inspections as part of the planned inspection strategy	Cyclic activity conducted each 96- or 192-hours dependant on location Included as part of the Master Train Plan (MTP) however optimised to

Task	Requirement	Planning Principle
		only consume unutilised or part paths where possible.
Asset Inspections	Automated measurement of track geometry, overhead alignment (Blackwater and Goonyella), fault identification and ultrasonic rail testing	Considered and planned as part of the MTP as a service

Table 9. Planning approach to works outside integrated closures

Risk Controls to Manage Assets

Aurizon Network employs several risk controls to manage asset faults and operations for a period ahead of a planned rectification. These include but are not limited to:

- Temporary speed restriction (TSR) – issues identified via inspections with track alignment or asset quality are assessed to have an immediate rectification or the assets can be held via a TSR until a planned outage is scheduled to rectify. Aurizon Network reduces train speed to reduce derailment or incident risk, as well as dynamic forces, in the period from fault identification to planned corrective action. TSR's are also applied to manage risk of incident resulting from the environmental effects of heat.

- Temporary Authorised Non-Conformance (TANC) – A TANC is applied if an asset is operating outsides its minimum operational standard. An engineering and safety risk assessment is undertaken to determine the treatment of these assets until the point that they can be rectified. Track speed may also be reduced, and the typical risk treatment is increased inspection to monitor asset performance.

- Temporary Track closure – if a fault has been identified on a section of track that can be isolated via operating on alternate tracks around the fault. The section is temporarily removed from service. This is achieved by putting a coded block in the train control system to remove the ability to route a train into the affected area.

Corrective Maintenance

General track maintenance encompasses the planned corrective maintenance effort, responding to faults identified by drivers, track inspections or specific asset inspections.

General maintenance activity is planned through assessing severity, criticality of the location and the time required to remedy the identified fault. Fault severity ranges from:

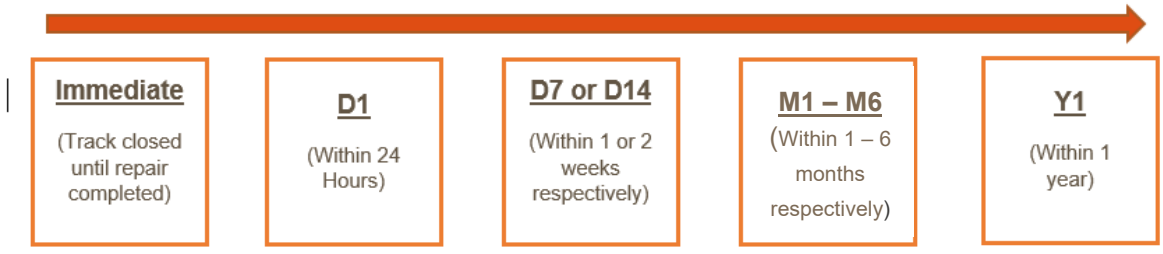


Figure 6: Planned corrective timing classes

Appendix 9 outlines the application of the maintenance and renewals strategies and a detailed view of maintenance and renewal tasks undertaking across the CQCN.

PROCUREMENT

Works Delivery and Resources

Aurizon Network seeks to apply the most efficient resources to deliver the scope derived by the maintenance and renewal strategies. It maximises the use of its internal Aurizon Network delivery teams and supplements resource requirements with pre-qualified contractor staff and plant.

The level of internal resource is optimised to meet the periodic inspection and planned corrective maintenance activities, required mechanised production activities, frequent renewal activities and respond to corrective maintenance requirements. Internal delivery staff work across both the maintenance and renewal programs.

Highly qualified internal staff allow Aurizon Network to respond to issues and incidents in a timely manner given proximity of depots to the rail network. Where additional resources are required to complete identified scope, suitably qualified contractor staff augment internal staff numbers.

As planned work is aligned to the closure plan, the volume of work performed each month can vary significantly during the year. The internal workforce is mobile to move between integrated closures and work locations, however given the peaky nature of closure work, contractor groups managed by Aurizon Network delivery teams are added when required.

If the scope requires a specific skill set or plant not held within the Aurizon Network group, it will engage pre-qualified contractors to perform work either under supervision or if approved, as contracted principal for short periods. Aurizon Network through its Enterprise Procurement group have established a series of engineering and technical service contractor panels. These include asset specific service panels, skilled labour hire, plant hire and plant transportation services.

All internal and contract workers are required to be accredited Rail Industry Workers and hold the appropriate qualifications for the activity they are undertaking. Aurizon Network has an internal assurance program for external contractors to ensure they have the required business and safety processes and policies that align with Aurizon Network's requirements.

Materials Procurement

Aurizon Network utilises its centralised enterprise procurement function to source the major materials required for the maintenance and renewal of the rail infrastructure.

Enterprise procurement has a performance-focused governance framework that ensures the right goods and services are procured to support Aurizon Network, at the right price, and quality ensuring delivery at the right place and time. The major materials utilised by Aurizon Network and their procurement approach are:

- Ballast – various quarries across Central Queensland are contracted to provide ballast and other rock and soil materials to defined Aurizon Network standards. Location is a critical consideration to reduce transit time and delivery cost
- Sleepers – Open tender contracted supplier producing and storing Aurizon Network specified sleepers in Central Queensland
- Rail – currently two international suppliers providing world leading heavy weight rail. Rail is delivered to the port of Brisbane, welded into 110m lengths at the Aurizon Rail Weld Facility in Brisbane and then transported via dedicated rail delivery rollingstock to trackside locations as per renewal scope
- Mechanised Plant – Periodic purchases based on open market tender

Inventory

Inventory is managed on a per asset class basis. For Asset Renewals inventory strategies include reducing the number of types of assets installed e.g. Turnouts or points machines to reduce the supporting component types required in inventory. Asset Managers also set emergency spares and component renewal inventory levels to ensure that minimum inventory is held balance with an ability to respond to emergencies. Control Systems inventory levels are managed to achieve system availability requirements and the renewals deployment schedule. Specialist replacement inventory is typically held at depot sites to support return to service response times. A centralised store is maintained for high volume consumables, and replacement stock for depot stores.

- The quantity of maintenance replacement inventory is typically set by procurement lead time requirements and usage frequency
- Additional inventory is held for equipment items that are becoming, obsolete in the market place, to defer renewal based on obsolescence
- Recovered obsolete components are retained in inventory to extend renewal intervals of components that are obsolete and beyond their economic life.

KEY THEMES AND NEXT STEPS

Key Themes

Aurzion Network has provided its proposed Maintenance and Asset Renewal forecast scope and budgeted costs for the FY21 year for consideration by the RIG in accordance with 7.4.11 of UT5.

These strategies are applied under the guiding principles of:

1. Integrated Closures – coordinated closures aimed at reducing total closure hours and maximising activity on track once a closure is taken,
2. Asset Reliability – asset renewed and maintained to be fit for purpose
3. Cost effectiveness – activities undertaken in a cost-effective way having regard to long-term asset reliability and providing Deliverable Network Capacity.

Aurizon Network manages the asset as the Rail Infrastructure Manager and has to balance safety, track possession time, mid to long term asset condition, number of unplanned delays and incidents and total spend across maintenance and renewals.

Aurzion Network maintains the assets in a typical way for linear assets. It does this via:

- Tonnage based interventions – activities carried out after a threshold of usage had passed
- Planned periodic inspections – set inspection times to monitor condition and identify faults
- Planed corrective maintenance – planned rectification of faults with the repair time dependant on the effect of the fault on system operations or safety
- Reactive maintenance – immediate remedy of faults that have disrupted operations of the rail network

Aurzion Network determines the renewal of assets based on:

- Asset condition – against the population of assets and degradation rates to defined end condition
- Asset location criticality – where the asset is located, what it supports and its effect on operations and safety in failure mode
- Supportability – the obsolescence of the asset class data or spares.

Next Steps

The RIG is now to review this submission in detail and Aurzion welcomes the opportunity to discuss the maintenance and renewal strategies at upcoming workshops and as required.

The following diagram provides the steps and key dates from this point through to the end of the FY21 RIG process

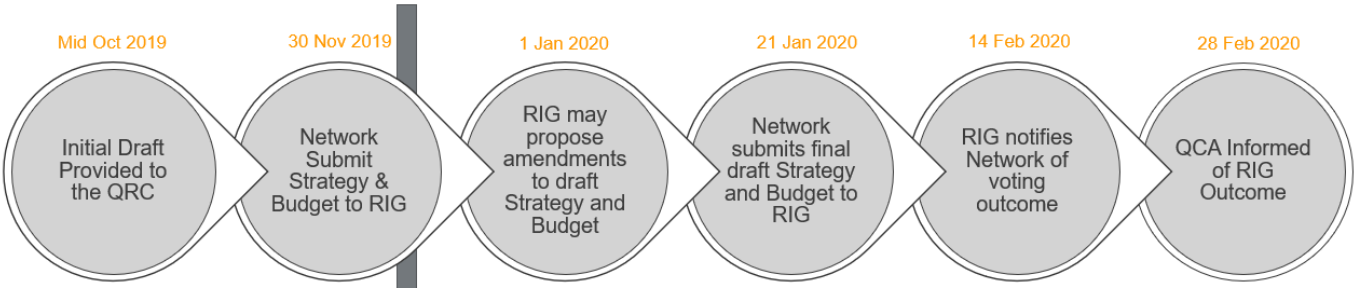


Figure 7: RIG Process Key Dates

APPENDIX 1 – Goonyella Maintenance Budget

Goonyella Maintenance Budget FY21 ($M)

	Scope Unit	Scope Quantity	Cost ($M)	Unit Rate FY21 ($/unit)	Unit Rate FY19 ($/unit)
Resurfacing			**$9.1**		
Resurfacing – Track	km	956	$7.4	$7,745	$6,915
Resurfacing - Turnouts	Number	189	$1.7	$9,078	$8,358
Rail Grinding			**$8.0**		
Rail Grinding Mainline	km	1556	$5.9	$3,778	$3,793
Rail Grinding Turnouts	Number	389	$2.1	$5,346	$5,333
General Track Maintenance			**$18.1**		
General track Maintenance			$16.7		
Track Recording	km	1940	$0.7	$390	$278
Ultrasonic Testing Car	km	7219	$0.7	$95	$98
Structures and Facilities Maintenance			**$2.0**		
Other Civil Maintenance			**$2.7**		
Signalling and Telecommunications Maintenance			**$8.8**		
Signalling Corrective Maintenance			$2.4		
Signalling Preventive Maintenance			$3.6		
Telecommunications Corrective Mt			$0.2		
Telecommunications Preventive Maintenance			$2.5		
Track Side Systems Maintenance			$0.9		
Electrical Overhead Maintenance			$5.0		
OHLE Corrective Maintenance			$1.2		
OHLE Preventive Maintenance			$2.4		
Traction Substation Corrective Maintenance			$0.3		
Traction Substation Preventive Maintenance			$1.2		
Other General Maintenance			$2.3		

Asset Management and Inventory	Item	$1.9
On Call		$0.5
MAINTENANCE TOTAL		**$56.9**
Ballast Depreciation		$3.1
GRAND TOTAL		$60.0

Notes to table:

Increase in Unit Rates between FY19 and FY21 are due to:

Resurfacing Mainline

- The increase in unit rate from FY19 to FY21 is due to the reduction in scope in FY21 from FY19 resulting in high fixed costs, particularly depreciation, being spread over less kilometres.

Resurfacing Turnouts

- The increase in unit rate is due to the slight increase in costs due to component replacement and the reduction in scope in comparison to the actual scope delivered in FY19.

Track Recording Car

- A new generation track recording car procured by QR is being utilised to replace the end of life old machine. This new machine provides increased & improved datasets, but at an increased contract price due to depreciation uplift for the new machine.

Unit rates do vary between systems, for example, the FY21 rate per unit in Blackwater for turnout resurfacing is $8,127 for 173 turnouts opposed to $14,970 for 21 turnouts in Newlands. This fluctuation is attributable to:

- The number of assets being maintained per system – mechanised plant has a significant fixed cost and the unit rate is a function of these fixed costs against the number of work task being completed in a system
- Travel requirements – variable costs related to machine travel time requirements from home station to system of work or when moving between systems.

Goonyella Maintenance Forecast Cost – FY19 – FY25 ($M)

	FY19A	FY21 (FD)	FY21	FY22	FY23	FY24	FY25
Resurfacing	**$8.5**	**$10.3**	**$9.1**	**$9.1**	**$10.2**	**$10.5**	**$9.8**
Resurfacing – Track	$6.8		$7.4	$7.4	$8.4	$8.7	$8.0
Resurfacing - Turnouts	$1.7		$1.7	$1.7	$1.8	$1.8	$1.8
Rail Grinding	**$7.9**	**$8.6**	**$8.0**	**$9.1**	**$8.7**	**$9.1**	**$9.1**
Rail Grinding Mainline	$6.4		$5.9	$7.0	$6.7	$7.1	$7.0
Rail Grinding Turnouts	$1.5		$2.1	$2.1	$2.0	$2.1	$2.1
General Track Maintenance	**$18.9**	**$20.2**	**$18.1**	**$18.0**	**$18.0**	**$18.0**	**$18.0**
General Track Maintenance	$17.6		$16.7	$16.6	$16.6	$16.6	$16.6
Track Recording	$0.6		$0.8	$0.8	$0.8	$0.8	$0.8
Ultrasonic Testing Car	$0.7		$0.7	$0.7	$0.7	$0.7	$0.7
Structures and Facilities	**$1.4**	**$2.3**	**$2.0**	**$2.0**	**$2.0**	**$2.0**	**$2.0**
Other Civil Maintenance	**$3.2**	**$0**	**$2.7**	**$2.7**	**$2.7**	**$2.7**	**$2.7**
Signalling and Telecommunications Maintenance	**$8.5**	**$11.4**	**$8.8**	**$8.7**	**$8.7**	**$8.7**	**$8.7**
Signalling Corrective Maintenance	$2.6		$2.4	$2.4	$2.4	$2.4	$2.4
Signalling Preventive Maintenance	$3.9		$3.6	$3.6	$3.6	$3.6	$3.6
Telecommunications Corrective	$0.3		$0.2	$0.2	$0.2	$0.2	$0.2
Telecommunications Preventive	$1.7		$2.5	$2.5	$2.5	$2.5	$2.5
Trackside Systems Maintenance	**$0.8**	**$0**	**$0.9**	**$0.8**	**$0.9**	**$0.8**	**$0.9**
Electrical Overhead Maintenance	**$4.3**	**$5.8**	**$5.0**	**$4.9**	**$4.9**	**$4.9**	**$4.9**
OHLE Corrective Maintenance	$1.0		$1.2	$1.2	$1.2	$1.2	$1.2
OHLE Preventive Maintenance	$2.1		$2.4	$2.3	$2.3	$2.3	$2.3
Traction Substation Corrective	$0.2		$0.3	$0.3	$0.3	$0.3	$0.3
Traction Substation Preventive	$1.0		$1.2	$1.1	$1.1	$1.1	$1.1

Other General Maintenance	**$3.5**	**$2.5**	**$2.3**	**$2.3**	**$2.3**	**$2.3**	**$2.3**
Asset Management and Inventory	$2.9		$1.9	$1.9	$1.9	$1.9	$1.9
On Call	$0.6		$0.5	$0.5	$0.5	$0.5	$0.5
MAINTENANCE TOTALS	**$57.0**	**$61.1**	**$56.9**	**$57.7**	**$58.6**	**$59.2**	**$58.6**
Ballast Depreciations	$2.4	$3.5	$3.1	$3.0	$3.0	$2.9	$2.9
GRAND TOTAL	**$59.4**	**$64.6**	**$60.0**	**$60.7**	**$61.6**	**$62.1**	**$61.5**

Notes to table:

Grinding Costs:
The slight increase in total expenditure is experienced in an increase in grinding costs. Aurzion renewed its grinding contract incorporating a reduced take or pay threshold of 80% compared to 95% under the old contract. This reduced threshold was to ensure the expected reduced grinding through the introduction of a new rail/wheel profile in FY20, which has the benefit of reducing track time for grinding by an anticipated 15%, could be accommodated with no take or pay triggering. The result is an expected cost in FY22 onwards consistent with costs in FY18 and FY19 as under the renewed contract the reduced take or pay threshold was achieved by agreeing to a slightly higher unit rate.

Accordingly, the new arrangement delivers similar overall cost but lower requirements for track time. FY21 cost is lower as the old lower unit rate was maintained for this year and FY20 with the increase only applying from FY22.

Other Civil Maintenance & Trackside Systems Maintenance:
The Maintenance Tables for FY19 Actuals to FY25 Budget for each System in Appendix 1 to 8, report the actual maintenance costs for FY19, FY21 QCA Final Decision Figures and FY21 to FY25 proposed budgets per System.

The Maintenance cost in the table are defined in terms of the Maintenance Categories detailed in the Undertaking Agreement and Schedules. Actual Costs for FY19 and Proposed Budgets for FY21 – FY25 are granular allowing for rollup and reporting to the Undertaking Maintenance Categories. The QCA FD FY21 Costs were reported to similar Maintenance Categorises however it excluded Other Civil Maintenance and Trackside System Maintenance Categories as these categories were included in General Track Maintenance and Signalling and Telecommunications Maintenance Totals respectively. This is reflected in the Maintenance Tables in the FY21 FD Cost Column for each system.

APPENDIX 2 – Goonyella Renewal Budget

Goonyella FY21 Asset Renewal Scope Forecast and Cost Budget ($M)

Asset	Scope Unit	Scope Quantity	% Total # Assets	Forecast Cost ($M)	Unit Rate FY21 ($M/unit)	Unit Rate FY19 ($M/unit)
Civil Assets						
Track Upgrade	Track KM	11	1.1%	$14.8	$1.3	$1.4
	Rail KM in Track Upgrade	20.8				
	KM Sleepers in Track Upgrade	10.5	1%			
	KM Sleeper and Ballast Renewal	4.5	0.4%	$4.0	$0.9	$0.9
	Reactive works			$0.3		
Rail	Rail KMs	24.4	1.2%	$10.0	$0.4	$0.5
Ballast Undercutting	KMs	66.3	6.5%	$29.2	$0.4	$0.4
Ballast Undercutting Turnouts	Number	23	5.4%	$2.8	$0.1	$0.1
Bridge Ballast	KMs	0.6	0.6%	$2.2		
Turnouts	Number Major Renewals	2	0.5%	$1.4		
	Turnout Component Renewals			$4.6		
Formation	KMs	1.7	0.2%	$4.8	$2.7	$4.8
Level Crossings	Major Level Crossings Renewals	1	0.4%	$0.8		
	Level Crossing Other Renewals		0.0%	$0.2		
Structures	Culvert Major Renewal	11	0.9%	$3.1		
	Bridges Major Renewal	1	1.0%	$2.2		
	Other Structures Renewals			$1.0		
Corridor Assets	Minor Civil Renewals			$1.3		
Control Systems Assets						
Safeworking system	Train Detection at Station	1	2.0%	$0.7		
	Interlocking Design or Renewal	1		$0.5		

	Asset Protection Sites and Sys wide	5	13.0%	$1.0		
Train Control System	UTC/DTC Packages System Wide FY21	14		$1.0		
Telecommunication Assets	KM of Optical Fibre Replacement	87	23.0%	$11.2		
Transmission and Data Network	Sites where renewal occurs	46	11.3%	$1.9		
Power Resilience	Sites and System Wide upgrades	8	15.3%	$4.8		
Electrical Traction Assets						
OHLE	Overhead component replacement - Major	12		$3.0		
	Overhead component replacement - Minor	32		$1.2		
Power Systems	Autotransformer Renewal – Major site	3	2.5%	$1.4	$0.5	$0.5
	Other Power Systems component replacement - Minor	62		$2.2		
Transformation						
NAMS Next				$1.8		
TOTAL				**$113.5**		

Notes to table:

Ballast Undercutting

- The FY21 unit rate increase is due to increases in ballast freight cost, more components and consumables for plant due to the new undercutter .

Turnouts

- Turnout renewal scope includes major component renewal within turnouts to extend asset life ahead of total replacement. This product also includes removal of redundant turnouts to consolidate turnouts in each system. This approach is in line with the Turnout Asset Strategy.

Formation

- Formation unit rate improvement reflects a move from reactive works to planned scope which is being delivered at the more efficient rate.

Corridor Assets

- Corridor Assets include Access Roads, Access Points (connections to major roads), Corridor Security (fencing) and a GPR Data Run to collect asset data to inform the Ballast and Formation Programs.

Telecommunications

- The telecommunications fibre asset was installed in 1980s. This asset is operating beyond its design life and requires replacement, particularly due to risks associated with cladding degradation which may not be able to be repaired when it breaks. This optical fibre asset renewal will take place in FY21 and FY24.

Asset Renewal products not showing unit rate analysis

- Products which don't include unit rates have a budget developed per site due to the complexity and variability of works at each site. These costs are estimated based on bottom up estimates. These products also include multiple asset activities within the same asset type.

Goonyella FY21 to FY25 Renewals Cost Budget ($M)

	FY21	FY22	FY23	FY24	FY25
Civil Assets	**$82.9**	**$87.7**	**$89.8**	**$87.6**	**$88.5**
Rail	$25.2	$24.4	$24.4	$24.4	$23.4
Sleepers	$4.0	$4.5	$4.5	$4.2	$4.5
Ballast Undercutting	$29.2	$29.3	$29.3	$29.3	$29.3
Ballast Undercutting Turnouts	$2.8	$2.8	$2.8	$2.8	$2.8
Bridge Ballast	$2.2	$3.1	$2.9	$2.9	$3.2
Turnouts	$6.1	$7.1	$7.7	$7.1	$7.7
Formation	$4.8	$6.1	$5.7	$5.5	$4.9
Level Crossings	$1.0	$1.0	$2.6	$2.4	$2.6
Structures	$6.3	$8.2	$8.6	$7.7	$8.8
Civil Renewals (fencing, earthworks, corridor)	$1.3	$1.2	$1.3	$1.3	$1.3
Control Systems Assets	**$21.1**	**$21.2**	**$18.3**	**$14.4**	**$14.4**
Electrical Assets	**$7.7**	**$9.1**	**$9.1**	**$9.1**	**$9.1**
Transformation	**$1.8**				
TOTALS	**$113.5**	**$118.0**	**$117.1**	**$111.1**	**$112.0**

Notes to Table:

Across years there is fluctuation of spend against products, this is more pronounced in point assets such as turnout renewals, structure renewals and level crossing renewal. The spend is a function of the number of tasks occurring within a system in a given year. For example, in FY21 21 culverts and 1 bridge structures are forecast for renewal and 17 culverts and 1 minor bridge structure in FY22, this differential in scope accounts for the cost forecast budget of $11.2m in FY21 and $7.7m in FY22

The forecast expenditure in the optic fibre asset is increasing the Control Systems spend profile with this program being delivered in FY21 to FY24. In the outer years this investment is offset with a reduction in other Control Systems renewal assets.

APPENDIX 3 – Blackwater Maintenance Budget

Blackwater Maintenance Budget FY21($M)

	Scope Unit	Scope quantity	Cost ($M)	Unit Rate FY21 ($/unit)	Unit Rate FY19 ($/unit)
Resurfacing			**$8.6**		
Resurfacing – Track	km	896	$7.2	$7,995	$8,225
Resurfacing - Turnouts	Number	173	$1.4	$8,127	$7,533
Rail Grinding			**$7.2**		
Rail Grinding Mainline	km	1413	$5.3	$3,784	$3,868
Rail Grinding Turnouts	Number	349	$1.9	$5,348	$5,260
General Track Maintenance			**$20.4**		
General Track Maintenance			$18.0		
Track Recording	km	2790	$1.1	$406	$329
Ultrasonic Testing Car	km	8443	$1.2	$147	$168
Structures and Facilities Maintenance			**$1.9**		
Other Civil Maintenance			**$2.6**		
Signalling and Telecommunications			**$10.0**		
Signalling Corrective Maintenance			$2.0		
Signalling Preventive Maintenance			$5.0		
Telecommunications Corrective Maintenance			$0.2		
Telecommunications Preventive Maintenance			$2.8		
Trackside Systems Maintenance			**$0.7**		
Electrical Overhead Maintenance			**$4.1**		
OHLE Corrective Maintenance			$1.2		
OHLE Preventive Maintenance			$1.9		
Traction Substation Corrective Maintenance			$0.1		
Traction Substation Preventive Maintenance			$0.8		
Other General Maintenance			**$3.6**		

Asset Management and Inventory	Item	$2.0
On Call	Item	$1.7
MAINTENANCE TOTAL		**$59.1**
Ballast Depreciations		$3.1
GRAND TOTAL		**$62.2**

Notes to table:
refer to notes at corresponding table in Appendix 1

Blackwater Maintenance Budget Cost – FY19 – FY25 ($M)

	FY19 A	FY21 (FD)	FY21	FY22	FY23	FY24	FY25
Resurfacing	**$8.6**	**$9.0**	**$8.6**	**$8.7**	**$9.4**	**$9.5**	**$8.7**
Resurfacing – Track	$7.2		$7.2	$7.3	$7.9	$8.1	$7.2
Resurfacing - Turnouts	$1.4		$1.4	$1.5	$1.5	$1.5	$1.5
Rail Grinding	**$8.1**	**$8.6**	**$7.2**	**$8.2**	**$7.9**	**$8.3**	**$8.2**
Rail Grinding Mainline	$6.1		$5.3	$6.4	$6.1	$6.4	$6.3
Rail Grinding Turnouts	$2.0		$1.9	$1.9	$1.8	$1.9	$1.9
General Track Maintenance	**$22.5**	**$23.8**	**$20.4**	**$20.3**	**$20.3**	**$20.3**	**$20.3**
General Track Maintenance	$20.2		$18.0	$17.9	$17.9	$17.9	$17.9
Track Recording	$0.9		$1.1	$1.1	$1.1	$1.1	$1.1
Ultrasonic Testing Car	$1.4		$1.2	$1.2	$1.2	$1.2	$1.2
Structures and Facilities Maintenance	**$1.4**	**$2.7**	**$1.9**	**$1.9**	**$1.9**	**$1.9**	**$1.9**
Other Civil Maintenance	**$2.9**	**$0**	**$2.6**	**$2.6**	**$2.6**	**$2.6**	**$2.6**
Signalling and Telecommunications Maintenance	**$9.7**	**$11.9**	**$10.0**	**$9.9**	**$9.9**	**$9.9**	**$9.9**
Signalling Corrective Maintenance	$2.1		$2.0	$2.0	$2.0	$2.0	$2.0
Signalling Preventive Maintenance	$5.1		$5.0	$5.0	$5.0	$5.0	$5.0
Telecommunications Corrective Maintenance	$0.3		$0.2	$0.2	$0.2	$0.2	$0.2
Telecommunications Preventive Maintenance	$2.2		$2.8	$2.8	$2.8	$2.8	$2.8
Trackside Systems Maintenance	**$0.6**	**$0**	**$0.7**	**$0.6**	**$0.7**	**$0.6**	**$0.7**
Electrical Overhead Maintenance	**$5.1**	**$4.8**	**$4.1**	**$4.1**	**$4.1**	**$4.1**	**$4.1**
OHLE Corrective Maintenance	$1.5		$1.2	$1.2	$1.2	$1.2	$1.2
OHLE Preventive Maintenance	$2.4		$1.9	$1.9	$23 $1.9	$1.9	$1.9
Traction Substation Corrective Maintenance	$0.2		$0.1	$0.1	$0.1	$0.1	$0.1
Traction Substation Preventive Maintenance	$1.0		$0.8	$0.8	$0.8	$0.8	$0.8
Other General Maintenance	**$5.2**	**$1.9**	**$3.6**	**$3.6**	**$3.6**	**$3.6**	**$3.6**

Asset Management and Inventory	$3.0		$2.0	$1.9	$1.9	$1.9	$1.9
On Call	$2.2		$1.7	$1.7	$1.7	$1.7	$1.7
MAINTENANCE TOTALS	**$64.0**	**$62.8**	**$59.1**	**$59.9**	**$60.4**	**$60.8**	**$60.0**
Ballast Depreciation	$2.0	$4.0	$3.1	$3.1	$3.0	$3.0	$3.0
GRAND TOTAL	**$66.0**	**$66.8**	**$62.2**	**$63.0**	**$63.4**	**$63.8**	**$63.0**

Notes to table:
refer to notes at corresponding table in Appendix 1

APPENDIX 4 – Blackwater Renewal Budget

Blackwater FY21 Asset Renewal Scope Forecast and Cost Budget ($M)

Asset	Scope Unit	Scope Quantity	% Total # Assets	Forecast Cost ($M)	Unit Rate FY21 ($M/unit)	Unit Rate FY19 ($M/unit)
Civil Assets						
Track Upgrade	Track KM	5.5	0.5%	$7.4	$1.3	$1.4
	Rail in Track Upgrade	11.1				
	KM Sleepers in Track Upgrade	5.0				
	KM Sleeper and Ballast Renewal	8.0	0.7%	$7.4	$0.9	$0.9
	Reactive works			$0.3		
Rail	Rail KMs	35.3	1.5%	$14.5	$0.4	$0.5
Ballast Undercutting	KMs	67.9	5.8%	$29.9	$0.4	$0.5
Ballast Undercutting Turnouts	Number	19	4.2%	$2.3	$0.1	$0.1
Bridge Ballast	KMs	1.1	0.7%	$4.0		
Turnouts	Number Major Renewals	4	0.9%	$4.6		
	Turnout Renewals Other			$2.9		
Formation	KMs	0.8	0.1%	$2.3	$2.7	$4.8
Level Crossings	Major Level Crossings Renewals	3	1.2%	$2.4		
	Level Crossing Other Renewals	13	5.3%	$0.5		
Structures	Culvert Major Renewal	24	1.6%	$9.0		
	Bridges Major Renewal	1	0.7%	$0.2		
	Other Structures Renewals			$1.9		
Corridor Assets	Minor Civil Renewals			$1.6		
Control Systems Assets						
Safeworking system	Train Detection at Station	4	6.7%	$5.6		
	Interlocking Design or Renewal	5	6.8%	$3.3		
	Asset Protection Sites and Sys wide	4	7.9%	$0.6		
Train Control System	UTC/DTC Packages System Wide FY21	14		$0.9		
Telecommunication Assets	KM of Optical Fibre Replacement	38	7.5%	$5.0		

Transmission and Data Network	Sites where renewal occurs	57	14.7%	$3.0		
Power Resilience	Sites and System Wide upgrades	1	3.0%	$0.2		
Other Control Systems	Mixed units minor upgrades	3		$0.5		
Electrical Traction Assets						
OHLE	Overhead component replacement - Major	4	0.4%	$0.3		
	Overhead component replacement - Minor	10		$1.0		
Power Systems	Autotransformer Renewal – Major site	1	0.1%	$0.5	$0.5	$0.5
	Other Power Systems component replacement - Minor			$2.2		
Transformation						
NAMS Next				$1.7		
TOTAL				**$116.1**		

Notes to table:
refer to notes at corresponding table in Appendix 2

Blackwater FY22 to FY25 Renewals Cost Budget ($M)

	FY21	FY22	FY23	FY24	FY25
Civil Assets	**$91.3**	**$86.2**	**$86.7**	**$84.7**	**$85.5**
Rail	$22.2	$22.7	$22.7	$22.7	$21.7
Sleepers	$7.4	$4.2	$4.2	$3.9	$4.2
Ballast Undercutting	$29.9	$29.9	$29.9	$29.9	$29.9
Ballast Undercutting Turnouts	$2.3	$2.3	$2.3	$2.4	$2.4
Bridge Ballast	$3.97	$3.7	$3.5	$3.5	$3.8
Turnouts	$7.5	$6.6	$7.2	$6.6	$7.2
Formation	$2.3	$5.7	$5.3	$5.1	$4.5
Level Crossings	$2.9	$2.2	$2.4	$2.2	$2.4
Structures	$11.2	$7.7	$8.0	$7.2	$8.2
Civil Renewals (fencing, earthworks, corridor)	$1.6	$1.1	$1.2	$1.2	$1.2
Control Systems Assets	**$19.1**	**$18.5**	**$16.0**	**$12.8**	**$12.8**
Electrical Assets	**$4.0**	**$5.9**	**$5.9**	**$5.9**	**$5.9**
Transformation	**$1.7**				
TOTALS	**$116.1**	**$110.5**	**$108.6**	**$103.3**	**$104.2**

Notes to table:
refer to notes at corresponding table in Appendix 2

APPENDIX 5 – Newlands Maintenance Budget

Newlands Maintenance Budget FY21

	Scope Unit	Scope quantity	Cost ($M)	Unit Rate FY21 ($/unit)	Unit Rate FY19 ($/unit)
Resurfacing			**$1.8**		
Resurfacing – Track	km	188	$1.5	$7,718	$8,191
Resurfacing - Turnouts	Number	21	$0.3	$14,970	$13,747
Rail Grinding			**$1.4**		
Rail Grinding Mainline	km	291	$1.1	$3,891	$3,906
Rail Grinding Turnouts	Number	43	$0.2	$5,352	$5,412
General Track Maintenance			**$5.3**		
General Track Maintenance	Item		$5.0		
Track Recording	km	645	$0.2	$256	$184
Ultrasonic Testing Car	km	1558	$0.1	$94	$86
Structures and Facilities Maintenance	**Item**		**$1.1**		
Other Civil Maintenance	**Item**		**$0.5**		
Signalling and Telecom Maintenance			**$2.2**		
Signalling Corrective Maintenance	Item		$0.7		
Signalling Preventive Maintenance	Item		$1.1		
Telecommunications Corrective Maintenance	Item		$0.1		
Telecommunications Preventive Maintenance	Item		$0.4		
Trackside Systems Maintenance	Item		**$0.2**		
Other General Maintenance			**$1.2**		
Asset Management and Inventory	Item		$0.5		
On Call	Item		$0.0		
Security	Item		$0.7		
MAINTENANCE TOTAL			**$13.7**		
Ballast Depreciations			$0.3		
GRAND TOTAL			**$14.0**		

Notes to table:

- refer to notes at corresponding table in Appendix 1
- Security has been included in the Maintenance Cost table for additional activities to manage Protest Events on the Network. Currently Newlands is the only system with costs as this is the current focus. – Newlands ONLY

Newlands Maintenance Budget Cost – FY19– FY25 ($M)

	FY19A	FY21 (FD)	FY21	FY22	FY23	FY24	FY25
Resurfacing	**$1.8**	**$1.6**	**$1.8**	**$1.7**	**$1.8**	**$1.8**	**$1.7**
Resurfacing – Track	$1.6		$1.5	$1.4	$1.5	$1.5	$1.4
Resurfacing - Turnouts	$0.2		$0.3	$0.3	$0.3	$0.3	$0.3
Rail Grinding	**$1.7**	**$1.6**	**$1.4**	**$1.6**	**$1.5**	**$1.6**	**$1.6**
Rail Grinding Mainline	$1.4		$1.1	$1.3	$1.3	$1.4	$1.3
Rail Grinding Turnouts	0.3		$0.2	$0.2	$0.2	$0.2	$0.2
General Track Maintenance	**$4.6**	**$6.1**	**$5.3**	**$5.3**	**$5.3**	**$5.3**	**$5.3**
General Track **Maintenance**	$4.3		$5.0	$5.0	$5.0	$5.0	$5.0
Track Recording	$0.1		$0.2	$0.2	$0.2	$0.2	$0.2
Ultrasonic Testing Car	$0.2		$0.1	$0.1	$0.1	$0.1	$0.1
Structures and Facilities Maintenance	**$0.9**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**	**$1.1**
Other Civil Maintenance	**$0.2**	**$0**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**
Signalling and Telecommunications Maintenance	**$3.3**	**$3.6**	**$2.2**	**$2.2**	**$2.2**	**$2.2**	**$2.2**
Signalling Corrective Maintenance	$1.1		$0.7	$0.7	$0.7	$0.7	$0.7
Signalling Preventive Maintenance	$1.7		$1.1	$1.0	$1.0	$1.0	$1.0
Telecommunications Corrective Maintenance	$0.1		$0.1	$0.1	$0.1	$0.1	$0.1
Telecommunications Preventive Maintenance	$0.4		$0.4	$0.4	$0.4	$0.4	$0.4
Trackside Systems Maintenance	**$0.4**	**$0**	**$0.2**	**$0.2**	**$0.2**	**$0.2**	**$0.2**
Other General Maintenance	**$0.9**	**$0.5**	**$1.2**	**$1.2**	**$1.2**	**$1.2**	**$1.2**
Asset Management and Inventory	$0.9		$0.5	$0.5	$0.5	$0.5	$0.5

On Call	$0.0		$0.0	$0.0	$0.0	$0.0	$0.0
Security			$0.7	$0.7	$0.7	$0.7	$0.7
MAINTENANCE TOTALS	**$13.8**	**$14.4**	**$13.7**	**$13.8**	**$13.8**	**$14.0**	**$13.8**
Ballast Depreciation	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3
GRAND TOTAL	**$14.1**	**$14.7**	**$14.0**	**$14.0**	**$14.1**	**$14.2**	**$14.1**

Notes to table:
refer to notes at corresponding table in Appendix 1

APPENDIX 6 – Newlands Renewal Budget

Newlands FY21 Asset Renewal Forecast Scope and Cost Budget ($M)

Asset	Scope Unit	Scope Quantity	% Total # Assets	Forecast Cost ($M)	Unit Rate FY21 ($M/unit)	Unit Rate FY19 ($M/unit)
Civil Assets						
Track Upgrade	Track KM	4.9	1.6%	$6.7	$1.3	$1.4
	Rail KM in Track Upgrade	6.9				
	KM Sleepers in Track Upgrade	4.9	0.02			
	KM Sleeper and Ballast Renewal	0.3	0.1%	$0.3	$0.9	$0.9
	Reactive works			$0.1		
Rail KMs	Rail KMs	7.6	1.2%	$3.1	$0.4	$0.5
Ballast Undercutting	KMs	5.8		$2.5	$0.4	$0.3
Ballast Undercutting Turnouts	Number	2		$0.3	$0.1	$0.2
Bridge Ballast	KMs	0.08	0.2%	$0.3		
Turnouts	Turnout Renewals Other			$0.8		
Formation	KMs	0.6	0.2%	$1.6	$2.7	$4.8
Level Crossing	Level Crossing Other Renewals	2	2.2%	$0.1		
Structures	Culvert Major Renewal	5	0.8%	$2.3		
	Other Structures Renewals			$0.7		
Corridor Assets	Minor Civil Renewals			$0.3		
Control Systems Assets						
Safeworking System	Asset Protection Sites and System Wide	3	14%	0.7		
Train Control System	UTC/DTC Packages System Wide	14		0.3		
Transmission and Data Network	Sites where renewal occurs	9	13%	0.7		
Power Resilience	Sites and System Wide upgrades	4	24%	0.3		
Transformation						
NAMS Next				0.5		
TOTAL				**$21.4**		

Notes to table:
refer to notes at corresponding table in Appendix 2

Newlands FY22 to FY25 Renewals Cost Budget ($M)

	FY21	FY22	FY23	FY24	FY25
Civil Assets	**$18.9**	**$18.4**	**$18.8**	**$18.2**	**$18.3**
Rail	$9.9	$6.8	$6.8	$6.8	$6.5
Sleepers	$0.3	$1.3	$1.3	$1.2	$1.3
Ballast Undercutting	$2.5	$2.7	$2.8	$2.8	$2.8
Ballast Undercutting Turnouts	$0.3	$0.4	$0.4	$0.4	$0.4
Bridge Ballast	$0.3	$0.3	$0.3	$0.3	$0.3
Turnouts	$0.8	$2.0	$2.1	$2.0	$2.1
Formation	$1.6	$1.7	$1.6	$1.5	$1.4
Level Crossings	$0.0	$0.6	$0.7	$0.7	$0.7
Structures	$3.0	$2.3	$2.4	$2.2	$2.4
Civil Renewals (fencing, earthworks, corridor)	$0.2	$0.3	$0.4	$0.4	$0.4
Control Systems Assets	**$2.0**	**$5.0**	**$4.4**	**$3.6**	**$3.6**
Transformation	**$0.5**				
TOTALS	**$21.4**	**$23.5**	**$23.2**	**$21.8**	**$21.9**

Notes to table:
refer to notes at corresponding table in Appendix 2

APPENDIX 7 – Moura Maintenance Budget

Moura Maintenance Budget FY21($M)

	Scope Unit	Scope quantity	Cost ($M)	Unit Rate FY21 ($/unit)	Unit Rate FY19 ($/unit)
Track Resurfacing			**$1.4**		
Resurfacing – Track	km	170	$1.3	$7,873	$7,915
Resurfacing - Turnouts	Number	10	$0.1	$9,420	$8,730
Rail Grinding			**$1.0**		
Rail Grinding Mainline	km	240	$0.9	$3,839	$3,965
Rail Grinding Turnouts	Number	20	$0.1	$5,157	$5,412
General Track Maintenance			**$5.4**		
General Track Maintenance			$5.0		
Track Recording	km	525	$0.2	$368	$282
Ultrasonic Testing Car	km	886	$0.1	$136	$135
Structures and Facilities Maintenance			**$0.6**		
Other Civil Maintenance			**$1.0**		
Signalling and Telecommunications Maintenance			**$2.3**		
Signalling Corrective Maintenance			$0.6		
Signalling Preventive Maintenance			$1.1		
Telecommunications Corrective Maintenance			$0.1		
Telecommunications Preventive Maintenance			$0.6		
Track Side Systems Maintenance			**$0.2**		
Other General Maintenance			**$0.5**		
Asset Management and Inventory			$0.5		
On Call			0		
MAINTENANCE TOTAL			**$12.5**		
Ballast Depreciation			**0**		
GRAND TOTAL			**$12.5**		

Notes to table:
refer to notes at corresponding table in Appendix 1

Moura Maintenance Forecast Budget – FY19 – FY25 ($M)

	FY19A	FY21 (FD)	FY21	FY22	FY23	FY24	FY25
Resurfacing	**$1.4**	**$0.9**	**$1.4**	**$1.4**	**$1.5**	**$1.5**	**$1.4**
Resurfacing – Track	$1.3		$1.3	$1.3	$1.4	$1.4	$1.3
Resurfacing - Turnouts	$0.1		$0.1	$0.1	$0.1	$0.1	$0.1
Rail Grinding	**$1.0**	**$0.8**	**$1.0**	**$0.5**	**$0.9**	**$0.5**	**$1.0**
Rail Grinding Mainline	$0.8		$0.9	$0.4	$0.8	$0.4	$0.9
Rail Grinding Turnouts	$0.2		$0.1	$0.1	$0.1	$0.1	$0.1
General Track Maintenance	**$5.6**	**$7.4**	**$5.4**	**$5.3**	**$5.3**	**$5.3**	**$5.3**
General Track Maintenance	$5.3		$5.0	$5.0	$5.0	$5.0	$5.0
Track Recording	$0.2		$0.2	$0.2	$0.2	$0.2	$0.2
Ultrasonic Testing Car	$0.1		$0.1	$0.1	$0.1	$0.1	$0.1
Structures and Facilities Maintenance	**$0.5**	**$0.5**	**$0.6**	**$0.6**	**$0.6**	**$0.6**	**$0.7**
Other Civil Maintenance	**$0.2**	**$0**	**$1.0**	**$1.0**	**$1.0**	**$1.5**	**$1.5**
Signalling and Telecommunications Maintenance	**$2.2**	**$1.6**	**$2.3**	**$2.3**	**$2.3**	**$2.3**	**$2.3**
Signalling Corrective Maintenance	$0.6		$0.6	$0.6	$0.6	$0.6	$0.6
Signalling Preventive Maintenance	$1.1		$1.1	$1.1	$1.1	$1.1	$1.1
Telecommunications Corrective Maintenance	$0.1		$0.1	$0.1	$0.1	$0.1	$0.1
Telecommunications Preventive Maintenance	$0.4		$0.6	$0.6	$0.6	$0.6	$0.6
Trackside Systems Maintenance	**$0.2**	**$0**	**$0.2**	**$0.2**	**$0.2**	**$0.2**	**$0.2**
Electrical Overhead Maintenance	**$0**	**$0.1**	**$0**	**$0**	**$0**	**$0**	**$0**
Other General Maintenance	**$0.7**	**$0.4**	**$0.5**	**$0.5**	**$0.5**	**$0.5**	**$0.5**
Asset Management and Inventory	$0.7		$0.5	$0.5	$0.5	$0.5	$0.5
On call	$0.0		$0.0	$0.0	$0.0	$0.0	$0.0
MAINTENANCE TOTALS	**$11.8**	**$11.6**	**$12.5**	**$11.9**	**$12.5**	**$12.5**	**$13.0**

Ballast Depreciation	$0.3	$0.3	$0.0	$0.1	$0.1	$0.1	$0.1
GRAND TOTAL	**$12.1**	**$11.9**	**$12.5**	**$12.0**	**$12.6**	**$12.7**	**$13.1**

Notes to table:
refer to notes at corresponding table in Appendix 1

APPENDIX 8 – Moura Renewal Budget

Moura FY21 Asset Renewal Forecast Scope and Cost Budget ($M)

Asset	Scope Unit	Scope Quantity	% Total # Assets	Forecast Cost ($M)	Unit Rate FY21 ($M/unit)	Unit Rate FY19 ($M/unit)
Civil Assets						
Track Upgrade	Track KM	2.0	0.8%	$2.7	$1.3	$1.4
	Rail in Track Upgrade	3.9				
	KM Sleepers in Track Upgrade	2	0.7%			
Rail	Rail KMs	1.5	0.3%	$0.6	$0.4	$0.5
Ballast Undercutting Turnouts	Number	1	1.4%	$0.1	$0.1	$0.1
Bridge Ballast	KMs	0.3	0.8%	$1		
Turnouts	Number Major Renewals	1	1.4%	$2.5		
	Turnout Renewals Other			$0.3		
Formation	KMs	0.6	0.2%	$1.8	$2.7	$4.8
Level Crossings	Major Level Crossings Renewals	1	0.7%	$0.8		
	Level Crossing Other Renewals	8	5.4%	$0.5		
Structures	Culvert Major Renewal	6	1.1%	$2.1		
	Other Structures Renewals			$0.3		
Corridor Assets	Minor Civil Renewals			$0.1		
Control Systems Assets						
Safeworking system	Asset Protection Sites and Systemwide	2	25%	0.9		
Train Control System	UTC/DTC Packages System Wide	14		0.2		
Transmission and Data Network	Sites where renewal occurs	40	30%	$0.7		
Power Resilience	Sites where renewal occurs	3	23%	$0.6		
Other Control Systems	Mixed units minor upgrades	2		$0.1		
Transformation						
NAMS Next				0.2		
TOTAL				**$15.4**		

Notes to table:
refer to notes at corresponding table in Appendix 2

Moura FY22 to FY25 Renewals Cost Budget ($M)

	FY21	FY22	FY23	FY24	FY25
Civil Assets	**$12.8**	**$7.7**	**$7.8**	**$7.9**	**$8.0**
Rail	$3.4	$2.8	$2.8	$2.8	$2.7
Sleepers	$0.0	$0.5	$0.5	$0.5	$0.5
Ballast Undercutting	$0.0	$0.7	$0.7	$1.1	$1.1
Ballast Undercutting Turnouts	$0.1	$0.1	$0.1	$0.1	$0.1
Bridge Ballast	$1.1	$0.6	$0.6	$0.6	$0.6
Turnouts	$2.9	$0.8	$0.9	$0.8	$0.9
Formation	$1.8	$0.7	$0.7	$0.6	$0.6
Level Crossings	$1.1	$0.3	$0.3	$0.3	$0.3
Structures	$2.4	$1.0	$1.0	$0.9	$1.0
Civil Renewals (fencing, earthworks, corridor)	$0.1	$0.1	$0.2	$0.2	$0.2
Control Systems Assets	**$2.4**	**$2.10**	**$1.85**	**$1.50**	**$1.50**
Transformation	**$0.2**				
TOTALS	**$15.4**	**$9.8**	**$9.6**	**$9.4**	**$9.5**

Notes to table:
refer to notes at corresponding table in Appendix 2

APPENDIX 9 – Detailed Asset Maintenance and Renewal Strategies

INTRODUCTION

This paper is to support the Aurizon Network Maintenance and Renewal Strategy submission to the Rail Industry Group (RIG). This paper is provided to members of the RIG with information on the application of the maintenance and renewal strategies across the various assets under Aurizon Networks management.

THE RAILWAY AS A SERIES OF SYSTEMS

This paper provides detail on the application of the defined Aurizon Network Maintenance and Asset Renewal strategies

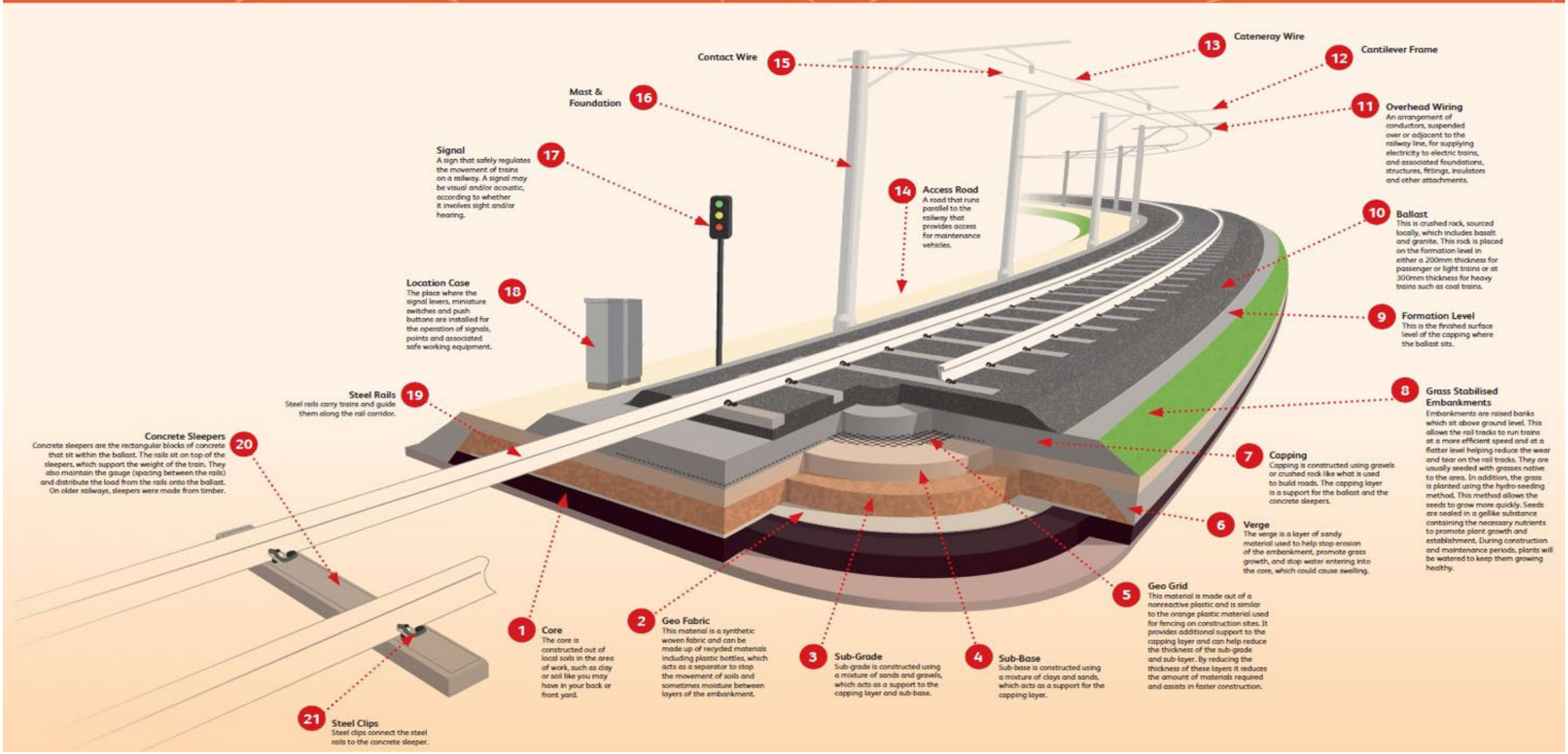
The railway is made up of several interrelated systems and asset classes

- Civil Assets
    - Track assets – rail, sleepers, ballast, turnouts, glued insulated joints, rail welds,
    - Formation and civil assets – formation, capping layer, cuttings, embankments
    - Structures and drainage assets – bridges, culverts, underpasses, pipes, formed drains
    - Level crossing access and security assets – railway crossings, access points, rail access roads, fencing
- Control Systems Assets
    - Train Control systems –eg Universal Traffic Control (UTC), Direct Traffic Control (DTC), Track Access System (TAS),
    - Signalling systems – signals, points machines to drive turnouts, signal interlockings, train detection (eg track circuits, axle counters), active protection for Level Crossings
    - Telecommunication assets – optic fibre and microwave radio links, digital radio system (TETRA), data network
    - Wayside monitoring systems – Series of assets providing real time reporting of the rolling stock and railway interface (eg Dragging Equipment Detectors, Weighers, Wheel Impact Load Detectors)
- Electrical Assets
    - Overhead line equipment (OHLE) – contact and catenary wires, poles, structures and isolators related to the traction system
    - Traction substations – Feeder stations, Track Sectioning Cabins and autotransformers as well as switching and harmonic's management
    - Power Management systems – SCADA and switching systems

Together these assets are under the management of Aurizon Network collectively known as “below rail’ assets and maintained and renewed to facilitate the assets required in the CQ coal supply chain.

The following diagram is a representation of the key below rail assets.

Elements in Building a Single Track Railway



CIVILS ASSETS

Track Assets

Track and formation assets are maintained and renewed to ensure track alignment quality and to reduce top and line faults that can lead to speed restrictions, unplanned maintenance or incidents. The track structure across the CQCN is predominately concrete sleepers with 60 kg rail and 300mm ballast depth on the main line sections. Sleeper type, rail weight and formation arrangements do vary across the systems typically in rail spurs and sidings.

The track and formation assets are the connection point between the track and rollingstock, as such the energy created through train movements influence and are affected by the quality of these asset classes. As such these assets attract most of the maintenance and renewal activity across the CQCN both in terms of scope and related costs.

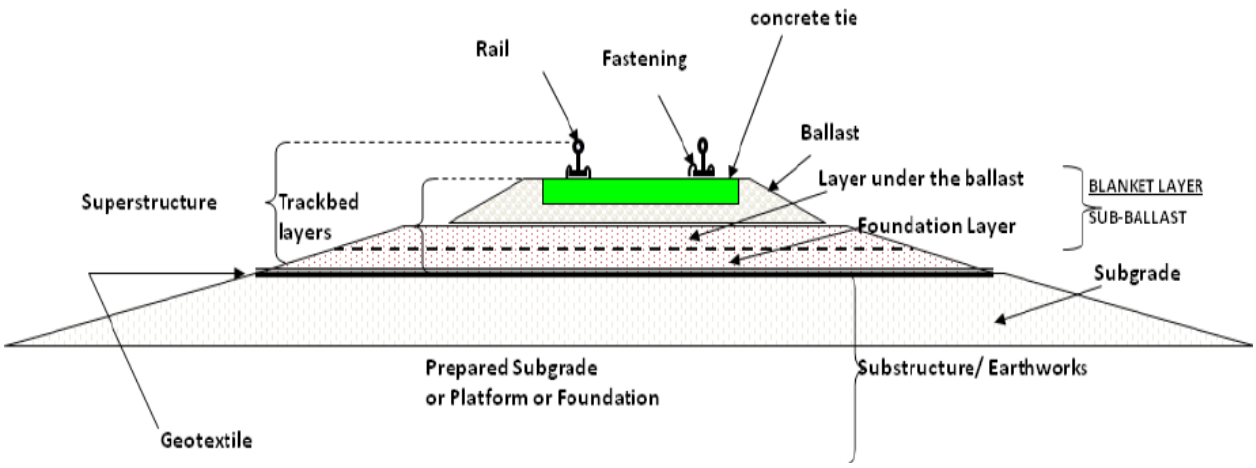
Rail is identified by its weight, 60kg means for every 1m long it weighs 60kg. The larger the weight, the larger its load carrying capacity and resistance to wear. Rail is also identified by its metallurgical properties. Some rail is head hardened or deep head hardened, this refers to the strength of the metal in the head of the rail, these types of rail are more costly to produce but have a longer life. Rail is imported as 25m or 27.5m lengths and welded into 110m sections at the rail weld facility in Brisbane. The rail is then transported via rail for delivery trackside to future renewal locations. The rail is then inserted and welded on site via exothermic welding to form continuously welded rail (no bolted joints). When rail is inserted it is stressed to install the rail at a stress-free temperature, this ensures the rail is at the same tension of the connecting rail to reduce the risk of buckling and breaking as the rail expands and contracts in weather extremes (buckles in heat and breaks in cold).

Formation

Railway formation is the engineered soils base that the track structure sits on. Formation's role is to provide a stable base that further distributes the load to the natural subgrade. The formation also directs water away from the railway. Across the CQCN there are variable subgrade soils including significant sections of Black Soil that hold moisture. Moisture transferring into the formation can cause top and line issues, formation failure or the development of clay holes that further affect track alignment. Formation is managed through either spot repair or formation reconstruction. Formation repairs require a track closure.

Aurizon Network monitor track resurfacing reoccurrences in same locations as a key indicator of formation or subgrade issues that require remedy. Track inspection and track recording data as well as Ground Penetrating Radar (GPR) also identify formation issues for repair or re build.

The following diagram provides a schematic of a typical arrangement of track from subgrade to rail.

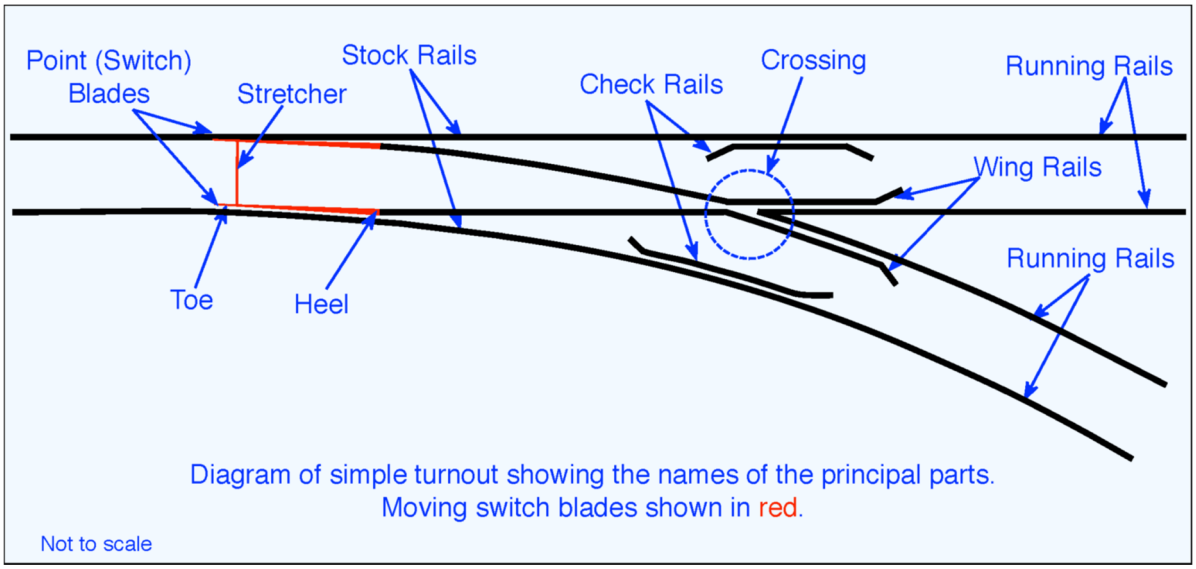


Turnouts

Turnouts (sometimes called Switches) allow trains to move between tracks in duplicated sections, as well to allow entry and exit from passing loops and to move from the main line into spurs and balloon loops. A turnout is a combination of civil assets being the steel rail and sleepers and Control Systems Assets being the points motors, rodding and electronics.

Aurizon Network completes either full turnout replacements or componentry renewal aimed at extending turnout life. There is a dedicated program to reduce the variability of turnout types across the CQCN to reduce the number of spares needed to be held in inventory and reduce the lead time to repair once a fault has been identified.

The following diagram identifies the typical elements within a turnout.



Structures and Drainage Assets

Structures and drainage assts are in place to allow for the flow or water across and away from the path of the railway, failure to maintain adequate drainage contributes for formation issues and access issues. Structures are either bridges or culverts and, in the CQCN there are 353 bridges and 3,045 culverts. 54 bridges in the CQ coal systems are road over rail or rail over road structures. Most structures across the CQCN are of concrete construction. However, there are also steel and timber structures which are adequate for their current operation, but do provide a different risk profile, maintenance requirements and

engineering treatment. Culverts are a mix of reinforced concrete box culverts and pipes and corrugated steel pipes. Structures are typically constructed with concrete.

Formed table and V drains direct water along the rail corridor to the closest culvert or bridge allowing water to flow along and under the railway.

In the CQCN structures and drains are designed to manage varying flood immunity with new structures being installed at a Q50 immunity level to top of formation. There are significant areas within the system that are located on flood plains or locations that see rapid water movements across track and Aurizon has a developed understanding of the flood locations and critical structures.

The structures renewal program is primarily driven from a condition perspective. Concrete structures are a long-life asset, but many were installed at a time where 26tal operations were not considered so are operating above their design parameters, as such programmed structures inspections and the assignment of asset condition drive the renewal program.

Ballast Management

Ballast is the material placed between and under the sleepers and its function is to:

- Provide a firm and even bearing for the sleepers and to distribute the train loads as evenly as possible to the formation to control the amount of cumulative, residual settlement
- Permit drainage of the track
- Resist lateral and longitudinal movement of the track.
- Afford a convenient medium for reinstating the vertical and horizontal track alignment

Over time, ballast becomes fouled through degradation or the introduction of external impurities e.g. mechanical abrasion due to rail traffic decreasing the average size of ballast or coal and clay filling the drainage voids in the ballast profile. Where the ballast profile or condition fails to comply with the limits specified, or deterioration of the ballast condition does not allow it to perform its intended function, undercutting to renew the ballast is conducted.

The main source of ballast fouling in the CQCN is from fugitive coal and dust, that the source of fugitive coal that ended up in the ballast was as follows:

- Coal blowing or falling from the surface of wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilt coal in the corridor
- Residual coal in unloaded wagons, that washes out of wagon doors during rain events
- Parasitic load on sills, shear plates, bogies, and brake gear of wagons
- Coal sediment in water draining from wagons
- Mechanical profiling of the coal load

The level of fouling is measured via analysis of Ground Penetrating Radar (GPR) data and comparison of GPR runs to determine degradation rates. This data is plotted to the Aurzion GIS to identify sections that are heavily y fouled and to determine the sections that are fouling the fastest Investigation by Aurizon

track engineers has determined that once ballast is between 30% and 50% fouled then the drainage and load distribution requirements of the ballast is reduced to a point that faults will appear through drainage and alignment issues. It has been determined that the fouling rate indicates that undercutting should be conducted at a strategic trigger of every 600 MNT.

Given that the undercutting process is a significant consumer of track time, Aurizon Network has introduced and continues to develop GPR testing to improve the measurement of the degradation rate to the 50% PVC across the networks. Using GPR measurements, it has been identified that track sections have different fouling rates than the single strategic trigger. The intention is to program undercutting to meet condition-based needs as opposed to time set periodic treatment.

Ballast fouling is managed via the following approaches dependant on the location of the fouling:

- Ballast Undercutting Machine - excavating the fouled ballast from beneath the sleepers by a dedicated ballast cleaning consist, after which fresh ballast is added to the track and then tamped to restore the track to the correct height and ballast depth.
- Ballast Undercutting Major - excavating fouled and life expired ballast from beneath the sleepers and fresh ballast is then added and tamped to restore the track to the correct height and ballast depth for a length of track greater than approximately 20 sleeper bays (as a guide). This ballast undercutting is completed with the use of major mechanised equipment such as excavators with side cutter bars and specialised on track ballast undercutters.
- Ballast Replacement as part of a formation repair or track upgrade – ballast can be replaced as part of the formation repair or track upgrade activity.
- Ballast Undercutting Turnouts - excavating the fouled ballast and mud holes from beneath a turnout by minor mechanised equipment such as an excavator (with attachments) or by other means.
- Bridge Ballast Roll Out – due to the width, height and environmental constraints on bridges regarding coal spilling into waterways fouled ballast on bridges is completely removed and new ballast added. This requires the track structure and ballast to be removed, new ballast placed and track reinstated.

Level Crossing, Access and Security Assets

Across the CQCN there are 759 at grade level crossings, these include public road crossings, occupations (private road) crossing and maintenance and access crossings. These road rail interfaces are protected by either active protection, boom gates and/or lights, or via stop signs. Level crossing safety is determined via the application of the Australian Level Crossing Assessment Model (ALCAM) that assigns a risk score of each crossing. Aurizon Network works with Local and State Governments to ensure that the shared responsibilities at level crossings are adhered to.

Aurizon has a program of works to continuously improve level crossing safety across the CQCN, this includes upgrades from passive protection to active protection, road resurfacing at crossings and signage and vegetation management to increase awareness and visibility at crossing points.

Safe access to the rail corridor and along the railway is required for the movement of train crew and maintenance staff and equipment for train crew shift changes, planned inspections, maintenance and construction activities. Access points need to allow for safe exit and entry to the public road network and access roads need to be passable in good and fair weather. Access roads are formed dirt roads or tracks.

The CQCN systems for their majority travel through rural country. Legislation requires the railway to be fenced from private land. In rural areas stock fencing is established. Access to the corridor in most locations is via gates or at level crossings. Security assets also include bridge throw prevention barriers and security fencing and panelling in built up areas.

Civil Asset Maintenance Activities

Aurizon Network maintains these assets via a combination of inspection, preventative and reactive maintenance activities. Work is conducted via dedicated narrow-gauge mechanised maintenance fleet, plant and tools as well as qualified rail maintenance workforce.

The railway maintenance activities undertaken by Aurizon Network are typical for heavy haul railways. For the purposes of this document the maintenance activities for the civil and permanent way assets have been organised as per the following table.

Track and formation assets are maintained and renewed to ensure track alignment quality and to reduce top and line faults that can lead to speed restrictions, unplanned maintenance or incidents. The track structure in CQCN is predominately concrete sleepers with 60 kg rail and 300mm ballast depth on the main line sections. Sleeper type, rail weight and formation arrangements do vary across the system typically in rail spurs and sidings.

The track and formation assets are the connection point between the track and rollingstock, as such the energy created through train movements influence and are affected by the quality of these assets. These assets attract most of the maintenance and renewal activity across the CQCN, in terms of scope and related costs.

Track Resurfacing

Railway track experiences multiple loads with the main stresses coming from the forces transmitted under traffic through the wheels of rolling stock. The forces increase when the vehicle is in motion creating dynamic loads in addition to the static load of the vehicle when stationary. The higher the train speed and axle load combination, the higher the forces transmitted to the track. Surface irregularities in the running surface (created by the plane between the two running rails) also have an influence on the dynamic load and resulting vibrations. Therefore, poor track quality accelerates track deterioration if not properly maintained.

Under normal conditions, ballasted track displaces slightly out of its original position under traffic. However, these changes of the horizontal and vertical positions initially occur at low rates. Over time with the passage of more traffic, the development of track geometry irregularities accelerates the rate of geometry deterioration; to the point that requires corrective work in order to restore the track geometry and assure safe running. A further factor that has a considerable impact on the ability of the track to hold its top and line is rainfall and the ability of the track to drain. In areas of heavily fouled ballast due to coal contamination, it may be necessary to treat areas of poor top and line through repeat resurfacing of relatively short lengths until the ballast undercutting operation is programmed to remediate the ballast profile and associated track drainage.

Mechanised Resurfacing restores the geometry of the track by lifting and lining the track to the appropriate level and alignment and compact the ballast underneath the sleeper. If track geometry is not corrected to a standard that is fit for the traffic task, track components deteriorate leading to a marked increase in the need to perform other maintenance on the track. For example, rails can develop surface irregularities and fault, kink or bend and develop a memory. Track pumping at mudholes may even result

in rail breaks over time, fastenings may work loose or break, sleepers may skew or even break, pads can abrade or fall out, ballast and formation deteriorates. Resulting poor track geometry can lead to temporary speed restrictions applied as a risk control prior to component renewal or full asset renewal.

Current deterioration of track geometry in the coal systems is affected by poor formations (historically constructed to suit 12 to 15.75 tonne axle loads), and coal fouling of the ballast. Coal fouling rates of track have become worse since the change in Rollingstock Fleet to bottom dump wagons from Tippler Wagons. Figures presented are the approximate historic requirements and would therefore represent historical wet weather patterns. Formation rehabilitation and additional ballast cleaning work (or reduction of coal spillage) could reduce the intervention period. In the electrified Goonyella and Blackwater systems geometry has to also consider the alignment of the track asset to the OHLE.

SAF/STD/0077/CIV/BUS - Civil Engineering Track Standard, Module 9, Track Geometry; outlines the intervention limits. Mechanised resurfacing is normally required between 25 Mgt and 50 Mgt of traffic to maintain track geometry within the limits set in abovementioned Standard. Originally, the frequency for scoping Track Resurfacing in the Central Queensland Coal Network (CQCN) was 40 MGT. Recent investigations and reviews have amended the frequency for track resurfacing to 50MGT for scoping purposes for the CQCN.

Maintenance Product	Frequency Required	Unit
Track Resurfacing	Every 50 MGT	Single Track Km
Turnout Resurfacing	Every 80 MGT	Turnout

Rail and Turnout Grinding

The interface between the loaded wheel of a coal train and the contact point of the rail is 130kN across a surface area of 100mm^2. Rolling Contact Fatigue (RCF) can occur in rail, which is subject to many wheel loading cycles. This can cause micro cracking in the rail surface, within the rail/wheel contact zone. Cracking sometimes occurs about 6 - 9 mm below the surface, if the contact band is very small. This cracking can result in rail spalling, which are pieces of rail cracking out at the gauge face. In extreme circumstances, these cracks can turn down in the rail, and cause complete rail failure via a shatter cracking mechanism (usually whilst under a wheel load, which can cause a derailment).

Regular rail grinding removes micro cracks, and small surface faults from the rail surface, and restores a profile that spreads the contact band, and positions it for better wheel set tracking around the curves. Experience over 30 years or more, has shown that attention is needed to rail profiles every 40 MGT on straights, 20 MGT on minor curves (1001 to 2500 metre radius), and every 10 MGT on sharp curves (less than 1000 metre radius). Failure to grind rail at these intervals can result in severe rail faults, which will require early replacement of the rail, or in extreme cases, may result in rail faults that can cause derailments. An annual program of rail grinding using these tonnage frequencies is developed by estimating the track tonnages on each line. To estimate close to the accurate track tonnages requires prediction of traffic flow changes due to required track work and other operational requirements.

The grinding of turnouts generally follows the same rationale as that for main line grinding. To maintain the specially designed wheel / rail transfer locations, production rail grinding is not permitted within 2 metres of the toe of switch and 1.5 metres either side of the crossing nose.

Turnout grinding is a high production process of establishing and maintaining the rail head profile on turnouts which is done by mechanised rail grinders. It includes any associated activity such as removal and reinstallation of lubricators or other trackside equipment

A well-maintained rail profile also limits wheel wear and significantly extends rail and wheel service life.

Current intervention rates across the CQCN are:

Maintenance Product	Frequency Required	Unit
Rail Grinding – Straights	Every 40 MGT	Single Track Km
Rail Grinding – Curves 1001 to 2500 metres radius	Every 20 MGT	Single Track Km
Rail Grinding – Curves less than 1000 metres radius	Every 10 MGT	Single Track Km
Turnout Grinding	Every 40 MGT	Turnout

Aurizon Network is currently trialling a revised rail profile in curves in the Goonyella system. Monitoring of rail wear rates have indicated early benefits and allowed for the reduction in grinding requirements and extension of life in the rail. This revised rail profile will be transitioned into the remaining coal systems over the coming 12 months. Once established it is forecast that the grinding intervention rates for curves can be extended by up to 50%.

Track Inspection

Planned periodic inspection of the below rail assets allows Asset Managers and Maintainers to effectively determine asset condition, identify faults and faults and trend asset performance.

To monitor the network, hi-rail vehicle inspections are conducted once a week or every 96 hours in selected locations. These visual inspections are used to detect faults along the corridor, including damaged fences and level crossing signage, ponding water and scour from recent rain, stones in points, undetected derailment damage, vegetation blocking visibility of speed boards and signals, foreign objects placed in rail wheel flangeways etc. High rail vehicles consume several train paths due to a maximum speed of 40 km/h, and vehicles requiring a train path clear on either side for safety.

Train drivers also observe and report simple faults, reducing the frequency of hi-rail vehicle inspections on high traffic areas.

After a long gap in train operations (such as after major system closures, for maintenance or construction purposes), it may be required to perform a general corridor inspection to ensure the safe operation of trains.

Aurizon Network is exploring technical means of inspecting track and the corridor at higher speeds, to eliminate manual inspections. Stereoscopic digital cameras are currently being investigated which can aid in fast detection of missing track components, or foreign objects in critical locations.

Scheduled inspections include road patrols, front of train inspections, engineering inspections, walking inspections, sleeper inspections, turnout inspections, track stability, track clearance, hot weather, yard inspections and audits. Unscheduled inspections include initial call out inspections, Temporary Speed Restriction management and Rail Strategy Inspections.

Maintenance Product	Frequency Required	Unit
Track Inspections	Corridor – (Concrete Sleepers and CWR) – every 192 hours Corridor (all other) - Weekly	Single Track Km
	Track – Detailed Track Inspection (Concrete sleepers and CWR) – Every 2 years Detailed Track Inspection (other) - Yearly	Single Track Km
	Turnouts – (part of scheduled patrol inspection)	Turnout
	Turnouts – yearly (detailed inspection)	Turnout

Track Geometry Recording

Track Geometry Recording is the cyclic operation of specialised track vehicles and rollingstock to measure and record the physical geometric characteristics of the track and traction wiring. It includes the maintenance staff accompanying the vehicle and the on-board vehicle ride accelerometers.

The data is recoded and analysed to:

- Determine alignment issues that are outside alignment tolerances for maintenance action between zero and 90 days depending on severity
- For comparison to prior runs to develop alignment trends used to identify future renewal scopes especially across formation and track upgrade products

Maintenance Product	Frequency Required	Unit
Track Geometry Recording	Blackwater North Coast Line (NCL) – 4 times per year	Single Track Km
	Blackwater – Central Line Mainline, Branches, Balloons and Passing Loops – 2 times per year	Single Track Km
	Goonyella – Mainline, Branches, Balloons and Passing Loops– 2 times per year	Single Track Km
	Moura and Newlands mainline, passing loops and branches – 2 times per year	Single Track Km

Ultra-Sonic Rail Testing

Cyclic ultrasonic testing of rail and associated components by on-track testing vehicles (ultrasonic testing car) as well as rail testers using hand held non-destructive testing equipment which validate faults identified by the vehicle. This testing assists in the prevention of rail breaks.

Maintenance Product	Frequency Required	Unit
Rail Flaw Detection	Every 10 MGT (on-track vehicle)	Single track km / year
	Verification Manual NDT	100m / 100 single track km
	Turnout Manual NDT	Turnout

General Track Maintenance

General track maintenance encompasses the planned corrective maintenance effort, responding to faults identified by drivers, track inspection or specific asset inspection. Activity can be planned according to the severity and the time period for fault/fault remedy of the identified fault. Fault severity ranges from:

General track maintenance activities include:

- Rail Joint Corrective Maintenance - the maintenance of a rail joint including flashbutt welding, thermit welding of joints, bolt and fish plate maintenance, and lifting and lining joints.
- Maintenance Ballast - the purchase, freight (Train or Truck) and distribution of ballast for restoration of ballast profile excluding any ballasting done in conjunction with other products.
- Sleeper Cluster management -corrective maintenance of sleepers requiring spot insertion of sleepers, reboring, regauging, replating, spot replacement of pads and biscuits and replacement of jewellery. Includes associated activities such as local sleeper tests, resleepering components/fastenings, sleepers, spot tamping, freight, distribution of sleepers, respacing, removal from site, flagging and cascading of part worn sleepers.
- Rail stress adjustment - any activities associated with the stand-alone product of rail stress testing and adjustment. Works include rail stress testing, creep marker installation and monitoring, rail stress adjustment, documentation and provision/insertion of additional rail and anchors etc.
- Track clean up - investigating and rectifying the localised spillage of coal and other materials (including animal remains) on the rail network. This product includes the coal cleaning of infrastructure with the use of the vacuum truck.
- Top and line spot resurfacing - localised top and line track adjustment using manual or mechanised – assisted processes but excluding those undertaken by the major mechanised production resurfacing machines. Involves restoring top and line on glued insulted joints, bridge ends and open track using manual processes or small spot tamping machinery.
- Rail repairs - corrective maintenance activities associated with repairs imminent that may cause train cancellations or delays due to identified faults and failures in rail such as wheel burns,

faultive welds, and internal rail faults. This includes activities such as signalling support, distribution and unloading rail, trackside flagging, insertion of rail, welding and weld testing.

Maintenance Product	Frequency Required	Unit
General track Maintenance	Planned corrective dependant on fault severity and time to remedy	Various

Structures and Facilities Maintenance

Aurizon Network uses monitoring and maintenance to ensure the condition of structures stays within intended limits compatible with the operational parameters, and consist of the following activities:

- Inspecting and testing of critical elements of the structures to determine its condition
- Recording of irregularities or faults which may affect, or have the potential to affect, the capability of each structure to safely perform its required function or shorten its effective life
- Assessing the inspection and test results to determine the necessary remediation to the structure
- Take actions before the structure is unable to carry out the required function safely (for example, where conditions are outside prescribed limits)

Type of Structure	Deck and Ground Level Inspection	Stage (scaffold) Inspection	Underground Pile Examination	Underwater Inspection
Timber	6 month – 1 year	4 girders – 1 year Other – 2 years	4 – 9 years depending on preservation treatment	Tidal streams – 1 year Non-tidal – 2 years
Steel	2 years	10 years	10 years	4 years
Concrete	2 years	10 years	10 years	4 years

Culvert and Bridge Repairs

From the inspection activity, remediations and timings are derived and assigned dependant on fault severity (see section on General Maintenance). This includes structural repairs and the clearing of silt and debris from drainage structures.

Culvert Repairs are minor corrective maintenance of culvert faults which includes painting kilometre marks on the culverts, minor concrete works or temporary supporting of a culvert structure until remediation can occur.

Concrete bridge maintenance includes the repair /replacement of minor components, kerb repairs, walkway repairs, cracking repairs, remedial repairs for corrosion of reinforcement or alkali – aggregate reactivity, and resultant spalling. It also involves keeping drain holes on the bridge deck free and flowing.

There is only one steel bridge remaining in the CQCN, which is in the Blackwater system over the Comet River on the Burngrove to Nogoa Section. The steel bridge has a fully galvanised superstructure. The maintenance activities on this structure includes spot painting and minor component renewal.

The only timber bridges in the CQCN are located on the Springsure Branch between the Nogoa and Wurba Junction Section. Timber Bridge repairs are corrective maintenance which result in the repair/replacement of any components of a timber bridge. It includes walkways/escape platform repairs, repair/replacement of a pier/abutment, corbel, headstock, girder, transom and pile, top and lining, tightening fastenings and regular pest control.

Maintenance Product	Frequency Required	Unit
Concrete, Steel and Timber Structures repair	Planned corrective dependant on fault severity and time to remedy	Various

General Earthworks Maintenance

Retaining wall repairs are quite infrequent and generally involve repairs to ensure weep holes are draining, and other related catch drains and base drains are not blocked. Some sectional “leaning” can require rebuilding, especially if design drainage was not effective in the early years of the structure’s life. It includes any work that is related to repair of retaining walls.

Temporary propping of a retaining wall is included in this maintenance activity however renewal or replacement of the retaining wall would be a renewal activity.

Ancillary structures maintenance is the repair to buffer stops, foundations to gantry cranes, inspection pits, noise barriers, tank stands, light towers, electrification barriers, position of safety platforms, slab to loadouts and crew change platforms.

Maintenance Product	Frequency Required	Unit
General Earthworks Maintenance	Planned corrective dependant on fault severity and time to remedy	Various

Maintenance Summary for Civil Assets

Asset Discipline	Maintenance Family	Asset Type	Maintenance Approach
Civil Assets	Mechanised Track Maintenance	Track resurfacing	Dedicated plant both planned and reactive
		Rail Grinding	Dedicated plant planned based on tonnages
		Turnout Grinding	Dedicated plant planned to align with tonnage wear triggers over assets
	Inspections	Track Inspection	Set cadence of inspection to identify faults and issues for further intervention
		Track geometry Recording	Set cadence to record track and OHLE alignment and report issues outside set tolerances

Asset Discipline	Maintenance Family	Asset Type	Maintenance Approach
		Rail Ultrasonic Inspection	Set cadence to identify faults and fault growth within rail
	General Maintenance	General Track Maintenance	Preventative and reactive tasks on the civil track assets
		General Earthworks Maintenance	Cuttings and drainage periodic inspection and reactive maintenance
		Level Crossing Assessment	Programmed measurement of sight distances, crossing characteristics etc.
		Fire and vegetation Maintenance	Seasonal treatment of vegetation within the rail corridor that has effect on operations and level crossing safety
		Other Maintenance	Reactive signage, access road, monument maintenance
	Structuresand Facility Maintenance	Culvert Maintenance	Programmed inspection, reactive spot repair and culvert cleaning
		Bridge Maintenance	Programmed inspection, preventative maintenance and reactive spot repair
		Facility Maintenance	Retaining wall and ancillary structures maintenance

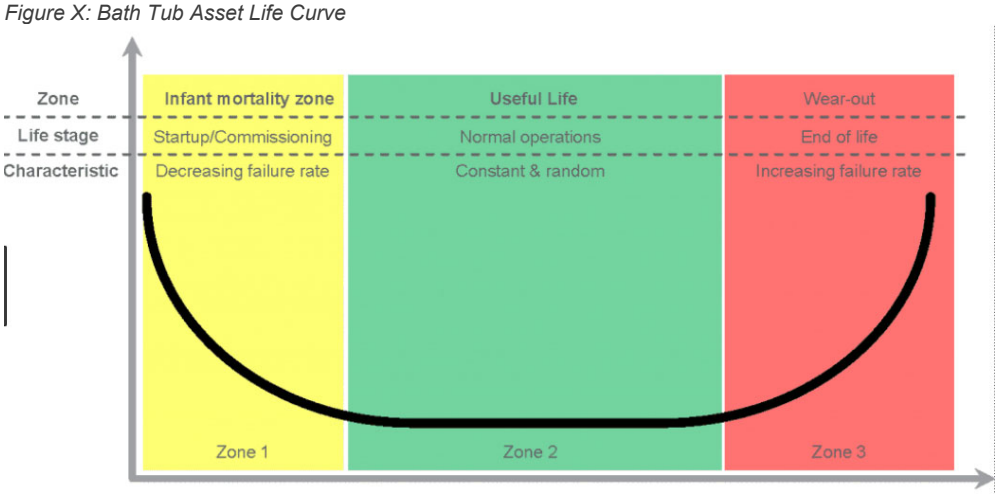
CONTROL SYSTEMS ASSETS

Control Systems assets are the physical and digital assets that provide, train control, signalling, and wayside monitoring systems. These assets provide the capacity multiplier for the track assets, that is they allow for the safe movement of more train services over the track structure. The Control Systems assets system also includes the telecommunication assets that facilitate digital and voice communications across the CQCN and the link between train control and in field equipment such as signals and points machines. Also included is wayside equipment that provides live information and monitoring of track and rolling stock interaction with the track structure.

Unlike Civil Assets, the trigger for the maintenance of Control System assets is predominantly driven by the age of the asset along its life cycle. These assets do not necessarily wear with tonnage, and often don't show degradation until the point of failure. This lifecycle is often referred to as a "bath tub" life curve; there is a failure rate on installation, steady condition during the useful life and then an accelerated failure

count ahead of a failure event at the end of life. Often with Control Systems assets obsolescence occurs during zone 2, that is the equipment cannot be repaired or replaced.

Figure X: Bath Tub Asset Life Curve



The asset management approach to this asset class is to:

- Maintain the assets to prolong the useful life stage
- Monitor asset to identify the commencement of the wear out stage, starting with design life and monitoring asset condition and failure trends

As a result, the maintenance strategy for Control Systems assets is one of:

- Preventative Maintenance – maintenance that is regularly performed on an asset to lessen the likelihood of it failing. Performed whist the asset is in place and working so that it does not break down unexpectedly. It is either:
    - Time based – planned periodic inspection and repair activities
    - Usage based – triggered after a defined usage metric
- Planned Corrective Maintenance – planned rectification work to return equipment to working condition. The planned period for recovery is dependent on the severity of the fault or criticality of the equipment being out of operation. (see General Maintenance)
- Reactive – service effecting failure

Train Control System

Aurizon Network controls train movements across the CQCN systems via the Train Control Centre (TCC) located in Rockhampton. The TCC also coordinates all day of operation activities on the network including track closures and protection for work groups performing maintenance or renewal tasks, inspection and work train movements.

Aurizon Network works across the following control approaches

- Remote Control Signalling (RCS) – Rollingstock operators have their route set by the TCC and are directed through the system via signals and direction signage set remotely. Train location is determined via rack circuits or axle counters. Points are moved mechanically via a remote direction for TCC

- UTC - Universal Train Control system (UTC) allows the controller to set and manage train paths across the geographic scope of the control board in Remote Control Signalling areas (RCS) .

- Direct Train control (DTC) – Uses a Graphical Interface in both the control centre and loco to store and manage authorities for sections. Uses fixed signs in the field to define locations.

- ATP – Automated train Protection system (North Coast Line Section only) safety system that checks speed of trains against the permitted speed allowed by the signalling (used by freight and passenger traffic only)

Capital upgrades in the UTC and DTC systems are driven by safe working enhancements to improve safety or improve operational performance, or upgrades to manage hardware and operating platform obsolescence.

- Other Train Control Assets

    - Signals – are typically housed in hot dipped galvanised steel housings and are open to the weather. There is a variety of arrangements across the CQCN including gantry mounted fixed and foldable poles. Poles have ladders and platforms for access and maintenance. Aurizon Network have replaced incandescent bulbs with LED bulbs over the last 5 years prolonging lamp life and increasing visibility.

    - Points – are the mechanical component of turnouts. These include the motors that drive the points, voltage recorders that are studied to remotely diagnose faults and the moving rail section to change the direction of the turnout.

    - Level Crossings – The signalling, active protection and CCTV recording devices at level crossings with active protection. This also includes over height detection systems.

    - Interlockings - are either Relay Interlockings or Processor Based Interlockings (PBI). Relay interlockings are typically the more aged interlockings in the system and have a nominal life of 35 years that has been proven in the Aurizon Network context to operate with minimal disruption out to 40 years. Relay interlockings and the older PBI interlockings installed in the 1990's are currently under review for renewal having reached their nominal service life.

Telecommunications Assets

Aurizon Network manages a significant telecommunication networks covering the CQCN. This system is made up of optic fibre links and microwave radio links, voice radio (currently both digital and analogue) and data communications network.

Aurizon Network has invested in the upgrade of multiple aging analogue radio systems to one Tetra Digital radio system for train control radio, shunting, asset protection and maintenance.

The predominant data communication path across the CQCN is the Optic Fibre that runs parallel with the track or as part of the OHLE. The fibre network is quite aged being installed on the initial main line electrification in 1980s. As additional nodes are added, or fault rectified the number of connections and repair slices in the network has increases due to the cut and connect of the aged assets.

Wayside System Assets

This asset class is inclusive of all devices that are in field and server infrastructure located in two key locations. Wayside Assets provide a level of monitoring and alarming to protect track and overhead assets as well as an information source to above rail operators on condition of rolling stock. Management and alarm interfaces are available to the Fault Control Centre (FCC), engineers and trade staff. Critical alarms from wayside devices are presented to UTC and are actioned by the Network Controller. Other alarms are presented to the FCC for tracking and action. Data collected from Wayside Systems is passed to individual operators under a licence agreement.

In addition, the alarms triggered via wayside devices provide a safety layer to the operations of the railway. These assets detect when rollingstock interfaces with the railway are uncontrolled or outside tolerances. Avoiding these instances reduces derailment, collision and Dewirement risk

Wayside equipment includes:

Equipment Name	Function	Protecting
Overload Detectors	Weigh wagons at load out to ensure they are within prescribed approved limits	The railway is designed to facilitate up to 26.5tal operations. Prolonged overloading will result in advanced wear rates of assets in direct connection with rollingstock increasing maintenance requirements and reducing asset life
Wheel Impact Load Detectors (WILD)	Monitors and alarms if flat wheels on rollingstock present	Flat spots on wheels pummel the rail leading to advanced wear patterns and in extreme cases rail breaks
Dragging Equipment Detectors (DED)	Detects if foreign objects, components of rollingstock trains in a derailed state or doors are dragging	Derailed wheels can damage rail and sleeper assets and can damage track circuits and points. In extreme cases can cause larger train derailment
Environmental monitoring stations	Dust opacity monitoring Rain and heat monitoring Rail temperature	Monitors environmental conditions that can have a detriment to rail operations and the effectiveness of controls, i.e. wagon veneering to manage dust lift off
Wheel Bearing Detectors	Measures heat and sound of wheel bearings	Hot bearings can indicate possible catastrophic failure leading to derailment. Cold bearings indicate stuck wheels dragging on rail causing damage
Level Crossing monitoring	CCTV trigger with the presence of trains to monitor and capture near misses	Provides evidence in the event of a near miss, collision or Dewirement / strike

Control Systems Maintenance Activities

As detailed above the control systems assets follow a typical bath tub asset life approach, as such the asset management approach to this asset class is to:

- Maintain the assets to prolong the useful life stage
- Monitor asset to identify the commencement of the wear out stage, starting with design life and monitoring asset condition and trend.

Some Control Systems assets have additional capacity to accommodate failures with minimal disruption to the operation of the systems. For example, there are redundant paths in the telecommunications system, so a failure of one leg will not stop communications as a backup path would carry the load whilst the primary leg is restored.

Maintenance Summary for Control Systems Assets

Asset Discipline	Maintenance Family	Asset Type	Maintenance Approach
Control Systems Assets	Train Control Assets Maintenance	Signals	Electrical Signals - yearly inspection and Preventative tasks, condition review, aspect alignment clean and service housing and lens Mechanical Signals – Planned corrective on identification of fault
		Points	6-week inspection and annual detailed inspection – Check operation, condition, security of fastenings, clean and service moving elements
		Level Crossings	Active Protection – 1, 13 week and annual inspection to check condition, align aspect, clean and service housings and lens Comm's link – 6-month inspection, test function
		Interlockings	6-month detailed inspection and test – Preventative maintenance to building, service batteries, test operation, record condition, clean housing and check PC applications
	Train Control Systems Maintenance	UTC	Telemetry – error rates are checked three times per day and fixed on failure
		ATP	Radio and transponder group – fix on fail due to criticality of system
		Control Systems	Lever frames and manual points – 6 week and annual inspection and preventative maintenance.
	Asset Protection Systems Maintenance	Wayside Systems	Weighbridges – 13, 26, 104- and 156-week services. Rail BAM – 4- and 17-week inspection and preventative maintenance HBD – 13-week inspection and preventative maintenance WILD – 13 and annual inspection and preventative maintenance

Asset Discipline	Maintenance Family	Asset Type	Maintenance Approach
			Coal Dust Monitors – 6 weeks, 3- and 6-month inspection
		Power Systems	UPS – annual inspection and preventative maintenance on alternators including test, voltage measurement clean and start up test Mains supply – fix on fail
	Telecommunications Maintenance	Transmission Maintenance	Microwave Tower sites – 13 - and 52-week inspection, test and condition review
		Data Systems	Continual surveillance via FCC, faults attended as part of planned corrective maintenance
		Radio Systems	13 - and 26-week inspection, test and frequency test 26-week visual inspection of radio towers and associated transmission equipment
	Train Detection	Axle counters	13-week inspection and function test
		Track Circuits	13-week inspection and function test

ELECTRICAL TRACTION ASSETS

The Blackwater and Goonyella systems are electrified, enabling the operation of electric rollingstock. The traction system comprises two main asset groups, Overhead Line Equipment (OHLE) and Traction Substations.

The operational management of the system is provided by electrical control officers (ECOs) collocated in the TCC. A Supervisory Control and Data Acquisition (SCADA) system, utilising the Control system telecommunication network allows the ECO to remotely monitor and control the electrical system, respond to system faults and coordinate switching operations.

As the owner and operator of a large high voltage distribution network Aurizon Network is listed as one Queensland's nine prescribed electrical entities under the Electrical Safety Act. As such, Aurizon Network has wide ranging responsibilities to maintain an electrically safe network, including adequate infrastructure maintenance and renewal activities.

These assets follow the same life cycle curve as the control systems assets (bath tub) and as such the asset management approach to this asset class is to:

- Maintain the assets to prolong the useful life stage
- Monitor asset to identify the commencement of the wear out stage, starting with design life and monitoring asset condition and failure trends

OHLE

The OHLE infrastructure distributes traction power to trains on the system. Trains connect to the OHLE via the pantograph on top of the train. There are approximately 2000km of overhead wires across the electrified Blackwater and Goonyella systems.

The OHLE comprises of a series of overlapping conductor sections arranged in 'tension lengths' supported by high voltage insulators on steel masts. The conductors are maintained at constant tension by a system of balance weights. The contact wire is energised at 25kV to ground (approximately 100 times the voltage of a domestic wall outlet).

The OHLE is made up of a variety of components that have differing asset design lives. For example, the steel structures, contact and catenary wires have 50 year lives while the clamps, dropper wires and insulators have 20 to 25 year lives. Over the last three years Aurizon Network has been systematically replacing the degraded, damaged or aged components in the OHLE though taking the track closure and electrical isolation opportunity in the shadow of the Ballast Undercutting works.

- Major components of the OHLE are:
    - Contact Wire – the electrified copper wire that contacts with the loco via the loc's pantograph
    - Catenary wire – steel cable that supports the contact wire across the electrical tension length
    - Return Wire – carries the return current within the electrical section circuit
    - Earth Wire – provides an electrical path to ground
    - Balance Weights – at each end of the tension length that applies the tension to the catenary wire and to take up expansion and contraction in the wire due to changes to temperature
    - Masts and portal structures – holds the cantilevers in place locating the contact and Catenary wires in the required place over the track
- Power SCADA – utilising the Control system telecommunication network allows the ECO to remotely monitor and control the electrical system, respond to system faults and coordinate switching operations.

Traction Substations

Aurizon Network has 44 Traction substations in its network: 19 Feeder Stations (FS) and 25 Track Sectioning Cabins (TSC) and together they provide three main functions:

- Feeder stations provide a means of connecting to the high voltage transmission network (Powerlink or Ergon) and converting the transmission voltage (132kV or 275kV) down to 50kV for the traction system

- High voltage switching for flexible feeding and configuration of the traction network
- Electrical protection and monitoring

The pictures below show a typical FS and TSC. The equipment in a TSC (i.e. a switchroom and autotransformers) is a subset of the equipment in a FS.

Typical Traction Feeder Station

Typical Track Sectioning Cabin

Future investment requirements

All the traction substations which were built as part of the main line electrification in the 1980s are nearing the end of their service life. Aurizon Network is employing best-practice asset management techniques to further life-extend this infrastructure. In parallel with this Aurizon Network is actively investigating modern technology alternatives to traditional substations which would allow for more cost-effective electrification topologies. It is likely that future renewals of traction substations will employ these new technologies.

Electric Traction Maintenance Activities

These assets follow the same life cycle curve as the control systems assets (bath tub) and as such the maintenance approach to this assets class is aligned.

Again aligned with the Control Systems Assets, the maintenance strategy for Electrical Traction assets is one of:

- Preventative Maintenance – maintenance that is regularly performed on an asset to lessen the likelihood of it failing. Performed whist the asset is in place and working so that it does not break down unexpectedly. It is either:
    - Time based – planned periodic inspection and repair activities
    - Usage based – triggered after a defined usage metric
- Planned Corrective Maintenance – planned rectification work to return equipment to working condition. The planned period for recovery is dependent on the severity of the fault or criticality of the equipment being out of operation. (see General Maintenance)

Reactive – service effecting failure

Maintenance Summary for Electrical Assets

Asset Discipline	Maintenance Family	Asset Type	Maintenance Approach
Electrical Assets	Substations	Feeder Station	Time-based inspection and maintenance programs at 6, 12- and 60-month intervals
		Transformers	Time-based inspection and maintenance programs at 6, 12- and 60-month intervals. Condition monitored via insulating oil sampling and analysis
		Switchgear	Time-based Inspection and maintenance programs at 6, 12- and 60-month intervals. Condition Monitoring, with actions taken to maintain the operational serviceability of the asset
		Earth Grid	Time-based Inspection and Maintenance regime, and Condition Monitoring, with actions taken to

Asset Discipline	Maintenance Family	Asset Type	Maintenance Approach
			maintain the operational serviceability of the asset
	Traction Power	OHLE	Time-based Inspection and Maintenance regime, and Condition Monitoring, with actions taken to maintain the operational serviceability of the asset.
		HV Protection and Cabling	Time-based Inspection and Maintenance regime, and Condition Monitoring, with actions taken to maintain the operational serviceability of the asset.
		Height and Stagger Maintenance	Regular monitoring of OHLE geometry by track recording vehicle. Height and stagger exceptions addressed as required.
	Power Management systems	SCADA	The legacy Citect SCADA system was replaced with a Schneider Clear SCADA system under the FY19 renewals program. Software maintenance performed as required.
		Monitoring Systems	Fix on fail

OTHER MAINTENANCE

The allocation to maintenance also includes several ad hoc activities and general costs

- Derailment and Collision repair – infrastructure repair works to the track assets required post an incident to return the infrastructure to pre-incident condition
- Dewirement repair - infrastructure repair works to the OHLE required post an incident to return the infrastructure to pre-incident condition
- Third party repairs – where a third party has damaged the infrastructure, costs to rectify damage go to the Network Maintenance Plan. Aurizon Network will pursue the Third party if there is evidence of them damaging the asset. For example, a truck hitting the OHLE causing Dewirement
- Inventory Management – costs related to the management of inventory stocks

Costs related to recovery post a natural event such as a cyclone or fire are also held against the Network Maintenance Plan (NMP) given the need to recover the operability of the assets. Depending on the severity and associated costs, this cost is either retained to NMP or recovered via a variation event to the maintenance allowance in a given period.

Appendix 10 – Response to QCA UT5 Draft Decision on Maintenance

This Appendix provides an overview of the QCA's Maintenance Consultants' key conclusions and outlines how AN has taken these conclusions into consideration when developing the Maintenance Strategy and Budget and Renewal Strategy and Budget for FY2021.

The conclusions can be grouped as relating to:

- Track access and possessions
- Mechanised fleet productivity
- Data and systems

The following table addresses these conclusions

	GHD Commentary	Aurzion Network Response
Track access and Possessions	"…any alteration to the MTP, ITP and DTP must not cause a Planned Possession to be interrupted (i.e. a Train Service in the CQCN should never take priority over a Planned Possession)"	Aurizon has used best endeavours to prevent conflicts between planned possessions and Train Services. Aurizon continues to believe that customers would (in general) prefer Aurizon to provide flexibility (where reasonable to do so) with a view to promoting supply chain throughput. Accordingly, Aurzion has not adopted the consultant's recommendation.
Mechanised fleet productivity	Most efficiency issues in the undercutting program relate to improving the productive capability of the undercutting assets and whether existing inefficiencies could be overcome by better spoil- handling practices	Aurizon actively investigating alternative spoil management practices – conscious of environmental issues. GHD assumed that RM900/902 could complete all ballast undercutting work. Turnout undercutting and small section of mainline undercutting rely on excavators as these areas ae inaccessible or inefficient for the ballast undercutter to operate in. These machines have a much lower production rate, and therefore, higher unit rate with no ability to screen ballast
	GHD attributed Aurizon Network's average 32 per cent resurfacing productivity rate to its inefficient CQCN possession management practices. For example, Aurizon Network does not undertake resurfacing works in System Shutdowns (1,018 system shutdown hours per annum), and only delivers resurfacing works during maintenance access windows	GHD misunderstood the full scope of the CQCN resurfacing operation. While cyclical maintenance resurfacing is not completed within system shutdowns, the resurfacing machines deliver scope to complete capex projects and ballast undercutting activities at all times during system closures. The resurfacing fleet is fully utilised during closures. To ensure as limited impact as possible to track capacity the fleet is sized to deliver as much scope as is feasible in closures. At other times it is underutilised to maintain track

		capacity. Any fleet size reduction which would result in more scope outside closures and would reduce track capacity.
	GHD also noted that Aurizon Network could also drive further efficiencies if it delivered resurfacing works during train operations (via singular access windows) where duplicated track permitted	Aurizon Network confirms that resurfacing works are delivered during train operations using single line operations
Data and Systems	GHD considered the failure of Aurizon Network to capture historic information on the scope and cost of general maintenance sub-categories delivered prior to UT4 to be indicative of an inefficient rail operator. Reviewing historic scope and cost information would provide an efficient rail operator with more transparency on the productive efficiency of labour, plant, materials, changes in work practices/technologies and material changes in network infrastructure Aurizon Network's information management systems do not readily provide information which would be expected of an organisation that was monitoring its costs in order to effectively manage and inform trade-offs between the cost of maintenance and the performance of the network.	AN has invested in asset management systems (NAMS) to capture and manage cost and scope data. Maintenance activities currently managed through NAMS. Aurizon is seeking approval for $4.2m in capital in this renewal budget to address the GHD recommendation in relation to the capital program

APPENDIX 11 – Information provided to RIG post Nov 29 2019 Submission

The flowing information was provided to or presented RIG members in the consultation period post the submission of the Draft Maintenance & Renewal Strategy & Budget.

Date	Information	Description
6 December 2019	Presentation	Provided to RIG Members as introduction to Nov 29 Submission
12 December 2019	Presentation	Provided to RIG Members in meeting
19 December 2019	Organisational Chart	Provided as clarity of responsibilities as requested by RIG members
19 December 2019	Q&A Response	Responses to clarification questions requested by RIG members
14 January 2020	Presentation	Provided to selected system representative RIG members providing additional detail of scope on condition and scope identification for selected products

These files have been provided electronically as an attachment ot this submission